The Government of Malaysia
The State of Pahang

# PAHANG TENGGARA

## Regional Masterplanning Study

## Soil Survey Studies and Interpretations

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# PAHANG TENGGARA REGIONAL MASTERPLANNING STUDY

## Soil Survey Studies And Interpretations In The Pahang Tenggara Region

# Soil Survey Studies And Interpretations In The Pahang Tenggara Region

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* Maps also reproduced in Pahang Tenggara Atlas.

# 1.0 INTRODUCTION

The Terms of Reference required detailed investigations, classifications, maps and proposals for agriculturally suited land likely to be developed during the Second Malaysia Plan to give a total not to exceed 250,000 acres. Soil survey information required for such studies, as outlined in the Terms of Reference, included,

(*a*) A terrain classification,

(*b*) A semi-detailed soil survey,

(*c*) A soil suitability classification.

In order to find 250,000 suitable acres it was estimated from the reconnaissance soil surveys of the region (Dumanski and Ooi, 1966; Ives, 1967) that 500,000 acres would have to be surveyed. It was accepted that the detailed soil survey information would be necessary firstly along the proposed primary North-South Kuantan to Segamat highway. Therefore an area of 500,000 acres of public land along the highway was outlined for soil survey.

It should be recognized that the entire Pahang Tenggara Region has not been surveyed at the same detail. However, all available soil survey information has been used in planning the development of the whole region. The planning decisions about the region have been governed by the detail and purpose of each survey. In the semi-detailed area (Fig. 1.1) it was possible to make detailed evaluations of land suitability for agricultural development during the first phases of the regional Masterplan. Information for the remainder of the area consisted of original reconnaissance surveys, more recent surveys at detailed reconnaissance and semi-detailed scales, schematic timber track checks made by this study and extrapolations from the semi-detailed area. Thus, evaluations outside the semi-detailed area are considerably more general and should be accepted as correspondingly less dependable than those in the semi-detailed area.

The soil survey team consisted of one senior soil surveyor on a half time basis, one assistant senior soil surveyor, one soil surveyor on a full time basis, two additional soil surveyors on a field season basis, plus a part time soil survey advisor who had previously surveyed the western portion of the region. Field work was carried out during the period from December, 1970 to September, 1971. The terminology and soil classification are based on those presently used by the Soils and Analytical Services Branch, Malaysian Department of Agriculture. Maintainance of these standards was facilitated by the cooperation and assistance of the Malaysian Soil Survey Unit in the form of familiarization tours, field correlation, part time field assistance, reviews of material, and exchange of information and ideas.

For this report, discussion in the Methodology, Soils, and Soil Interpretation Sections has been made separately for the semi-detailed area and for the rest of Pahang Tenggara. In other sections discussion pertains collectively to the entire region.

This soil survey was a special purpose program designed to facilitate preparation of a Masterplan for the development of the Pahang Tenggara Region. The main conclusions on the suitability of the area for specific crops and consequently for agricultural development are contained in the sections on Assessment for Agriculture (Sections 5.1.4 and 5.2.2).

# 2.0 METHODOLOGY

## 2.1 SEMI-DETAILED SOIL SURVEY AREA

### 2.1.1 Location and Extent

The area selected for semi-detailed soil and terrain analysis forms a corridor through the central portion of the Pahang Tenggara Region. The area is bounded on the north by the S. Pahang while the southern boundary is formed by the S. Rompin, Lesong Uplands and the Pahang-Johore border. The eastern border of the area is bounded by the coastal peats and the west is bordered by steepland in the north and the Keratong Nucleus Estates in the south. The area is composed of 449,510 acres of lowland (slopes <20°), 46,970 acres of steepland (slopes >20°), and 64,670 acres of peat swamps.

### 2.1.2 Soil Survey Methods for Semi-detailed Area

#### 2.1.2.1 Initial approach

The initial approach to the survey was to study existing information available for the area and the classifications presently adopted by the Soils and Analytical Services Branch. Field correlation tours to familiarize the surveyors with the soil types and survey methods were held in conjunction with the Malaysian Soil Survey Unit. Assistance during this stage was received from the project soil advisor. A soil legend was set up based on current Malaysian soil classifications.

#### 2.1.2.2 Field work

The field work was planned to give maximum ground coverage of the area designated for semi-detailed investigation. The dense uniform jungle covering most of the area presented special problems with regard to logistics and access. Vehicle access within the region was limited to major timber tracks and a few navigatable rivers. Therefore, most field observations were made by traversing on foot along planned cut lines, called rentis lines in Malaysia. Topographic maps, existing soil maps, the latest geological information, and aerial photographs were used in planning the rentis network. All rentis lines were cut at predetermined bearings and planned in such a manner that double walking was avoided to a large extent. The network made maximum use of existing access routes. Where possible, rentis lines were planned perpendicular to the strike of the country rocks, giving greatest coverage in areas where complex soil patterns were indicated in previous surveys ($\frac{1}{2}$ mile intervals over most of the area). In some areas, where uniform soil patterns were indicated, sufficient coverage was obtained by making maximum use of existing timber tracks with a limited number of rentis lines (1 mile interval). The rentis network and timber tracks surveyed are indicated in Atlas Map 1. A total of 1,188 miles of rentis were cut. All rentis lines were traversed by members of the soil survey team. Soil bore examinations were made at each 1/8 mile interval with pit examinations at each 1/2 mile interval. The L8010 series of topographic maps was used to achieve ground control, plot field data, and to assess the soil, terrain and landform patterns. Recent aerial photography was available for part of the region and was used where possible. However, the sporadic coverage by unscaled photographs precluded extensive use of them for interpretative purposes.

Soil-site descriptions are based on the system used by the Soil Science Division (Leamy and Panton, 1966). This system has only minor variations from the standard USDA (Soil Survey Staff, 1951) and FAO (Guidelines For Soil Descriptions) systems. Soil borings were made to 100cm using a 3-inch Jarret-type auger. Soil pits were dug at $\frac{1}{2}$ mile intervals to a depth of approximately 60cm and additional borings to 100-150cm were made in the bottom of each pit. Where impenetrable layers occurred, borings and pits were correspondingly shallower. In addition to observations along rentis lines, soil road cut and bore examinations were made at varying intervals along major timber tracks to check the soil map and select additional sampling areas. A total of 243 soil profiles were sampled (1,050 individual soils samples) in selected locations along both timber tracks and rentis lines.

All field notes, traverse summaries and pit descriptions have been typed and bound in loose leaf form. These have been turned over to the Soils and Analytical Services Branch, Department of Agriculture. Representative profile descriptions together with means, medians, quartiles and ranges for chemical and physical data for major soils within the area are presented in this report. In addition, soil chemical and physical data has been tabulated on an equivalent depth basis for purposes of comparing the properties for the main soils.

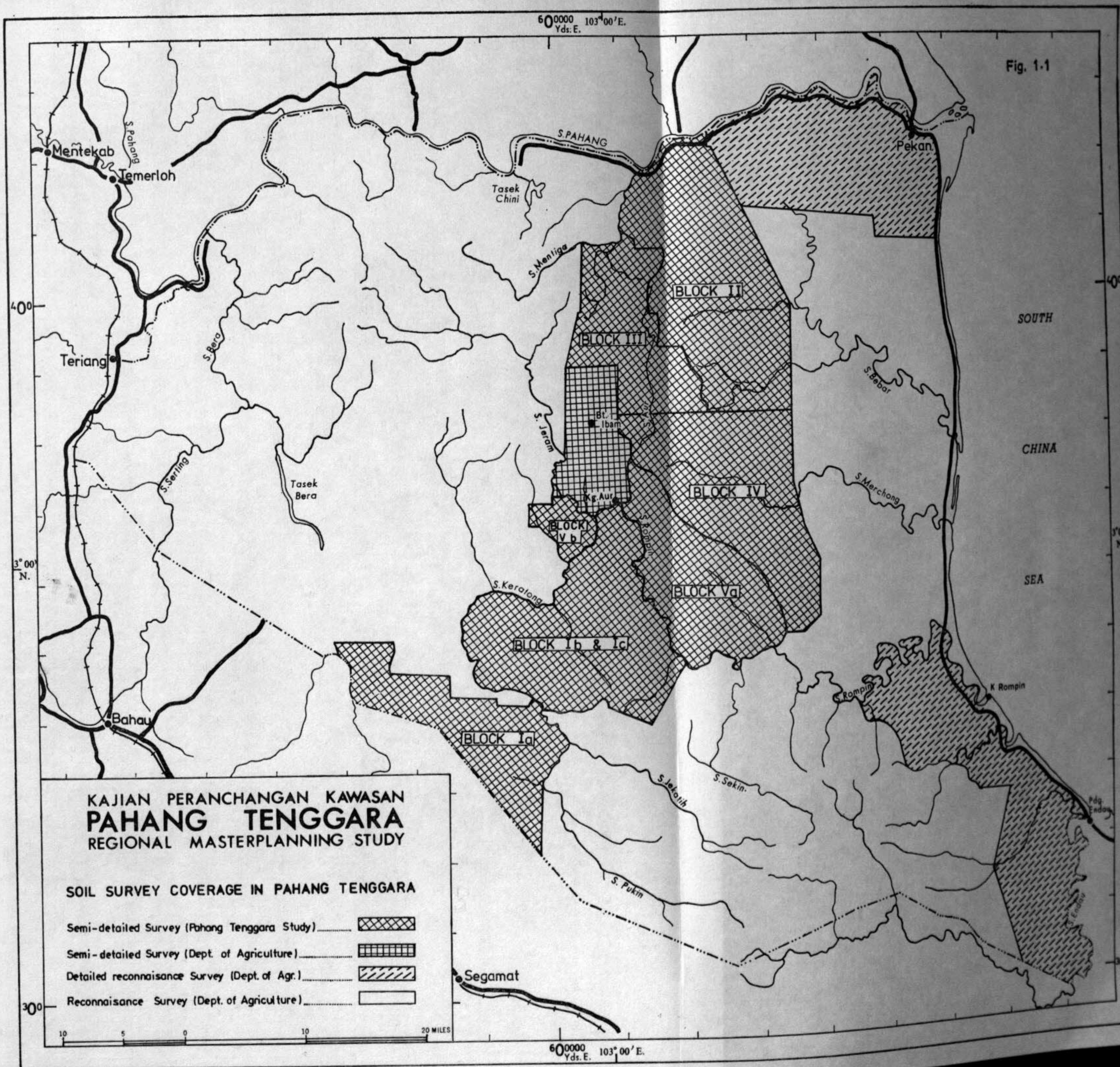
Fig. 1.1
KAJIAN PERANCHANGAN KAWASAN
PAHANG TENGGARA
REGIONAL MASTERPLANNING STUDY
SOIL SURVEY COVERAGE IN PAHANG TENGGARA
Semi-detailed Survey (Pahang Tenggara Study)
Semi-detailed Survey (Dept. of Agriculture)
Detailed reconnaisance Survey (Dept. of Agr.)
Reconnaisance Survey (Dept. of Agriculture)
10 5 0 10 20 MILES
600000 Yds. E. 103°00'E.
Mentekab
Temerloh
S. Pahang
S. PAHANG
Tasek Chini
Pekan
S. Mentiga
BLOCK II
BLOCK III
BLOCK IV
BLOCK Va
BLOCK Vb
BLOCK Ib & Ic
BLOCK Ia
SOUTH
CHINA
SEA
Teriang
S. Bera
S. Bebar
Bt. Ibam
S. Jeram
S. Serting
Tasek Bera
Kg. Aur
S. Rompin
S. Merchong
S. Keratong
K Rompin
Bahau
S. Jekatih
S. Sekin.
Pdg. Endau
S. Pukin
S. Endau
Segamat
4°0'
3°00' N.
3°0'

#### 2.1.2.3 Map compilation

The soil and terrain information was compiled into one map. Final map compilation was based on field observations, topographic maps, knowledge of soil-landform associations and, in limited cases, aerial photographs. Mapping of soil and terrain together is a further evolution of the procedure used in Malaysia where soil and terrain maps have been compiled separately. This method proved very satisfactory and a good correlation between soil patterns and terrain was established.

The main building block for map compilation is the soil mapping unit. A soil mapping unit is a portion of the landscape that has a certain range in characteristics and qualities and whose range is fixed within field identification and cartographic limits. Each mapping unit is described on the basis of the soil series, soil phases and variants, and dominant terrain therein.

The accuracy of the survey is controlled by the location of rentis lines, complexity of soil patterns and extrapolations possible between rentis lines. Although each soil series is defined by a limited range of soil characteristics, it should be recognized that soils form a variable continuum throughout the landscape. In general, an attempt was made to represent the soil and terrain pattern of at least 75% of the area within each mapping unit. In more uniform areas a higher representation can be expected.

The final Soil-Terrain Map (Map 1) was produced by photographically reducing the 1:25,000 scale field compilation maps to 1:63,360 scale. A Soil Capability Map (Map 2) and an Agricultural Development Map With Soil Suitability For Crops (Map 3) both at 1:63,360 were produced based on information from the Soil-Terrain Map.

#### 2.1.2.4 Laboratory methods

Soil chemical and physical analysis was carried out by the Soils and Analytical Services Branch, Department of Agriculture, Kuala Lumpur. The analyses done and methods used are presented in Appendix 8.1.

## 2.2 SOIL SURVEY FOR THE ENTIRE PAHANG TENGGARA REGION

### 2.2.1 Soil Survey Methods for Entire Region

#### 2.2.1.1 General approach

A uniform base of soil information was required for the entire Pahang Tenggara Region. The initial approach to producing such information was to study all available information and delineate areas where more information was required. In this regard, the reconnaissance soil survey reports, the new series topographical maps, recent geological information and to a limited extent, aerial photographs were used. Taking into account the information requirements in terms of overall masterplanning, schematic checks along accessible timber tracks were laid out.

#### 2.2.1.2 Field work

Field work consisted of soil road cut or bore observations at approximately ½ mile intervals along major timber tracks in the areas designated for the schematic checks. The Roads And Rentis Network Map (Map 4) gives an indication of the road coverage in each area.

#### 2.2.1.3 Map compilation

Map compilation consisted of correlating and editing the previous soil maps, then combining the results of the schematic timber track surveys and a generalized version of the semi-detailed map into the Generalized Soil Map at 1:250,000 scale (Map 5). The basic mapping units for this map are soil series and soil associations. These units are similar in definition to those used in the semi-detailed area except terrain is not taken into account and the range within each unit is broader. The map is only a broad assessment of the soil conditions and more detailed work has shown that the complex pattern and soil types cannot be adequately represented at this scale. Therefore the map should only be used as a general guideline to soil conditions and possible potential. A Generalized Soil Capability Map (Map 6), based on information on the generalized soil map, was produced.

## 3.0 SOIL FORMATION

Soils acquire their properties as a result of the interaction of the main soil-forming factors; climate, parent material, topography, time and vegetation. Man is also considered a factor but his activities in Pahang Tenggara are of minimal influence on the soil to date. These soil forming factors cause the development of soil horizons. A cross section of these horizons from the surface to the relatively unaltered parent material is known as a soil profile. The horizons which make up a soil profile differ from one another in one or more of the following features: color, texture, structure, consistency, reaction, and chemical and biological composition. The major soil forming factors and their relationship to the soils in Pahang Tenggara are discussed in this section.

### 3.1 CLIMATE

The climate in the Pahang Tenggara Region is described in the supporting report "Climate and Water Resourses of Pahang Tenggara". Climatic factors in the region which most affect soil formation and soil properties are the high rainfall, high temperatures, low evaporation compared to rainfall, and alternating wet and dry periods. High rainfall and low evaporation has resulted in large amounts of water percolating through the soil, thus enhancing chemical and physical weathering and the downward translocation of nutrient elements and clay minerals. Dry periods intensify the development of soil structure. High temperatures increase the rate of soil weathering as well as the oxidation of organic matter. As a combined result of climatic factors, the soils formed are highly weathered, low in organic matter, and low in fertility.

Climate has also had considerable effect on the evolution of landforms through gradual leveling of the landscape. The closely spaced dendritic drainage systems and mature topography in the lowland regions are results of intensive rainfall and high surface runoff. In some cases the processes of erosion have occurred at faster rates than soil formation resulting in shallow soils. In addition, large areas of alluvial deposits have been formed by deposition of the eroded soil materials in lowland areas.

### 3.2 VEGETATION

The majority of the soils in the region have been formed under dense primary or secondary forest. The present forest cover is described in the supporting report, "Forestry Development in Pahang Tenggara". Forest vegetation affects soil formation by recycling nutrient bases, supplying organic matter, and increasing permeability through root penetration. Although differences in vegetative patterns exist throughout the region, it is generally felt that forest types are not dissimilar enough to produce marked differences in soil properties. The main effect on soil development is the uniform protective canopy which the dense jungle provides against the forces of erosion. Under undisturbed forest a delicate balance between soil formation and erosion has been established after centuries of growth.

### 3.3 BEDROCK GEOLOGY

This account gives only those main features of the geology which help towards an understanding of the soil characteristics and distribution. A more complete description of the bedrock geology is provided in the supporting report, "Geology and Mineral Resources of Pahang Tenggara".

The area is essentially a basement of sedimentary rocks into which igneous intrusives and flows have been injected causing considerable folding and metamorphism. The sedimentary rocks have been divided into five lithologic and structural units. Tentative ages have been assigned to them as well as to the igneous intrusives and flows. The distribution of the bedrock formations throughout the region is illustrated in Map 1 of the above supporting report.

Most of the soils in the region are formed by intensive weathering of residual rocks. The nature of the geologic bedrock is the most important factor governing soil properties under the relatively uniform conditions of climate and vegetation within the region. Soil physical, chemical and morphological characteristics are controlled by the acidity, texture, composition and hardness of the residual rock. Soil distribution and terrain characteristics are also influenced by the underlying rock. Complex soil and terrain patterns are often associated with sedimentary rock areas, especially those subjected to intense folding and metamorphism, while igneous rock areas are generally more uniform. A broad assessment of the major soils mapped on the different geologic deposits is given in Table 3.1. A range of soils is usually found within each rock group because each can represent a range of rock types. Only the general characteristics of the main soil types will be discussed.

The Mersing Group is the oldest sedimentary rock formation. It is composed of metamorphosed conglomerates, quartzites and phyllites with volcanic indurated tuffs, agglomerates and crystal tuffs. The conglomerate, quartzite and phyllite

**Table 3.1—Relationship Between Soils Mapped and Geological Deposits within the Pahang Tenggara Region**

| | Age | Geologic Deposit | Description | Major Soil Series or Mapping Unit |
|---|---|---|---|---|
| Quaternary | Recent | Peats<br>Alluvium | Organic accumulation<br>Recent alluvium | Peat, Organic clay and mucks<br>Telemong, Akob, Local Alluvium, Riverine Alluvium |
| | | | Marine sands<br>Marine clays | Rusila, Rudua, Baging, Rompin<br>Briah, Kranji, Linau |
| | Pleistocene | | Subrecent alluvium<br>Older alluvium | Rasau, Holyrood, Lunas, Serok<br>Harimau, Ulu Tiram, Tampoi, Kawang |
| Tertiary | Pliocene<br>Miocene<br>Oligocene<br>Eocene | Basalt<br>(extrusive) | Segamat basalt flows | Segamat |
| | U. Cretaceous<br>L. Cretaceous | I Gagau Group<br>(sedimentary) | (*a*) Conglomerate, sandstone<br>(*b*) Minor shale interbeds | Serdang, Bungor<br>Bungor |
| | | Younger intrusives<br>(hypabyssal) | Diorite, syenite, granodiorite dykes and stocks | Katong, Segamat |
| | Jurassic<br>U. Triassic | II Tembeling Group<br>(sedimentary) | (*a*) Predominantly argillaceous<br>(soft shales, mudstones)<br>(*b*) Predominantly arenaceous (conglomerate, quartzite, sandstone) | Jeram, Serdang (red variant)<br>Serdang, Bungor |
| Mesozoic | | Andesite (extrusive) | Andesite flows | Segamat, Katong |
| | Triassic | III Gemas Group<br>(sedimentary) | (*a*) Predominantly agrillaceous (shales)<br>(*b*) Predominantly arenaceous (sandstones)<br>(*c*) Predominantly tuffaceous<br>(volcanic tuffs) | Batu Anam, Durian, Marang<br>Bungor, Serdang, (Munchong)<br>Jempol, Munchong |
| | | Batholithic (plutonic) | Biotite granite | Rengam, Jerangau |
| | L. Triassic | IV Jasin—Gayong Group<br>(sedimentary) | (*a*) Ignimbrite<br>(*b*) Agglomerate, crystal tuff | Jempol, Jeram<br>Durian, Bungor, Serdang |
| | U. Permian | V Mersing Group<br>(sedimentary) | (*a*) Indurated tuffs, agglomerates and crystal tuffs<br>("quartz porphyry")<br>(*b*) Limestone<br>(*c*) Metasediments (metamorphosed conglomerates, quartzites phyllites) | Katong, Jempol<br><br><br>Pohoi, Marang, Kemuning |
| Younger Palaeozoic | Permian | | | |
| | Carboniferous | | | |

facies of this formation occurs predominantly in the north central part of the region with a small area outcropping to the northeast of the Lesong Highlands. Soils developed on these materials are light colored, usually moderately deep and commonly contain vein quartz bands. The other facies of this formation is composed of quartz porphyry and crystal tuff. This facies outcrops near Bukit Ibam and also close to the S. Serai. The soils formed are strong brown to reddish yellow, very friable, fine textured and deep. In general the rocks in the Mersing Group are very closely folded, often isoclinally, and overturned producing very complex soil and terrain conditions.

The Jasin-Gayong Group is the second oldest sedimentary group. It lies unconformably over the Mersing Group and is composed of ignimbritic or welded tuffs and their agglomeratic equivalents and crystal tuffs. This unit is located in the central part of the region north of the S. Rompin and also in the Lesong Highlands. Soils developed from these deposits are mainly brownish yellow to reddish yellow, friable and fine to moderately fine textured.

The Gemas Group occupies the entire western portion of the region. The moderately folded nature of the rocks is reflected in the uniform rolling terrain throughout the area. The arenaceous facies of this formation occurs mainly along its eastern fringe and gives rise to soils which are predominantly yellow brown to strong brown, friable to slightly firm and moderately fine textured. The argillaceous facies contains shaly sedimentary rocks which form light colored, fine textured, firm soils.

A fourth group of sedimentary rocks, the Tembeling Group, occurs in the northcentral part of the region and encompasses the Jeram Highlands and Jeram Valley. This formation forms an inverted U with the legs being composed of resistant conglomerate, quartzite and sandstone. The resistant nature of these rocks limit their occurrence to steepland where no soil investigations have been conducted. The central syncline of this group contains broadly folded shales and mudstones and occurs entirely within the Jeram Valley. Weathering of these materials yields soils which are reddish brown to strong brown, friable, and moderately fine to fine textured.

The youngest of the sedimentary formations is known as the Gagnau Group. They comprise conglomerates and sandstones with minor shale interbeds and occur in three separate areas bordering the peat swamps. The rocks are essentially not folded giving rise to the most uniform soil patterns on sedimentary derived materials in the region. Soils developed on these materials are yellowish brown to strong brown friable and moderately coarse to moderately fine textured.

The main igneous area is a large granite batholithic intrusive in the south which lies in a north-northwesterly direction extending from Bukit Chermingat in the central part of the region south to the Pahang-Johore border. Another granitic intrusion occurs to the east of the Lesong Uplands in the Rompin Plateau area. The rock is mainly biotite granite with some areas having a greater content of amphiboles. Weathering of biotite granite gives rise to yellowish brown to strong brown, deep, friable soils. Soils are characterized by approximately equal proportions of sand and clay, with a high percentage of coarse sized sand reflecting the high quartz content in the parent rock. A narrow range of soil types are formed on igneous materials. Soils are much more uniform in characteristics and depth than those developed on sedimentary or metamorphosed sedimentary rocks.

Igneous rocks in the form of andesite flows outcrop in the northwest part of the region, south of the S. Pahang and northwest of the Jeram Uplands. These materials develop into soils which are reddish brown to strong brown, deep, very friable and fine textured.

Syenite, diorite and granodiorite intrusive stocks occur in two more or less northerly trending zones, one in the southwest and the other in the north-central part of the area. These rocks intrude into the Mersing and Gemas sedimentary formations causing considerable folding and metamorphism. The soils developed on these intrusives are similar to soils on andesite, being reddish brown to strong brown, very friable and fine textured.

## 3.4 GEOMORPHOLOGY

### 3.4.1 History

Understanding the geomorphological history of the Pahang Tenggara region is necessary for predicting the landform distribution of soils. The bedrock map indicates the complex geology of this region as being due to the intrusive granitic batholiths crossing the region roughly in the centre of the region. Effects of metamorphic activity are present on the east side of the batholith but not on the west side. This difference is an added complexity of the bedrock geology and complicated subsequent stream dissection of the region.

There has been a great deal of erosion in the Pahang Tenggara region as indicated by the small areas of laterite capped hill (Eyles, 1967 and Ives, 1967) and the exposure of the granitic batholith over a large area. The directional changes and sharp turns of many streams in the Keratong, Jeram and Rompin river basins attest to bedrock control of these streams.

As the bedrock is very complex in most of the area, a complete understanding of the geomorphic history can be obtained only if each watershed is studied in detail. However, several broad conclusions are possible from previously published reports and our field surveys.

Sea level in Malaysia is considered to have fluctuated between—400 to +230 feet during the Pleistocene times (Nossin, 1964). During periods of higher sea level, terraces were deposited in stream valleys. During periods of lower sea levels erosion must have been excessive as presently in upland hilly areas pronounced terraces are not prevalent. Presently sea level is slowly receding (Nossin, 1961). This lowering of base level causes continuing erosion from the inland areas and deposition of sediments in the sea off the present coast onto the shallow shelf. As a result, a series of beach ridges are formed on the east coast. The exact age of each stage of the beach line is not known at this time, however several buried soils have been located. Two grab samples were dated [1] giving some indication of the chronology of the geomorphical events. Time did not permit measurement of exact elevation control of either sample, however the dates obtained do correlate well with Pleistocene dates from other parts of the world. At the Bukit Payong tin mine a buried soil was dated at 29,546 ± 533 years. Near Kampong Ayer Jerneh in the northern part of the semi-detailed soil survey area, a buried soil was dated at 18,123 ± 178 years. Both of these buried soils had very thick Ah horizons. Both were buried by about 15 feet of sediment within which a mature soil profile was formed. Although the exact geomorphology was not worked out, the dates indicate that major erosional cycles corresponding to Wisconsin glacial period occurred in Malaysia. The thickness of deposits on these buried surfaces and the high carbon content (4.32% and 2.77% respectively) also indicate that the erosional events were quite rapid. This is evidence that a major part of the land mass in Pahang Tenggara has probably undergone erosion and/or deposition during the last 30,000 years.

[1] C14 dates courtesy of the Dept. of Geology, Brock University St. Catherines, Ontario, Canada.

### 3.4.2 The Major Landscape Features of the Area

#### 3.4.2.1 The river systems

*The Sungei Pahang System*

Large areas within the region were affected by the past course changes of the S. Pahang. The most notable of the relic landforms is the series of marshes and interconnected narrow swampy areas of Tasek Bera and Tasek Dampar. During earlier times it is likely that the S. Pahang flowed southward from Kg. Kuala Bera through Tasek Bera, then via the S. Palong and S. Muar into the Straits of Malacca (Richardson, 1947). The present divide separating the Muar basin from the Tasek Bera occurs at the headwaters of the S. Palong and is only slightly higher than 100 feet elevation. During severe flood conditions the water levels at Kg. Kuala Bera on the S. Pahang, where past debouchment likely occurred, rise above 100 feet (+125 feet at Temerloh and +96 feet at Kg. Chenor, 1971).

The present drainage system was likely captured by the headwaters of a river flowing eastwards into the South China Sea. This event, probably accompanied by a slight eustatic rise in base level in the Bahau area, resulted in diversion of the S. Pahang to its present course leaving a conspicuous elbow south of Temerloh and a wide incised channel in the Tasek Bera region. The Bera channel is now being slowly filled with sediments from the surrounding hills and drainage for the entire area, except a small portion in the extreme south which is drained by the S. Palong, presently flows into the S. Pahang.

To the west of the Jeram Highlands the low-lying drowned valleys of the Tasek Purun and Paya Langgal areas are also likely remnants caused by past activity of the S. Pahang. In addition, the Tasek Chini, S. Tasek, and the peat and subrecent alluvial deposits in the Mentiga area indicate that a former S. Pahang delta was formed in the region when sea level was higher.

*The Sungei Keratong and Rompin System*

Another likely change from earlier times is the flow of water from the Keratong basin. It is probable that the two main hill ranges formed a divide with waters from the Keratong basin flowing westward into the former course of the S. Pahang at Tasek Bera. The S. Aur and S. Rompin appear to have been one river forming the eastern catchment. River capture of the S. Jeram and Keratong by the S. Rompin in the Kg. Aur area has diverted to the S. Jeram into the Rompin and reversed the flow of the S. Keratong so that the entire Keratong basin is now drained to the east through the S. Rompin.

*The Rivers West of the Peat Swamp*

Most rivers along the northeastern side of the region flow into the peat swamps, except for the Mentiga area which drains into the S. Pahang. Most streams in the southeastern part of the region drain into the S. Rompin except for the Rompin Plateau area which drains directly into the peat swamps. All these rivers probably flowed directly into the sea when sea level was higher and most likely flowed through channels buried by the peat swamp when sea levels were much lower. Present watershed areas are more fully defined in the Hydrology Section of the main report.

### 3.4.2.2 Steeplands

*Location, extent and origin*

Steepland refers to those areas with average slopes of greater than 20° and usually occurring above 250 feet elevation. The two major areas of steepland are the Jeram and Lesong Highlands. These are located centrally in a northwest to southeast trending zone. The Jeram Highlands form the northern most zone and the Lesong Highlands are located in the south. The ranges are separated in the Kg. Aur area by lowlands. Other areas of steepland occur as isolated peaks or ridges, mostly to the east of the major zone.

The Jeram Highlands are located immediately south of the S. Pahang in the north-central part of the region. These hills form an inverted U with the outer legs composed of resistant conglomerate, quartzite and sandstone. The central syncline of this area is composed of less resistant shales and mudstone in which the Jeram Valley has been formed by backcutting of the S. Jeram. The Bukit Ibam area also forms part of the northern steepland complex. Relief in the overall complex is generally over 500 feet with peaks commonly between 1,000-1,800 feet elevation.

The Lesong Highlands occur south of the lower reaches of the S. Rompin and extend southward beyond the Pahang-Johore border. The area reflects the presence of sandstone and volcanic rocks (possibly rhyolites or dacites) that are more resistant to weathering than surrounding granites or shales. The relief of this area is generally higher than that of the Jeram Highlands and peaks are commonly between 2,000-2,800 feet elevation. Scarps and plateaus are common. These factors indicate that the geomorphic processes in this area are in a less advanced stage than in the Jeram Highlands.

*Drainage*

All steepland areas are in a youthful stage of geomorphic evolution. The larger steepland formations are characterized by radial or parallel drainage patterns along the lower edges with subdendritic or trellis drainage patterns on broader areas of high relief. The drainage patterns are largely controlled by fault zones, jointing, and rock structures. The smaller and more isolated areas of steepland usually reflect a later stage of geomorphic evolution. These are generally characterized by radial drainage patterns which usually do not reflect to any extent the underlying bedrock formations. Streams in steepland areas are nearly all deeply incised, often to the bedrock.

*Terrain*

Steeper slopes generally occur at higher elevations. Terrain is usually characterized by sharply crested ridges and in some cases by exposed scarps. Plateaus do occur and are likely the result of horizontal bedding of resistant materials such as conglomerate, quartzite or sandstone. It is less likely that these plateaus are erosion surfaces of laterite because it is theorized that the formation of laterite does not occur under these conditions. Laterite observed in steepland is immature, usually taking the form of weakly laterized parent rock where the rock structure is still readily discernable and resistance to weathering is low.

*Erosion*

Erosion in steepland is severe even under undisturbed forest cover. Landslips and sheet erosion are readily observable in nontimbered areas. Disturbances such as uprooting of trees by wind can greatly accelerate erosion. In the steeplands, erosion normally exceeds soil formation resulting in shallow soil profiles and common bedrock exposures. Headward erosion by streams, as evidenced by common nickpoints in stream beds, is a continuous process.

### 3.4.2.3 Lowlands

*Location, extent and origin*

Lowlands are those areas and associated drainage networks with average slopes less than 20°, being formed on sedentary rocks and usually occurring below 250 feet elevation The lowland areas are located to the east and west of the Jeram Highlands. They are essentially broad peneplains in a mature to submature stage of development. There is a sharp inflection of slope between steeplands and lowlands. Relief generally decreases and slopes are less steep in the lowlands areas as distance from steepland increases.

*Drainage*

Primary drainage systems of the lowland regions still reflect the underlying geology. The main faulting in the region is oriented in northwest, northeast, and north directions. Nearly all major rivers follow these fault line directions with the majority oriented in northwest-southwest directions. In addition, the S. Keratong, Pukin, Jekatih and Kepasing which flow through granitic areas follow a characteristic rectangular pattern. Besides the S. Pahang, only the S. Rompin has a large enough flood plain and a low enough gradient to allow a degree of meandering in the lowland areas.

Secondary drainage patterns seldom reflect the influences of faults, joints, and the varying resistances to weathering of the underlying bedrock formation. The area has reached a fairly mature stage of development in which the bedrock controlled drainage patterns have been mostly obliterated. The most common drainage pattern is dendritic or subdendritic. These are characterized by irregular branching of streams in many directions, many times almost at right angles. Rectangular drainage patterns should be typical in granite rock areas and trellis or subparallel drainage patterns should be typical in folded sedimentary rock areas, but these are more an exception than the rule in Pahang Tenggara.

In general, the regularity of spacing and frequency of drainage lines is greatest in metamorphosed sedimentary areas. Density of streams in sedimentary and igneous areas is fairly similar with perhaps a slightly higher frequency in the sedimentary areas.

Valley incision varies throughout the area. Incision is generally the most severe in lateritic and metamorphosed sedimentary areas. The protective laterite caps result in deep, steep sided stream valleys with flat topped interflues. The sedimentary areas provide alternating soft and hard zones thus resulting in resistant surfaces essentially like a laterite cap. Thus deeply incised streams are more characteristic in sedimentary areas than in igneous areas. In general the secondary streams are characterized by moderately steep banks and narrow valleys.

Larger streams and rivers are generally in more deeply incised valleys propably caused by downcutting during times of lower sea levels because now these streams are in under-fed channels during normal rainfall periods. Valley drowning occurs along the eastern edge of the region where water flow has been deterred by the peat swamp formation. Valley drowning is also evident in the Tasek Bera and Tasek Dampar regions These drowned valleys were cut by the former course of the S. Pahang in times when sea level was lower than at present.

*Terrain*

The terrain in the lowland area is classified according to arbitrary slope classes following the criteria of Leamy and Panton (1966):

| Terrain Class | Average Slopes | Description |
|---|---|---|
| C1 | 0-2° | Level or nearly level |
| C2 | 2-6° | Undulating |
| C3 | 6-12° | Rolling |
| C4 | 12-20° | Hilly |

Slope classes are based on complex slopes since single slopes of any extent are virtually non-existent in the region. Within each complex of slopes differences in slope types and frequency exist, but these do not occur in a predictable enough fashion nor was the detail of the soil survey fine enough to indicate such patterns on a map. Certain generalizations can be made about the consistency of the relationship between soil type, geology, releif and terrain. More detailed surveys will undoubtedly uncover these relationships. Table 3.2 shows the distribution of the different terrain classes mapped in the major soil areas in the semi-detailed soil survey region. The breakdown does not take into account associated series or lateritic phases, both of which have effects on the terrain conditions.

**Table 3.2—Percentage Distribution of Terrain Classes for Some of the Major Soils in the Semi-Detailed Area**

| Soil Series | Acreage | Geologic Deposit | Terrain Class 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|
| SDG | 28,190 | arenaceous rock ... ... ... | ... | 39.9 | 44.6 | 15.5 |
| BGR | 87,320 | argillaceous—arenaceous rock ... | 0.4 | 44.3 | 41.1 | 14.2 |
| DRN | 8,700 | argillaceous rock ... ... ... | — | 43.0 | 34.2 | 22.8 |
| MRG | 12,240 | metamorphosed sedimentary rock ... | — | 45.6 | 23.7 | 30.7 |
| PHI | 16,540 | metamorphosed sedimentary rock ... | — | 19.9 | 41.0 | 39.1 |
| RGM | 114,490 | igneous rock ... ... ... | 0.5 | 44.2 | 48.4 | 6.9 |
| HMU | 15,050 | older alluvium ... ... ... | 8.0 | 81.1 | 10.9 | — |
| MCA | 34,320 | variable ... ... ... | — | 42.0 | 42.8 | 15.2 |

Terrain in the region is characterized by narrow ridges and relatively short side slopes. The terrain classes in the sedimentary rock and in Malacca areas are essentially in the same distribution. Areas of metamorphosed sedimentary rocks have the highest incidence of hilly terrain. The broken nature of the terrain in these areas reflects the severe folding and overturning which has taken place in these geologic materials. Igneous rock areas are characterized by more uniform slopes, generally undulating and rolling, indicating a more uniform bedrock deposit.

*Erosion*

Erosion is more severe in areas with steeper slopes. Undisturbed forested lowland areas are characterized by a relatively slow rate of sheet erosion. The incidence of land slips are fewer than in steepland areas. Disturbing the soil surface and exposure of the surface to the forces of erosion will most certainly accelerate the rate of erosion in these areas.

### 3.4.2.4 Alluvial terraces

*Location, extent and origin*

There are three terrace levels mapped in Pahang Tenggara namely the older, subrecent and recent. Older alluvium deposits of unconsolidated clays, sands and gravels forming low hills in Johore and Singapore have been identified (Burton, 1964). It is postulated that the Johore deposits were formed in a broad delta during the early Pleistocene with the sea level at about 250 feet above the present sea level.

Older alluvium deposits have been identified to the south and north of the S. Keratong. These deposits occur at elevation of 150 to 250 feet and consist of broad, flat plains. Older alluvium of this type also occurs along the present course of the S. Pahang at similar elevations. As both occur on similar elevations to deposits in Johore, it is postulated that older alluvium terraces were present in all of Pahang Tenggara. The fact that they occur in present day inland areas corresponds to the fact that sea level was much further inland at one time in the past. Older alluvium surfaces have not been identified in association with sedimentary rocks in Malaysia. This may be due to more rapid erosion of sedimentary rock derived terraces than igneous rock derived terraces.

Subrecent terraces occur along present and abandoned stream valleys. They also occur along sedentary rock areas next to the peat swamp. Large areas of the subrecent terraces occur in the Keratong and Jeram valleys and in the northeastern part of the region.

Recent alluvial terraces occur in all stream valleys as narrow strips between the stream and sedentary rock areas of subrecent terraces. The major areas of recent alluvial terraces occur in the down stream positions of the major river systems. The S. Pahang and S. Rompin systems have large areas of recent terraces. Many of the recent terrace positions in the S. Pahang system, in the northen part of the semi-detailed survey area, are under peat at present.

*Terrain*

Older alluvium deposits have more uniform terrain characteristics than sedentary soils areas (Table 3. 2). This is likely due to the deposit being younger than sedentary deposits. In addition older alluvium deposits consist of uniform horizontal bedding. Subrecent alluvial deposits occur on nearly level terrain.

*Drainage*

The older alluvium terraces have been subjected to more erosion and dissection than the subrecent terraces or recent terraces but probably less than sedentary surfaces. The drainage network is controlled by the uniform composition of the older alluvial deposits and the presently receding sea level. The subrecent terraces are beginning to be dissected at present.

*Erosion*

Erosion on older alluvium surfaces is limited to side slopes. Erosion on subrecent and recent surfaces is virtually nonexistent except for banks of rivers. The recent terrace positions are areas of sediment accumulation during present geologic time.

### 3.4.2.5 Coastal beach ridges and peat swamps

*Location, extent and origin*

The coastal beach ridges and peat swamps have been developed as the beach line has gradually moved seaward with subsequent accumulation of peat and alluvial material forming an "inland" swamp basin behind the present beach. Progressive outward growth of this formation is indicated by a series of interior beach ridges running parallel to the land and spaced at varying intervals out to the present beach (Nossin 1961, 1964). Further evidence of relatively recent lagoon formation is given in records and maps documenting a bay in the area between Kuantan and Pekan prior to the eighteenth century (Nossin, 1965). An accelerated process of coastal accretion is likely due to a eustatic lowering of the sea level. Interior beaches prograding from approximately 25 feet elevation to the present coastal beach elevations of approximately 10 feet (Nossin, 1961) indicate such a process.

Former beaches create natural barriers to the flow of water through the swamp. River courses through the peat areas are often irregular indicating the obstructed flow. "Drowned" valleys, common along the entire eastern edge of the sedentary area bordering the peats, are further indications of restricted water flow. In addition, southward building of coastal sandbars has caused repeated obstruction of rivers and considerable southward diversion of all rivers running through the swamps. The S. Bebar is the best example of this phenomena.

Deltas form an integral part of the east coast marine and peat swamp formation. Six major deltas have formed between Pekan and Endau at the mouths of the S. Pahang, Bebar, Merchong, Rompin, Pontian and Endau. Within each delta considerable area is generally occupied by a complex association of freshwater swamps, tidal swamps, levees, alluvial floodplains and marine sand ridges. Beach deposits outside the delta areas consist of only narrow strands of marine sands, often less than one half mile in width.

As the coastline has prograded eastward there have been many changes in channel form in the delta areas. The S. Pahang delta is the largest in the region and it reflects a very complex history (Nossin, 1965). Within the last 300 to 400 years the lower reaches of the S. Pahang have changed courses several times, formerly having distributaries to the north and more recently to the South of its present outlet. An important point is the active rate at which the Pahang delta is forming and changing. In addition to course changes, land accretion at the mouth has been at the rate of approximately 3 miles over the past 300 years, an average of over 15 meters per year. Opening more land in the S. Pahang catchment area will considerably increase the flow rates and silt loads leaving the possibility of further course changes and increased flooding, or both.

*Drainage*

The swamp area is flooded for half the year. However in the other half of the year the water table is at or slightly below the soil surface. Drainage from the swamp area is by streams under the organic soil surface and very slow. The sand ridges are well drained and droughty through most of the year.

*Terrain*

The terrain is essentially of zero slope in the peat swamps. The scanty spot elevation information across the peats indicates a gradual lowering of elevation from the uplands to the coast with perhaps a slight doming in the centre. The sand ridges have very gentle slopes of usually less than 6 degrees.

*Erosion*

Erosion is generally nonexistent as this is a land area of accretion. However changes in stream channels at the mouth of rivers cause very localized erosion near the coast.

### 3.4.2.6 Composite soil-landform diagrams

Soil landform diagrams were drawn to give a quick impression of how different soils are visualized in the landscape. These diagrams are composites of impressions gained during the survey and not any specific case in the semi-detailed soil survey area. Four diagrams (Fig. 3.1-3.4) are used to represent different soil-landform areas. The diagrams are essentially a compression of a drainage system in such a way that all its component parts are displayed. Therefore no scale is included.

In Fig. 3.1 the igneous rock areas are represented. Rengam, Jerangau, Katong and Segamat soils do not all occur on one hill but they all occur on igneous rocks on a wide range of slopes. In association with these lowland surfaces the three terrace surfaces and their associated soils can be found. In certain areas the older alluvium terraces have been eroded, as illustrated by the association of Rengam soils next to Rasau soils. Usually major areas of subrecent terraces occur downslope from the igneous rock areas. The major areas of recent terraces are on the lowest terrace further downslope from the subrecent terraces and sedentary surfaces. Kampong Kubor soils occur only in a few of the very recent terraces abutting the igneous rock derived soils. Riverine Alluvium occurs in positions where streams join. Local Alluvium occurs in positions where a fairly uniform sediment deposit is laid down, usually down stream from where rivers join.

In Fig. 3.2 the sedimentary rock areas are depicted. In these areas the slopes are steeper than in igneous rock areas. The older alluvium terraces were not mapped in sedimentary rock areas, however downslope large areas of subrecent terraces maybe prevalent. In the many sedimentary rock areas sedentary surfaces adjoin the recent surfaces. This is in accord with the dropping sea level and steady erosion present in the area. Bungor and Durian soils are generally found on the same slope. Bungor and Serdang soils can occur on the same slopes also. Malacca soils usually occur at the top of these hills. Jempol and Munchong soils occur in small isolated areas enclosed by other soils. This survey was not of sufficient detail to work out the minor landform variations giving rise to Serok, Rasau, Holyrood and Lunas soils, but Serok soils are generally viewed as being on a higher substage surface of the subrecent terrace. Lunas soils occur in slight depressional areas, rising to Rasau then Holyrood on the highs.

The metamorphosed sedimentary rock areas (Fig. 3.3) are composed of steeper slopes in the main rock areas and only subrecent and recent terrace sequences in the lower slope areas. Serok soils are only of very limited extent in these areas with Rasau, Lunas and Holyrood occurring on most of the subrecent terrace areas. In the narrow valleys Local Alluvium and Riverine Alluvium soils occur. Malacca complex soils are common on hilltops and side slopes in the metamorphosed sedimentary rock areas. Pohoi soils usually occur on steeper slopes with Marang soils on less steep slopes. In some areas the sedimentary and metamorphosed sedimentary rocks occur on the same slope, with a corresponding complexity of soils.

Fig. 3.4 represents those areas where only the three terrace landforms are found. In some areas the three terrace sequences are very distinct with the subrecent and recent terraces downslope from the older alluvium terraces. In other parts of the semi-detailed region, large areas are composed of only the recent and subrecent surfaces. These areas occur mainly nearer the east coast swamp. In these areas, Holyrood soils are usually found on slightly elevated positions, perhaps on another substage of the subrecent terrace. Serok soils are not common.

Work should be done to map in more detail the soil landform patterns on the subrecent and recent terrace positions. More work should be done on the location of remnant older alluvium terraces in the shale and sedimentary rock areas.

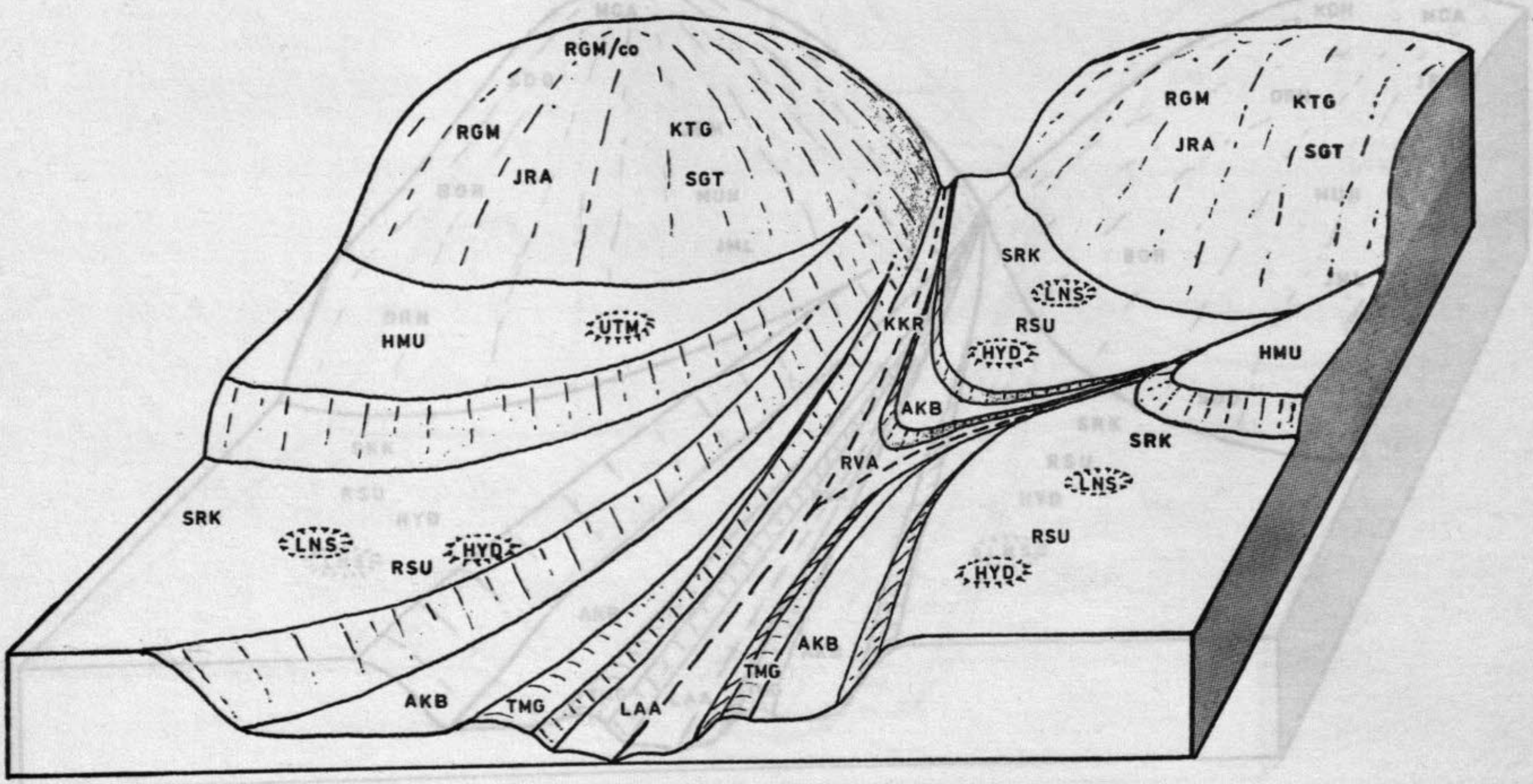


Fig. 3·1 Igneous rock areas and associated soil-land forms

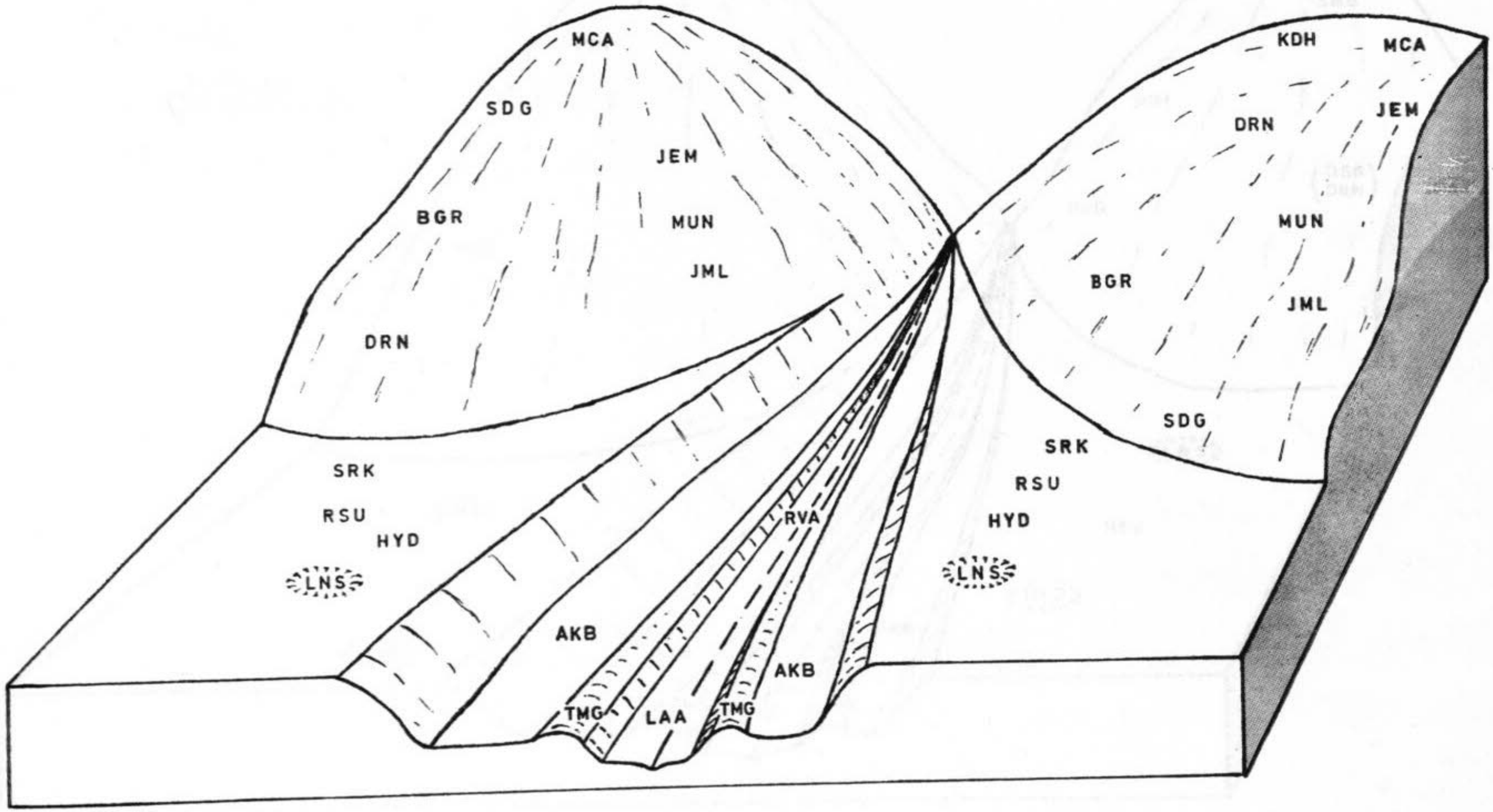


Fig. 3·2 Sedimentary rock areas and associated soil-land forms

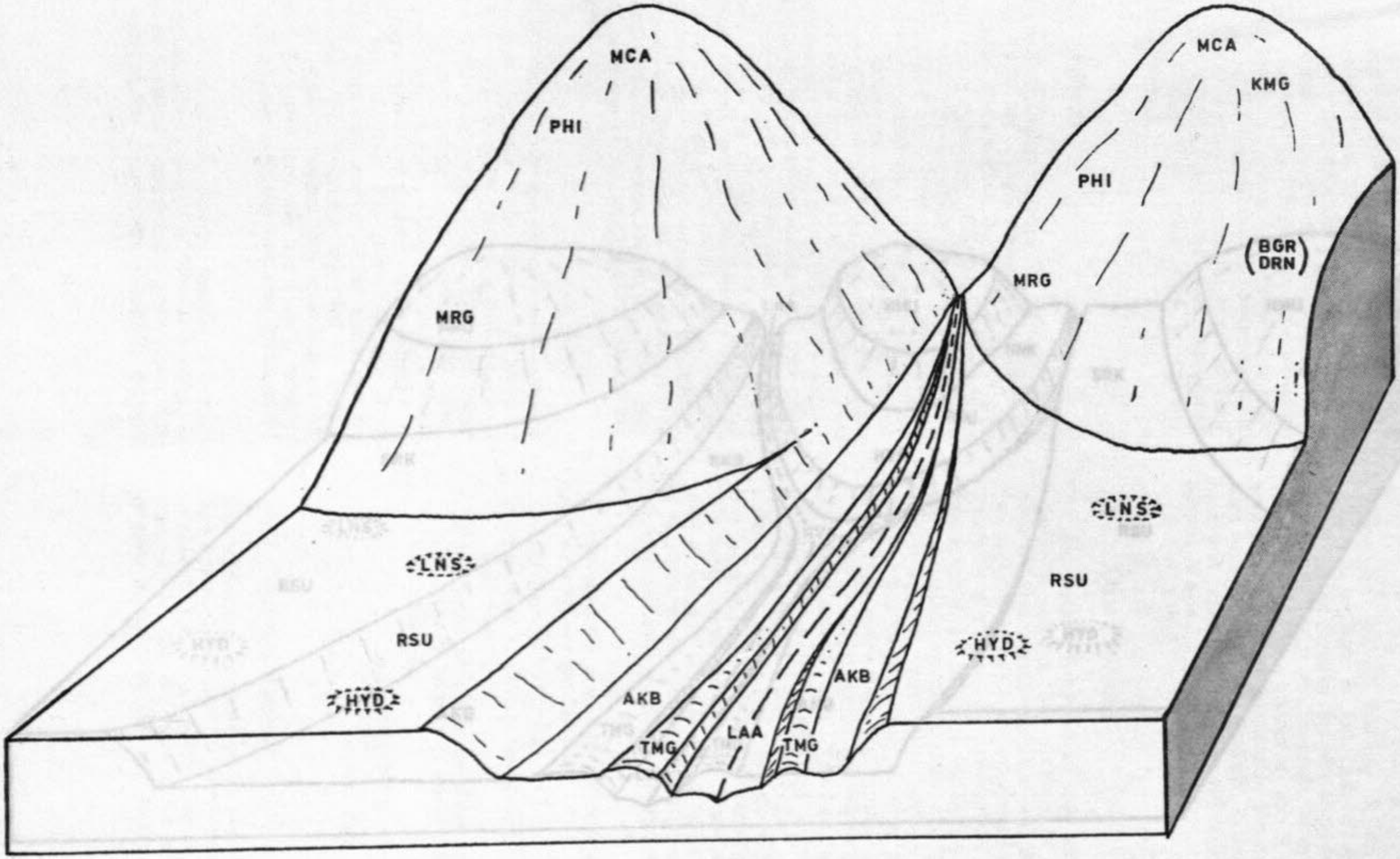


Fig. 3·3 Metamorphosed sedimentary rock areas and associated soil-land forms

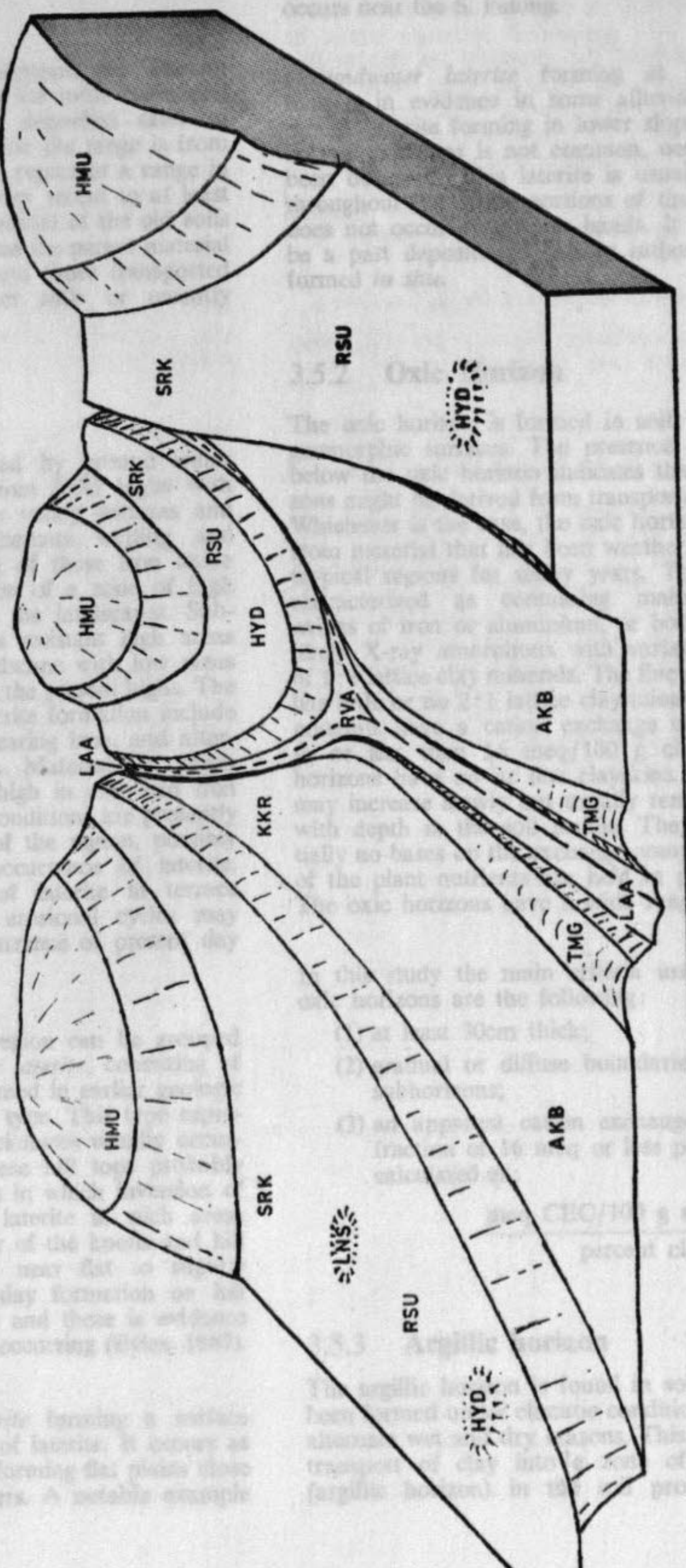


Fig. 3·4 Major Terraces and associated soil-land forms

## 3.5 MAJOR GENETIC SOIL FEATURES

The range in soil development in Pahang Tenggara varies from nil to the most developed possible, or from recently deposited sand to massive laterite. Soil series wise the range is from Telemong to Malacca. These represent a range in effective age of soils from very recent to at least late Tertiary. The parent material of the old soils is the original bedrock whereas the parent material of the younger soils is several times transported material eroded from older soils or recently exposed bedrock.

### 3.5.1 Laterite

Laterite is probably formed by ground water transport of iron oxides from local highs with subsequent accumulation in valley bottoms and lower slope positions. Alternate wetting and drying results in hardening of these iron oxide accumulations and formation of a zone of high resistance to weathering in the landscapes. Subsequent erosion of the less resistant high areas causes inversion of the landscape with low areas containing laterite becoming the present highs. The conditions conducive to laterite formation include a source of groundwater bearing iron, and alternate wet and dry periods. Materials in which laterite forms are usually high in clay and iron content. Climatic and soil conditions are presently favourable in large parts of the region, possibly explaining the common occurrence of laterite. However the deposition of laterite in terrace positions during previous erosional cycles may also contribute to the occurrence of present day laterite.

Laterite observed in the region can be grouped into three categories. *Relic laterite*, consisting of laterite which has been formed in earlier geologic time, is the most common type. This type represents layers of varying thicknesses usually occurring as caps on hills. These hill tops probably represent former low areas in which inversion of relief has occurred. The laterite in such areas usually follows the contour of the knolls and hill tops which are generally near flat to slightly convex. Rate of present day formation on hill tops is probably very low and there is evidence of a disintegration process occurring (Eyles, 1967).

*Nodular or pisolitic laterite* forming a surface pavement is another type of laterite. It occurs as part of erosional surfaces forming flat plains close to some of the major rivers. A notable example of this is the Mentiga area immediately south of the S. Pahang. A similar area of fairly large extent occurs near the S. Palong.

*Groundwater laterite* forming at the present time is in evidence in some alluvial areas. Although laterite forming in lower slope and valley bottom positions is not common, occurrence has been observed. This laterite is usually dispersed throughout the lower portions of the profile and does not occur as distinct bands. It may in fact be a past depositional feature rather than being formed *in situ*.

### 3.5.2 Oxic Horizon

The oxic horizon is formed in soils on very old goemorphic surfaces. The presence of stonelines below the oxic horizon indicates that these horizons might be derived from transported sediments. Whichever is the case, the oxic horizon is derived from material that has been weathering in humid tropical regions for many years. The horizon is characterized as containing mainly hydrated oxides of iron or aluminium, or both, more than likely X-ray amorphous with variable quantities of 1:1 lattice clay minerals. The fine earth fraction has little or no 2:1 lattice clay minerals. The clay minerals have a cation exchange capacity equal to or less than 16 meq/100 g clay. The oxic horizons have no or few clayskins. Clay content may increase slowly but usually remains constant with depth in the soil profile. They have essentially no bases on the exchange complex and most of the plant nutrients are held in plant remains. The oxic horizons have a wide range of color.

In this study the main criteria used to identify oxic horizons are the following:

(1) at least 30cm thick;

(2) gradual or diffuse boundaries between its subhorizons;

(3) an apparent cation exchange of the clay fraction of 16 meq or less per 100 g clay, calculated as:

$$\frac{\text{meq CEC/100 g soil} \times 100}{\text{percent clay}}$$

### 3.5.3 Argillic horizon

The argillic horizon is found in soils which have been formed under climatic conditions which have alternate wet and dry seasons. This allows for the transport of clay into a zone of accumulation (argillic horizon) in the soil profile. Thus the presence of an argillic horizon indicates an older stable geomorphic surface (but younger than that of soils containing an oxic horizon) which has a soil climate with periods of moisture stress. In the humid tropics the presence of the argillic horizon is used to indicate soils with some weatherable minerals present (this concept must be tested further). In this area the main criteria used to identify the argillic horizon are as follows:

(1) increase in clay in the argillic horizon over the eluvial horizon (according to accepted limits);

(2) presence of clay skins on ped surfaces;

(3) cations exchange capacity per 100g clay of greater than 16 meq.

### 3.5.4 Low pH, and Base Saturation

All the soils sampled in the region had pH values of less than 5.0 and base saturation less than 10 per cent. As the soils sampled came from all geomorphic surfaces ranging from very recent to very old, the low pH and base saturation values indicate that the materials from which the soils have been derived have been through more than one weathering sequence. All the soils have been weathered and leached of plant nutrients. The pedogenic processes presently active are simply redistributing highly weathered clay in the soil profile and removing last traces of the more resistant minerals. The soils as a whole are simply a rooting and a water supplying medium for plants. The nutrients are in a cycle and if this cycle is broken (clearing) they will be lost. New nutrients will have to be added and hopefully a new cycle established for each crop.

### 3.5.5 Low Cation Exchange Capacity

All soils derived from igneous rocks have the lowest CEC/100g clay (Table 3.3). Other than the horizons in the top 30cm they have CEC/100g clay well below the 16 meq used as a diagnostic criteria for the oxic horizon.

Soils derived from sedimentary and metamorphosed sedimentary rocks have a CEC above 16 meq/100g clay.

Except for the finer textured soils from the subrecent and recent terraces all others have CEC above 16 meq/100g clay.

The dominant clay mineral present in the soils of the area is probably kaolinite, but hydrated iron and aluminium oxides are present. The coarser textured subrecent and recent alluvial soils may have some micaceous minerals.

**Table 3.3—Average CEC/100g Clay for each Series (Calculated by AV. CEC/100g Soil × 100 ÷ AV. % Clay)[1]**

| Soil Series | Depth (cm) 0–30 | 30–60 | 60–100 |
|---|---|---|---|
| *Soils developed on igneous rocks:* | | | |
| Jerangau | 16.8 | 12.5 | 10.5 |
| Katong | 17.0 | 12.7 | 12.9 |
| Rengam | 27.7 | 14.5 | 13.0 |
| Segamat | 17.5 | 11.3 | 9.9 |
| *Soils developed on sedimentary rocks:* | | | |
| Bungor | 35.0 | 20.7 | 19.0 |
| Durian | 29.8 | 19.0 | 18.9 |
| Jempol | 39.2 | 31.4 | 22.9 |
| Jeram | 25.8 | 35.4 | 32.2 |
| Kedah | 38.1 | 25.0 | 22.9 |
| Serdang | 47.1 | 23.6 | 21.3 |
| Serdang Sandy Clay phase | 39.7 | 24.1 | 16.3 |
| *Soils developed on metamorphosed sedimentary rocks:* | | | |
| Kemuning | 28.8 | 19.1 | 25.0 |
| Marang | 38.8 | 24.2 | 21.9 |
| Pohoi | 35.0 | 19.9 | 19.0 |
| *Soils developed on older alluvium:* | | | |
| Harimau | 38.8 | 21.2 | 18.4 |
| *Soils developed on subrecent alluvium:* | | | |
| Holyrood | 82.2 | 50.5 | 41.9 |
| Lunas | 105.4 | 75.0 | 50.0 |
| Rasau | 44.1 | 24.9 | 21.6 |
| Serok | 21.7 | 14.8 | 15.2 |
| *Soils developed on recent alluvium:* | | | |
| Akob | 27.9 | 16.9 | 16.5 |
| Telemong | 67.0 | 33.9 | 24.6 |
| Kampor Kubor | 46.1 | 27.3 | 27.6 |
| *Soils developed on variable parent materials:* | | | |
| Alluvial Complex | 108.0 | 90.2 | 57.8 |
| Malacca Complex | 32.2 | 19.9 | 18.8 |

[1] The limitations of these values should be well understood before they are used for any other purpose than classification.

# 4.0 SOILS IN THE PAHANG TENGGARA REGION

## 4.1 SEMI DETAILED SOIL SURVEY AREA

### 4.1.1 Development of the Mapping Units

The basic unit used in the field classification of the soils in the semi-detailed soil survey area is the soil series. A *soil series* consists of soil profiles that are developed on similar parent material and have genetic horizons that, except for the texture of the surface layer, are similar in differentiating characteristics and arrangement in the profile. The soil is classified as a different series if it has a significant variation in one or more of the soil properties.

Individual soil series may occupy large continuous land areas but more commonly, because of local differences in relief, drainage or parent material, more than one soil series will be represented in any one area. Soil *associations* are groups of soil series which have similar parent materials and occupy a contiguous given area. *Soil complexes* are groups of soil series developed on different parent materials but occupying a contiguous given area.

The soils are classified as *phases* of a soil series when they have similar profile characteristics to the main series but vary in some physical feature significant to their use and management. Soil phases are based on external features such as stoniness, texture, profile thickness or the presence of a nonconforming subtrate that may occur below the solum. Lateritic, depth and textural phases were separated in the semi-detailed soil survey area. A lateritic phase is one in which the soils have the characteristics of the prescribed series but contain an indurated horizon which is 25-60cm thick. The depth phases apply to the thicknesses of the solum in mineral soils, and the thicknesses of the organic layer in organic soils. These include the following categories: very shallow (0-25cm depth), shallow (25-50cm depth), moderately deep (50-100cm depth), and deep (>100cm depth). Three textural phases of the B horizon as it deviates from the modal concept of the series were used in the semi-detailed soil survey. These are the coarse sandy clay phase, sandy clay phase and the fine sandy clay phase. Beside these phases, one soil variant was mapped. The soil variant was used to distinguish between profiles that were similar in all properties to the series from which it derived its name, except for color.

*Mapping units* are soil series or groups of soil series together with any applicable phases or variants that occur within a defined area and on a defined terrain. This is the basic unit which was used on the semi-detailed soil survey map. *Miscellaneous mapping units* include those areas in which no attempt was made to differentiate soil series, either because of their extent or complexity, or because of the limited survey coverage.

In the field, mapping basically consisted of first delineating areas of uniform terrain; then, from soil observations and concepts of soil landforms (Fig. 3.1-3.4), designating the soils present in these areas. In complex areas decisions were made as to what proportion of each soil was present. In places it was possible to map out different soils in areas of uniform terrain. It is on this basis that the mapping units were defined and the final map drawn.

Any of the various soil terrain mapping units on the soil map can be mentally visualised by making reference to the block diagrams (Fig. 3.1-3.4). The single soil units are just an expanded portion of the appropriate block diagram. The complex mapping units can be visualized mentally by combining the appropriate parts of the proper block diagrams.

### 4.1.2 Mapping Legend

A summary of the soils and their major characteristics is presented in the form of a mapping legend (Table 4.1). A brief description of the distinguishing characteristics of each soil is presented, as well as the soil's parent material and drainage status. The soils in the area consist of 24 soil series, 1 soil complex, 7 miscellaneous mapping units, 7 soil phases and 1 soil variant.

### 4.1.3. Classification of Soils into the New Comprehensive System

While series, complexes, phases and variants are the basic units used in field classification of soils, other categories are used to group soils into broader classes. Soil classification in West Malaysia is under review at present, and attempts have been made to adopt the diagnostic horizon limits proposed in the New Comprehensive System of Soil Classification (Soil Survey Staff, 1960, 1967 and 1970). In accordance, the soils mapped in the semi-detailed soil survey area have been classified to the Family level of the New Comprehensive System (Table 4.2). Classification of soils in the Pahang Tenggara Region into the new system is an approximation because of a lack of data specific to the classification system and because the system has not been fully developed for tropical soils. However it is felt that for ease of future comparisons of Malaysian soils to soils in other parts of the world they should be classified into the New Comprehensive System. These comparisons will be made for the extrapolation of agronomic practices by loan agencies, F.A.O. and Malaysian agricultural experts.

*Principles used:*

1. Temperature

   All soils have been classified into one temperature class, namely isohyperthermic, as all soils will have mean annual temperature >22°C (72°F) and the mean summer temperature will not differ by more than 5°C (9°F) from the mean winter temperature. However when cultivated the difference in temperature may be greater than 5°C (9°F) (Chan, 1971;[1] Rice, 1969).

2. Reaction Class

   All soils have been classified into one reaction class, namely acid, as the pH into $H_2O$ (1:2.5) is less than 5.5.

3. Mineralogy Classes

   Specific criteria for mineralogy classes is not available for the soils in the Pahang Tenggara region. However, on the basis of published work (Ng, 1966 and Eswaran, 1969), and on recent unpublished work (Tan, 1972)[2], it is estimated that the following three mineralogy classes are applicable:

   (*a*) *Oxidic*—(Applied to loamy, silty and clayey textures). Less than 90% quartz and less than 40% of any other single mineral and the ratio of:

   $$\frac{\%\ \text{extractable iron oxide and gibbsite}}{\%\ \text{clay}} \geq .20$$

   (For iron and clay ratios use the whole soil < 2mm; for quartz and other minerals use the 0.002-2mm fraction).

   (*b*) *Siliceous*—(Applied to sandy, silty and loamy textures). More than 90% (weight) of silica minerals (quartz, chalcedony, opal) and other minerals with a hardness of 7 or more in the Mohs scale. (Determined on the 0.02-2mm fraction).

   (*c*) Kaolinitic—(Applied to clayey textures). More than half by weight of kaolohite, dickite and nacrite, and with smaller amounts of other 1:1 nonexpanding 2:1 layer minerals or gibbsite. (Determined on the < 0.002mm fraction).

4. The specific soil profile described in detail in Section 4.1.4 was classified. The data averaged on a depth basis was used as an aid for certain series.

5. If soils had argillic horizons and high CEC/100g clay they were put into the Ultisol order. If soils had an oxic horizon of low CEC/100g clay they were classified as Oxisols. If soils had no argillic horizons, high CEC/100g clay and weak structural B horizons they were classified as Inceptisols. Soils with little horizon differentiation and high CEC/100g clay were classified as Entisols.

More detailed morphological micromorphological, mineralogical, chemical and physical analysis have to be made specifically for genetic and classifactory studies before correct classification into any system can be adopted. The criteria for separation of Ultisols, Oxisols and Inceptisols is particularly important in these soils for classification into the New Comprehensive System.

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[1] Personal communication from Enche' Chan Huen Yin. 1972. Soils Division, R.R.I.M., Kuala Lumpur.

[2] Personal communication from Enche' Tan Meng Hue. 1972. Soils and Analytical Services Branch, Malaysian Department of Agriculture.

### Table 4.1—Soil Mapping Legend Used in the Semi-Detailed Soil Survey Area

| Symbol | Series | Description | Parent Material | Drainage |
|---|---|---|---|---|
| AKB | Akob | Light gray to very pale brown, fine to moderately fine textured, firm, moderately deep soils | Recent Alluvium | Poorly |
| BGR | Bungor | Brownish yellow to strong brown, moderately fine to fine textured, friable, deep soils | Arenaceous Shales and Quartzite | Well |
| DRN | Durian | Brownish yellow to reddish yellow, fine textured, firm to very firm, moderately deep soils | Shales or Phyllites | Moderately Well |
| HMU | Harimau | Brownish yellow to yellowish brown, moderately fine to fine textured, firm, moderately deep to deep soils | Older Alluvium | Well to Moderately Well |
| HYD | Holyrood | Brownish yellow to pale yellow, moderately coarse to coarse textured, friable to very friable, deep soils | Subrecent Alluvium | Somewhat Excessively |
| JML | Jempol | Yellowish red to red, moderately fine to fine textured, friable, deep soils | Tuffaceous Shales and Conglomerate | Well |
| JEM | Jeram | Yellowish red to reddish brown, fine textured firm, deep to moderately deep soils | Shales | Well |
| JRA | Jerangau | Strong brown to yellowish red, fine textured, friable, deep soils | Granodiorite | Well |
| KKR | Kampong Kubor | Light gray to pale yellow, moderately coarse textured, friable soils | Colluvium and Recent Alluvium | Poorly |
| KTG | Katong | Strong brown, fine textured, friable, deep soils | Quartz Andesite | Well |
| KDH | Kedah | Strong brown to brownish yellow, moderately coarse to moderately fine textured, friable, shallow to moderately deep soils | Sandstones, Conglomerate and Quartzite | Well to Somewhat Excessively |
| KMG | Kemuning | Grayish brown to olive, fine to moderately fine textured, slightly firm to firm, moderately deep soils | Dark Carbonaceous Shale and Vein Quartz | Moderately Well |
| LNS | Lunas | Pale brown to light gray, moderately coarse textured, friable, deep soils | Subrecent Alluvium | Moderately Well to Imperfectly |

**Table 4.1—Soil Mapping Legend Used in the Semi-Detailed Soil Survey Area—(*cont.*)**

| Symbol | Series | Description | Parent Material | Drainage |
|---|---|---|---|---|
| MCA | Malacca Complex .. .. | Brownish yellow to red, moderately fine to fine textured, firm, very shallow to shallow, lateritic soils | Variable .. .. .. | Well |
| MRG | Marang .. .. .. | Very pale brown to yellow, moderately fine textured, slightly firm to firm, moderately deep soils | Sandy Indurated Shales and Vein Quartz | Moderately Well |
| MUN | Munchong .. .. .. | Strong brown, fine textured, friable, deep soils .. .. | Shales .. .. .. | Well |
| PHI | Pohoi .. .. .. .. | Light yellowish brown to very pale brown, moderately fine textured, firm, moderately deep dan deep soils | Carbonaceous Shales, Sands stones and Vein Quartz | Moderately Well |
| RSU | Rasau .. .. .. | Light yellowish brown to brownish yellow, moderately fine to moderately coarse textured, friable, deep soils | Subrecent Alluvium .. | Well |
| RGM | Rengam .. .. .. | Brownish yellow to strong brown, fine textured, friable, deep soils | Biotite Granite .. .. | Well |
| SGT | Segamat .. .. .. | Yellowish red to red, fine to very fine textured, friable, deep soils .. | Andesite .. .. .. | Well |
| SDG | Serdang .. .. .. | Brownish yellow to reddish yellow, moderately coarse to moderately fine textured, friable, deep soils | Sandstones, Quartzite and Conglomerate | Well |
| SRK | Serok .. .. .. .. | Reddish yellow to brownish yellow, fine textured, firm, moderately deep soils | Subrecent Alluvium .. | Imperfectly to Moderately Well |
| TPI | Tampoi .. .. .. | Strong brown, moderately coarse textured, friable, deep soils .. | Older Alluvium .. .. | Somewhat Excessively to Well |
| TMG | Telemong .. .. .. | Very pale brown to brownish yellow, coarse to moderately coarse textured, very friable, deep soils | Recent Alluvium .. .. | Somewhat Excessively |
| UTM | Ulu Tiram .. .. .. | Brownish yellow, moderately fine textured, firm, shallow to moderately deep soils | Older Alluvium .. .. | Well |
| ALC | Alluvial Complex .. .. | Light brownish gray to dark brown, moderately coarse to moderately fine textured, friable to very friable soils | Alluvium .. .. .. | Moderately Well to Very Poorly |

**Table 4.1—Soil Mapping Legend Used in the Semi-Detailed Soil Survey Area—*(cont.)***

| Symbol | Series | Description | Parent Material | Drainage |
|---|---|---|---|---|
| **DLD** | Disturbed Land .. .. | Present and past open cast mined land | Variable .. .. .. | Variable |
| **LAA** | Local Alluvium .. .. | Pale gray to white, coarse to fine textured, friable, highly variable soils | Recent Alluvium .. .. | Very Poorly to Poorly |
| **OCM** | Organic Clay and Muck .. | Gray to dark gray, fine textured, or lighter colored moderately coarse textured, friable, highly variable, organo-mineral soils | Organic and Alluvium .. | Very Poorly |
| **PET** | Peat .. .. .. .. | Relatively undecomposed, highly variable, organic soils .. .. | Organic .. .. .. | Very Poorly |
| **RVA** | Riverine Alluvium .. .. | White to brownish yellow, moderately fine to moderately coarse textured, friable to firm soils | Recent and Sub-recent Alluvium | Imperfectly to Poorly |
| **STP** | Steepland .. .. .. | Areas with an average slope of greater than 20° .. .. | Variable .. .. .. | Somewhat Excessively to Excessively |

SOIL PHASES AND VARIANTS

| Symbol | Phase or Variant |
|---|---|
| /m | Moderately deep phase |
| /d | deep phase |
| /co | coarse sandy clay phase |
| /c | sandy clay phase |
| /l | lateritic phase |
| /cl | sandy clay and lateritic phases |
| /f | fine sandy clay phase |
| /r | red variant |

**Table 4.2—Classification of Soils Mapped in the Semi-Detailed Area into the New Comprehensive System of Soil Classification**

| Soil Series | Subgroup | Family: Texture | Family: Mineralogy |
|---|---|---|---|
| *Soils developed on igneous rocks:* | | | |
| Jerangau | Typic Haplorthox | very fine clayey | oxidic |
| Katong | Typic Haplorthox | fine clayey | oxidic |
| Rengam | Orthoxic Tropudults | fine clayey | kaolinitic |
| Segamat | Typic Haplorthox | very fine clayey | oxidic |
| *Soil developed on sedimentary rocks:* | | | |
| Bungor | Orthoxic Tropudults | fine clayey | kaolinitic |
| Durian | Orthoxic Tropudults | fine clayey | kaolinitic |
| Jempol | Ultic Haplorthox | fine loamy | oxidic |
| Jeram | Orthoxic Tropudults | fine clayey | kaolinitic |
| Kedah | Orthoxic Tropudults | fine loamy | siliceous |
| Serdang | Typic Tropudults | fine loamy | siliceous |
| Serdang/c | Orthoxic Tropudults | fine clayey | kaolinitic |
| *Soils developed on metamorphosed sedimentary rocks:* | | | |
| Kemuning | Orthoxic Tropudults | fine loamy | siliceous |
| Marang | Typic Dystropepts | fine loamy | siliceous |
| Pohoi | Orthoxic Tropudults | fine clayey | kaolinitic |
| *Soils developed on older alluvium:* | | | |
| Harimau | Orthoxic Tropudults | fine clayey | kaolinitic |
| Tampoi | Typic Dystropepts | coarse loamy | siliceous |
| *Soils developed on subrecent alluvium:* | | | |
| Holyrood | Typic Dystropepts | coarse loamy | siliceous |
| Lunas | Typic Dystropepts | coarse loamy | siliceous |
| Rasau | Typic Dystropepts | fine loamy | siliceous |
| Serok | Typic Umbraquox | fine clayey | kaolinitic |
| *Soils developed on recent alluvium:* | | | |
| Akob | Aeric Tropaquepts | fine clayey | kaolinitic |
| Telemong | (Typic) Tropofluvents | coarse loamy | siliceous |
| Kampong Kubor | Aeric Tropaquepts | coarse loamy | siliceous |
| *Soils developed on variable parent materials:* | | | |
| Alluvial | Aeric Tropic | coarse loamy | siliceous |
| Complex | Fluraquents | — | — |
| Malacca | Plinthic | clayey skeletal | kaolinitic |
| Complex | Haplorthox | — | — |

### 4.1.4 Soil Series

#### 4.1.4.1 Akob Series (AKB) (33,130 acres)

Soils of the Akob series consist of firm moderately deep, light gray to very pale brown, fine to moderately fine textured soils developed on recent alluvium. They are poorly drained with the water table generally encountered at depths ranging from 50 to 140 cm below the surface. A diagnostic feature is the mottling which consists of prominent strong brown to yellowish red mottles, indicative of a fluctuating water table close to the surface.

The surface soil is a pale brown to dark brown, friable, fine sandy clay loam to silty clay loam which possesses a well developed crumb structure. This passes into a friable, light gray to very pale brown fine sandy clay loam to silty clay, which is sometimes intensely mottled and exhibits moderately to strongly developed medium subangular blocky structures. The underlying light gray, firm, fine sandy clay to clay, contains prominent, reddish yellow mottles and strong subangular blocky structures. Below this, light gray to white blotching commences and at greater depth this becomes the dominant color. Rooting rarely exceeds 70 cm, which is usually the level of the water table.

These soils are formed on the recent alluvium away from the banks of the larger rivers or in the basins of the smaller floodplains. They are the dominant soils in about 6 per cent of the area surveyed and sometimes are associated with other soils developed on recent alluvium such as Local Alluvium and Riverine Alluvium. These soils are easily flooded and tend to remain flooded for long periods of time.

The depth to the mottled horizon and texture are highly variable in this series. Slight changes in elevation (or the depth to the water table) result in soils with well drained surface horizons (0-50 cm) or in other instances a soil profile that is mottled to the surface. The latter profiles often show an Ah/ACg horizon sequence. Textural variations from fine sandy clay loam to silty clay or clay occur in this series. There are often textural variations within an Akob mapping unit as well as between Akob mapping units due to depositional characteristics of the streams. Soils in the vicinity of the S. Rompin, S. Mentiga, S. Merba, and S. Gayong are finer textured than those found elsewhere in the surveyed area. The following is a typical morphological description of an Akob soil profile (Field No. T20):

Ah—0 to 7 cm, pale brown (10YR6/3)* silty clay loam; moderate, medium and fine crumb; friable; many roots; few channels; abundant pores; weak, patchy clayskins; boundary distinct.

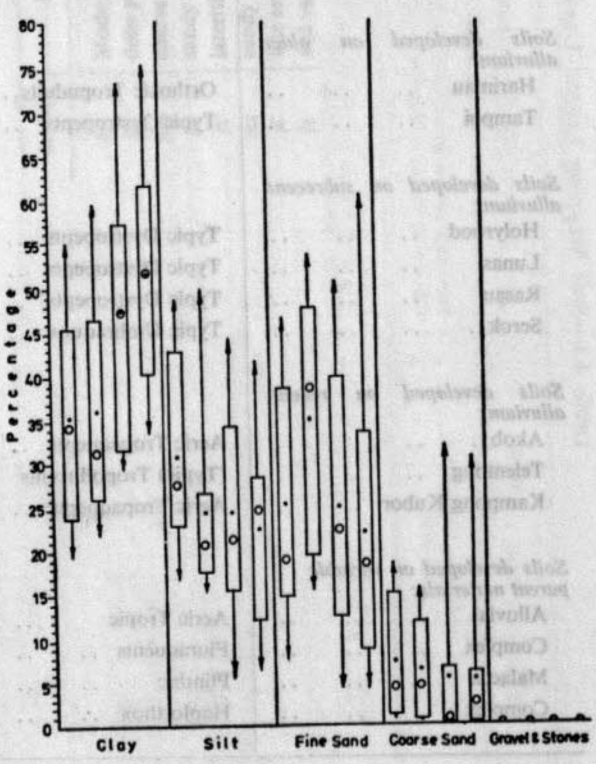
ABg—7 to 18 cm, light gray (10YR7/2) silty clay loam to silty clay; many, medium, distinct reddish yellow mottles; moderate to strong, medium subangular blocky; friable; many roots; few channels; many pores; discontinuous clayskins; boundary indistinct.

Bg—18 to 68 cm, light gray (5Y7/1) silty clay; many, medium, prominent reddish yellow mottles; strong, coarse subangular blocky breaking to strong, medium subangular blocky; firm; few roots; many pores; discontinuous clayskins; boundary indistinct.

Cg—68 to 100 cm, light gray (5Y7/1) clay; abundant, medium, prominent reddish yellow mottles; strong, coarse subangular blocky; firm; few pores; patchy clayskins.

* Munsell color designation.

Fig. 4·1a Particle size distribution of 12 Akob soil profiles



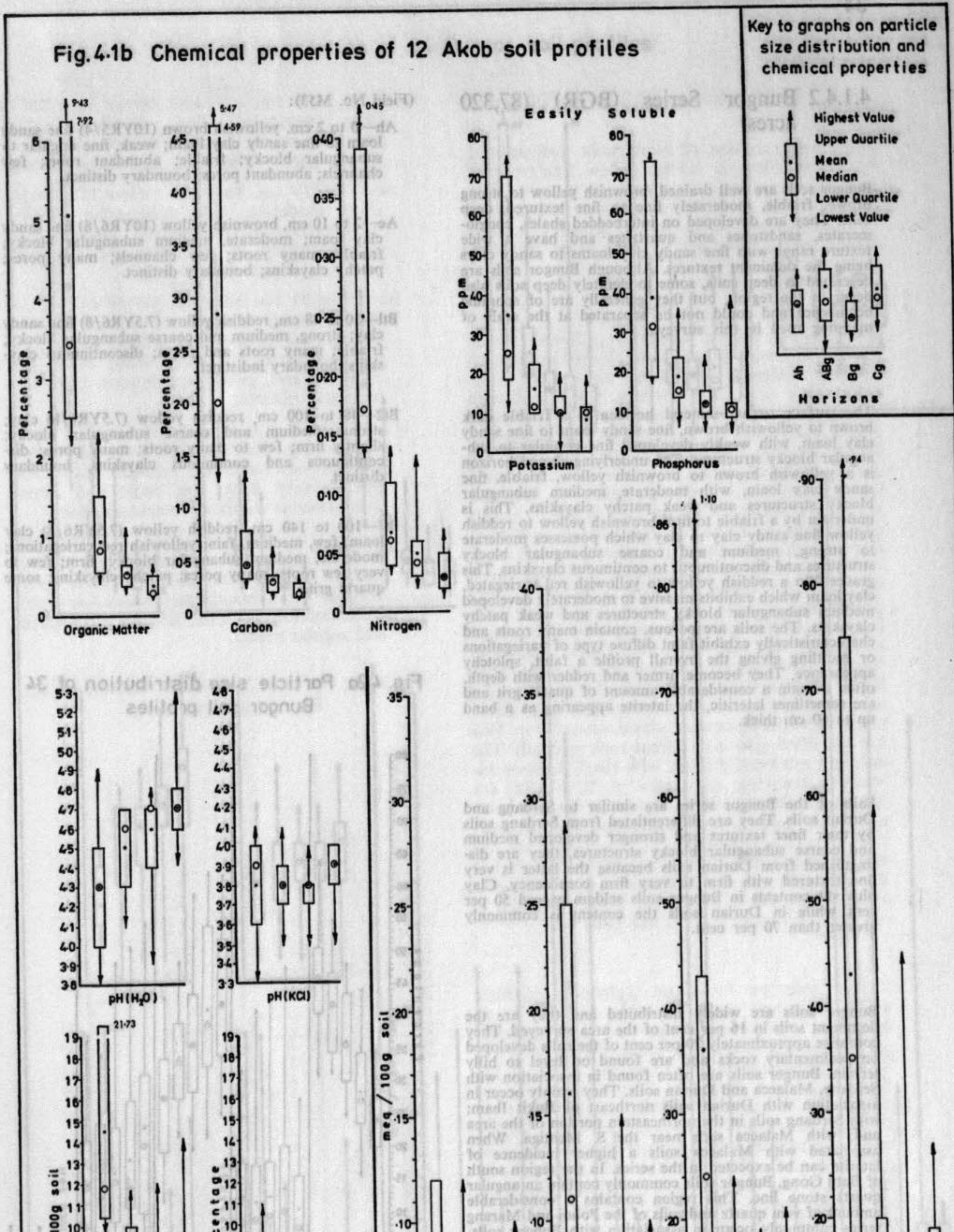



Fig. 4·1b Chemical properties of 12 Akob soil profiles

### 4.1.4.2 Bungor Series (BGR) (87,320 acres)

Bungor soils are well drained, brownish yellow to strong brown, friable, moderately fine to fine textured, deep soils. They are developed on interbedded shales, conglomerates, sandstones and quartzites and have a wide texture range with fine sandy clay loams to sandy clays being the dominant textures. Although Bungor soils are described as deep soils, some moderately deep soils also occur in the region, but they generally are of sporadic occurrence and could not be separated at the scale of mapping used in this survey.

The surface organo-mineral horizon is a friable dark brown to yellowish brown, fine sandy loam to fine sandy clay loam, with weakly developed fine granular to subangular blocky structures. The underlying eluvial horizon is a yellowish brown to brownish yellow, friable, fine sandy clay loam, with moderate, medium subangular blocky structures and weak patchy clayskins. This is underlain by a friable to firm brownish yellow to reddish yellow fine sandy clay to clay which possesses moderate to strong, medium and coarse subangular blocky structures and discontinuous to continuous clayskins. This grades into a reddish yellow to yellowish red variegated, clay loam which exhibits massive to moderately developed medium subangular blocky structures and weak patchy clayskins. The soils are porous, contain many roots and characteristically exhibit faint diffuse type of variegations or mottling giving the overall profile a faint, splotchy appearance. They become firmer and redder with depth, often contain a considerable amount of quartz grit and are sometimes lateritic, the laterite appearing as a band up to 60 cm thick.

Soils of the Bungor series are similar to Serdang and Durian soils. They are differentiated from Serdang soils by their finer textures and stronger developed medium and coarse subangular blocky structures, they are distinguished from Durian soils because the latter is very fine textured with firm to very firm consistency. Clay plus slit contents in Bungor soils seldom exceed 50 per cent while in Durian soils the content is commonly greater than 70 per cent.

Bungor soils are widely distributed and they are the dominant soils in 16 per cent of the area surveyed. They comprise approximately 70 per cent of the soils developed on sedimentary rocks and are found on level to hilly terrain. Bungor soils are often found in association with Serdang, Malacca and Durian soils. They mainly occur in association with Durian soils northeast of Bukit Ibam; with Serdang soils in the northeastern portion of the area and; with Malacca soils near the S. Mentiga. When associated with Malacca soils a higher incidence of laterite can be expected in the series. In the region south of Batu Gong. Bungor soils commonly contain an angular quartz stone line. This region contains a considerable amount of vein quartz and soils of the Pohoi and Marang series commonly occur in association with Bungor soils. A red variant of the Bungor series in which yellowish red colors dominate throughout the profile occurs in a small area northeast of Bt. Perlah. A representative soil profile of the Bungor series is described as follows:

(Field No. M53):

Ah—0 to 2 cm. yellowish brown (10YR5/4) fine sandy loam to fine sandy clay loam; weak, fine angular to subangular blocky; friable; abundant roots; few channels; abundant pores; boundary distinct.

Ae—2 to 10 cm, brownish yellow (10YR6/8) fine sandy clay loam; moderate, medium subangular blocky; friable; many roots; few channels; many pores; patchy clayskins; boundary distinct.

Btl—10 to 48 cm, reddish yellow (7.5YR6/8) fine sandy clay; strong, medium and coarse subangular blocky; friable; many roots and pores; discontinuous clayskins; boundary indistinct.

Bt2—48 to 100 cm, reddish yellow (7.5YR6/8) clay; strong, medium and coarse subangular blocky; slightly firm; few to many roots; many pores; discontinuous and continuous clayskins, boundary distinct.

BC—100 to 140 cm, reddish yellow (7.5YR6/8) clay loam; few, medium, faint yellowish red variegations; moderate, medium subangular blocky; firm; few to very few roots; many pores; patchy clayskins; some quartz grit.

Fig. 4.2a Particle size distribution of 34 Bungor soil profiles

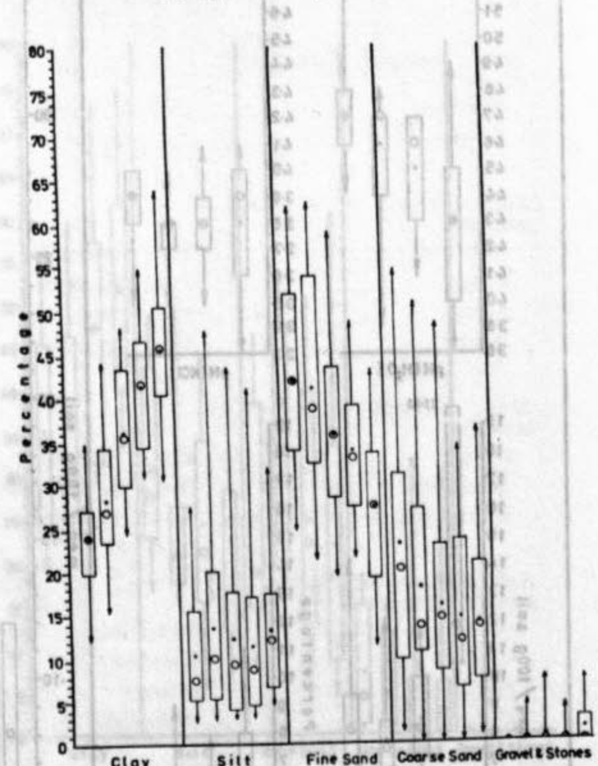
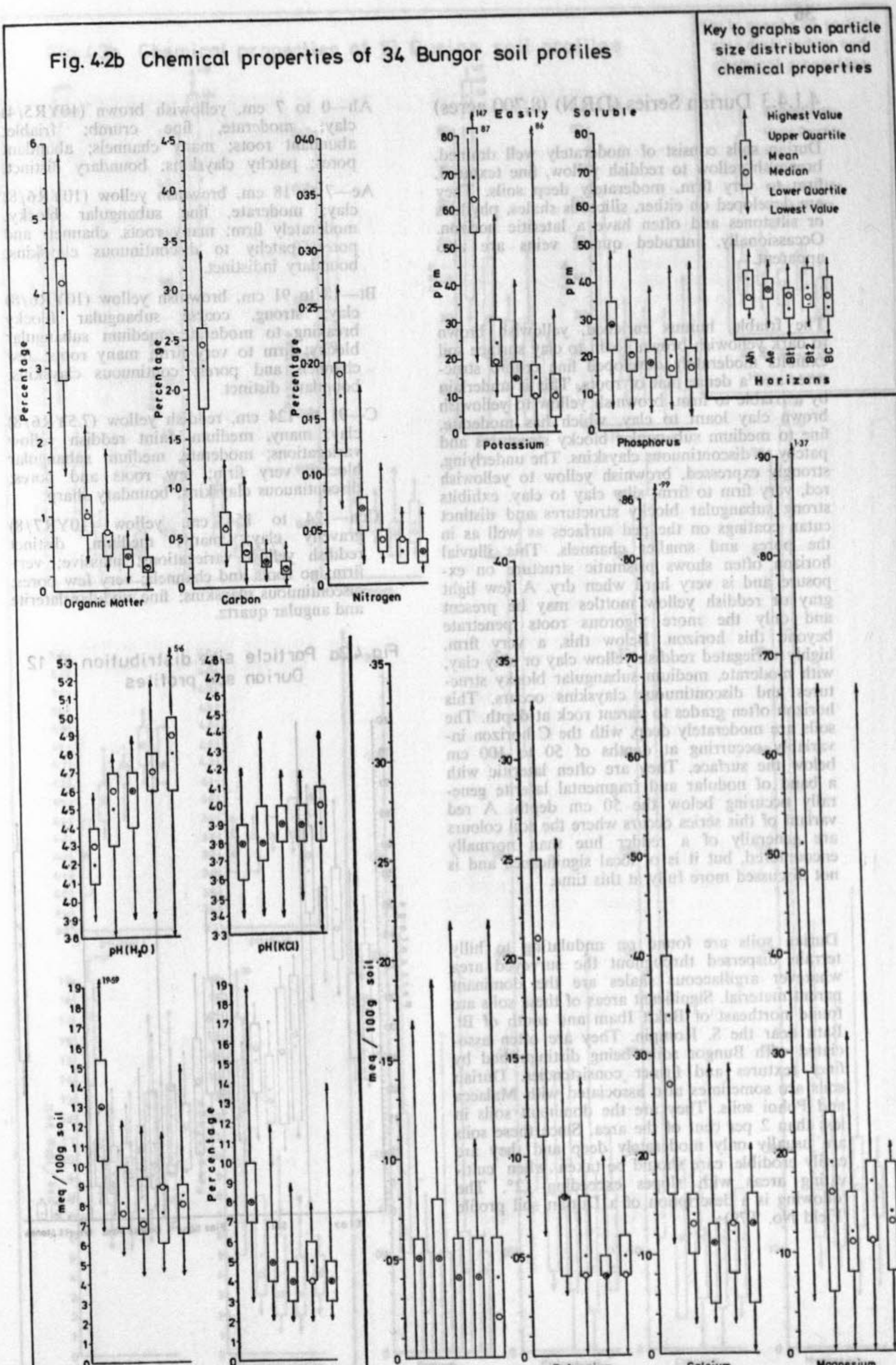


Fig. 4.2b Chemical properties of 34 Bungor soil profiles



### 4.1.4.3 Durian Series (DRN) (8,700 acres)

Durian soils consist of moderately well drained, brownish yellow to reddish yellow, fine textured, firm to very firm, moderately deep soils. They are developed on either, siliceous shales, phyllites or siltstones and often have a lateritic horizon. Occassionally, intruded quartz veins are also apparent.

The friable, humus enriched, yellowish brown to dark yellowish brown, loam to clay surface soil exhibits moderately developed fine crumb structures and a dense mat of roots. This is underlain by a friable to firm, brownish yellow to yellowish brown clay loam to clay, which has moderate, fine to medium subangular blocky structures and patchy to discontinuous clayskins. The underlying, strongly expressed, brownish yellow to yellowish red, very firm to firm, silty clay to clay, exhibits strong subangular blocky structures and distinct cutan coatings on the ped surfaces as well as in the pores and smaller channels. This illuvial horizon often shows prismatic structure on exposure and is very hard when dry. A few light gray or reddish yellow mottles may be present and only the more vigorous roots penetrate beyond this horizon. Below this, a very firm, highly variegated reddish yellow clay or silty clay, with moderate, medium subangular blocky structures and discontinuous clayskins occurs. This horizon often grades to parent rock at depth. The soils are moderately deep, with the C horizon invariably occurring at depths of 50 to 100 cm below the surface. They are often lateritic with a band of nodular and fragmental laterite generally occuring below the 50 cm depth. A red variant of this series occurs where the soil colours are generally of a redder hue than normally encountered, but it is of local significance and is not discussed more fully at this time.

Durian soils are found on undulating to hilly terrain dispersed throughout the surveyed area wherever argillaceous shales are the dominant parent material. Significant areas of these soils are found northeast of Bukit Ibam and south of Bt. Batu near the S. Rompin. They are often associated with Bungor soils, being distinguished by finer textures and firmer consistencies. Durian soils are sometimes also associated with Malacca and Pohoi soils. They are the dominant soils in less than 2 per cent of the area. Since these soils are usually only moderately deep and they are easily erodible, care should be taken when cultivating areas with slopes exceeding 12°. The following is a description of a Durian soil profile (Field No. T79):

Ah—0 to 7 cm, yellowish brown (10YR5/4) clay; moderate, fine crumb; friable; abundant roots; many channels; abundant pores; patchy clayskins; boundary distinct.

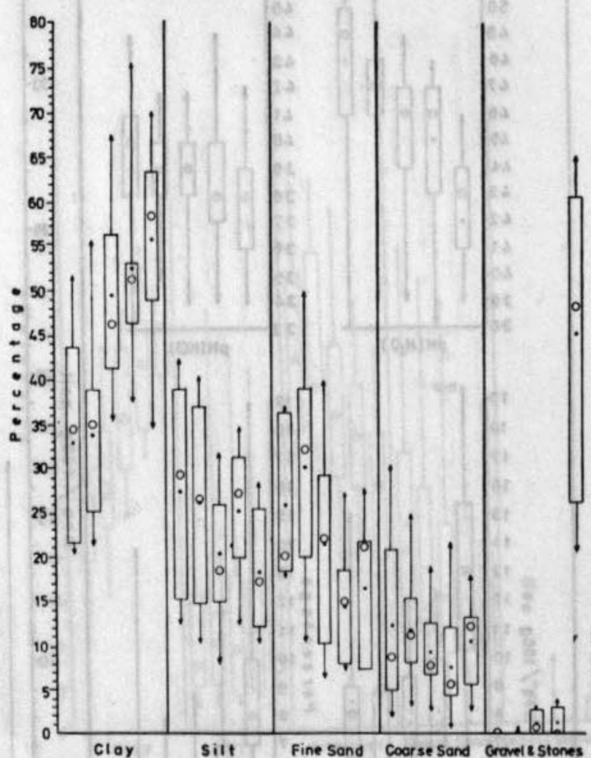
Ae—7 to 18 cm, brownish yellow (10YR6/8) clay; moderate, fine subangular blocky; moderately firm; many roots, channels and pores; patchy to discontinuous clayskins; boundary indistinct.

Bt—18 to 91 cm, brownish yellow (10YR6/8) clay; strong, coarse subangular blocky breaking to moderate, medium subangular blocky; firm to very firm; many roots; few channels and pores; continuous clayskins; boundary distinct.

C—91 to 124 cm, reddish yellow (7.5YR6/8) clay; many, medium, faint reddish yellow variegations; moderate, medium subangular blocky; very firm; few roots and pores; discontinuous clayskins; boundary sharp.

Ccn—124 to 154 cm, yellow (10YR7/8) gravelly clay; many, medium, distinct reddish yellow variegations; massive; very firm; no roots and channels; very few pores; discontinuous clayskins; fine nodular laterite and angular quartz.

Fig. 4.3a Particle size distribution of 12 Durian soil profiles



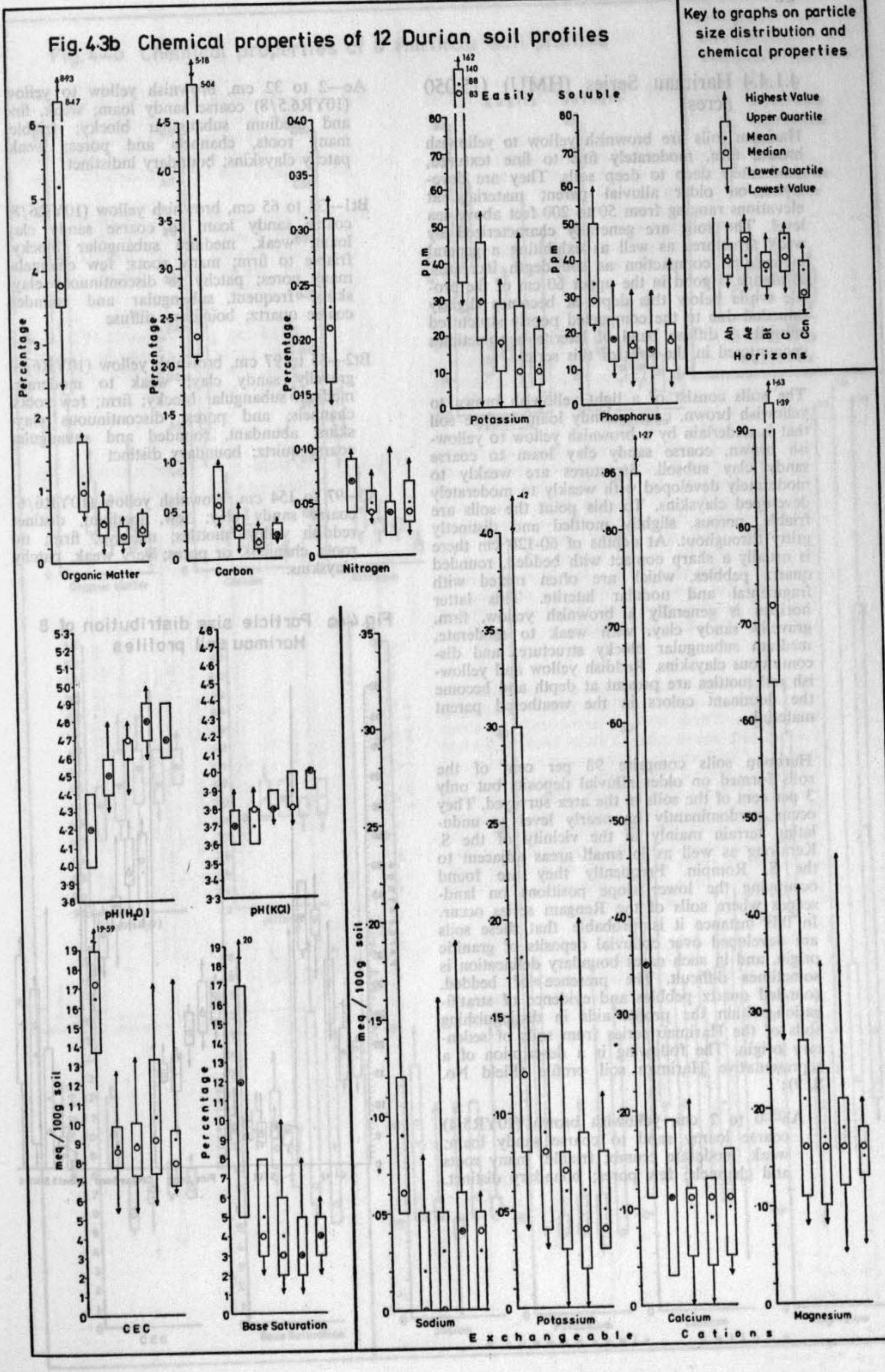



Fig. 4.3b Chemical properties of 12 Durian soil profiles

### 4.1.4.4 Harimau Series (HMU) (15,050 acres)

Harimau soils are brownish yellow to yellowish brown, firm, moderately fine to fine textured, moderately deep to deep soils. They are developed on older alluvial parent materials at elevations ranging from 50 to 200 feet above sea level. The soils are generally characterized by weak structures as well as exhibiting a general increase in compaction as soil depth increases. Drainage is good in the upper 60 cm of the profile while below this depth it becomes slightly impeded due to the compacted poorly structured subsoil. A diffuse band of laterite is sometimes encountered in the soils of this series.

The soils consist of a light yellowish brown to yellowish brown, coarse sandy loam surface soil that is underlain by a brownish yellow to yellowish brown, coarse sandy clay loam to coarse sandy clay subsoil. Structures are weakly to moderately developed with weakly to moderately developed clayskins. To this point the soils are friable, porous, slightly mottled and distinctly gritty throughout. At depths of 60-120 cm there is usually a sharp contact with bedded, rounded quartz pebbles, which are often mixed with fragmental and nodular laterite. This latter horizon is generally a brownish yellow, firm, gravelly sandy clay, with weak to moderate, medium subangular blocky structures and discontinuous clayskins. Reddish yellow and yellowish red mottles are present at depth and become the dominant colors in the weathered parent material.

Harimau soils comprise 98 per cent of the soils formed on older alluvial deposits but only 3 per cent of the soils in the area surveyed. They occur perdominantly on nearly level to undulating terrain mainly in the vicinity of the S. Keratong as well as in small areas adjacent to the S. Rompin. Frequently they are found occupying the lower slope positions on landscapes where soils of the Rengam series occur. In this instance it is probable that these soils are developed over colluvial deposits of granitic origin, and in such cases boundary delineation is sometimes difficult. The presence of bedded, rounded quartz pebbles and evidence of stratification within the profile aids in distinguishing soils of the Harimau series from soils of sedentary origin. The following is a description of a representative Harimau soil profile (Field No. S. 9):

Ah—0 to 2 cm, yellowish brown (10YR5/4) coarse loamy sand to coarse sandy loam; weak, moderate crumb; friable; many roots and channels; few pores; boundary distinct.

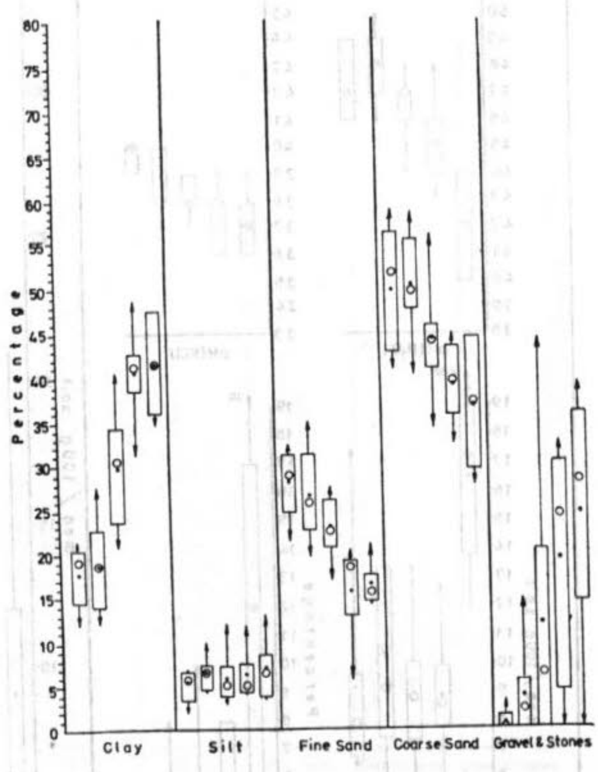
Ae—2 to 32 cm, brownish yellow to yellow (10YR6.5/8) coarse sandy loam; weak, fine and medium subangular blocky; friable; many roots, channels and pores; weak, patchy clayskins; boundary indistinct.

Bt1—32 to 65 cm, brownish yellow (10YR6/8) coarse sandy loam to coarse sandy clay loam; weak, medium subangular blocky; friable to firm; many roots; few channels; many pores; patchy to discontinuous clayskins; frequent, subangular and rounded coarse quartz; boundary diffuse

Bt2—65 to 97 cm, brownish yellow (10YR6/8) gravelly sandy clay; weak to moderate, medium subangular blocky; firm; few roots, channels; and pores; discontinuous clayskins; abundant, rounded and subangular coarse quirtz; boundary distinct

C—97 to 154 cm, brownish yellow (10YR6/6) coarse sandy clay; few, medium, distinct reddish yellow mottles; massive; firm; no roots, channels, or pores; very weak, patchy clayskins.

Fig. 4.4a Particle size distribution of 8 Harimau soil profiles



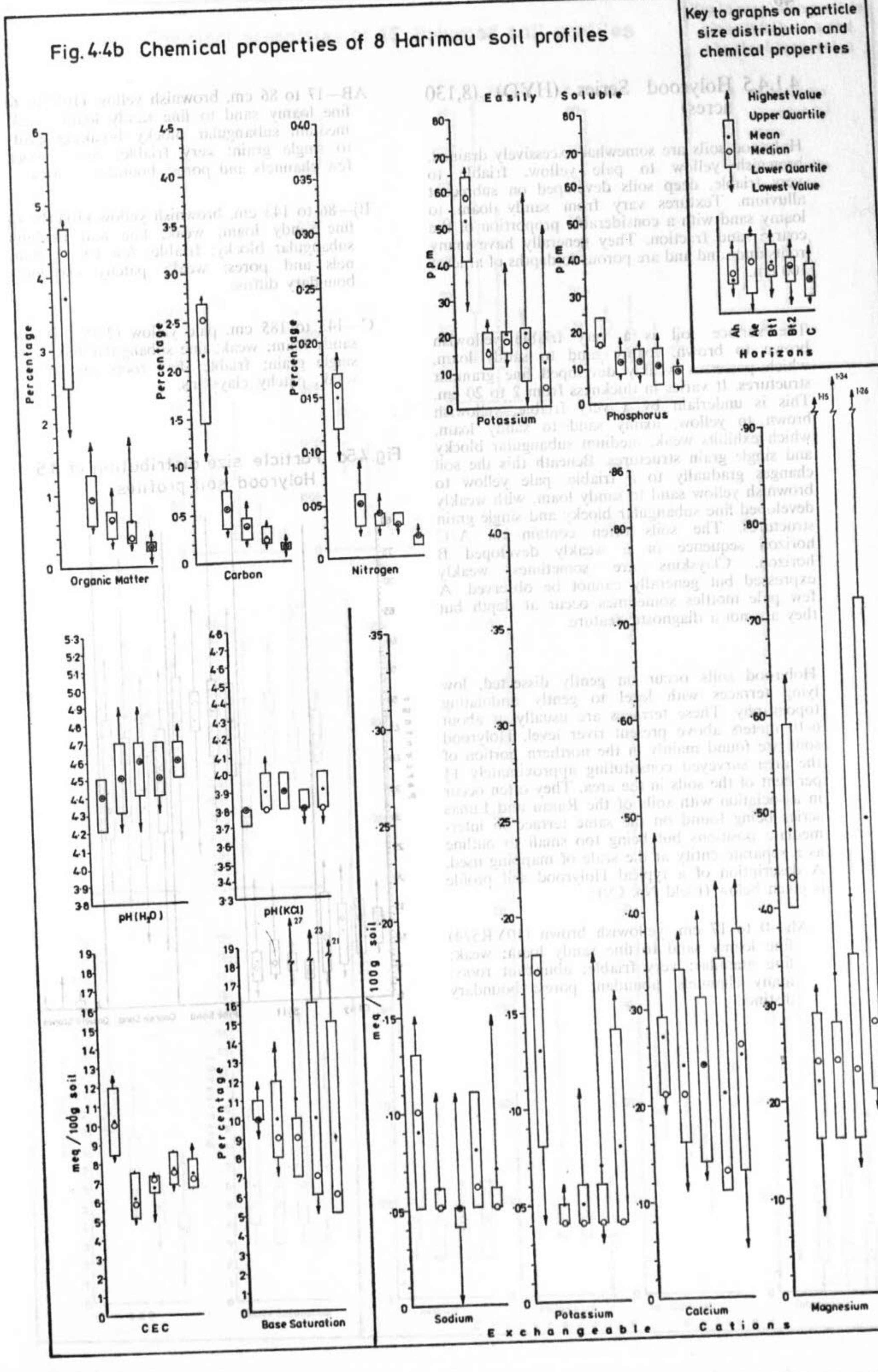



Fig. 4.4b Chemical properties of 8 Harimau soil profiles

### 4.1.4.5 Holyrood Series (HYD) (8,130 acres)

Holyrood soils are somewhat excessively drained, brownish yellow to pale yellow, friable to very friable, deep soils developed on subrecent alluvium. Textures vary from sandy loam to loamy sand with a considerable proportion of the coarse sand fraction. They generally have many roots and sand and are porous to depths of at least 100 cm.

The surface soil is a very friable yellowish brown to brown, loamy sand to sandy loam, which possesses weakly developed fine granular structures. It varies in thickness from 2 to 20 cm. This is underlain by a very friable, yellowish brown to yellow, loamy sand to sandy loam, which exhibits weak, medium subangular blocky and single grain structures. Beneath this the soil changes gradually to a friable, pale yellow to brownish yellow sand to sandy loam, with weakly developed fine subangular blocky and single grain structures. The soils often contain an A/C horizon sequence or a weakly developed B horizon. Clayskins are sometimes weakly expressed but generally cannot be observed. A few pale mottles sometimes occur at depth but they are not a diagnostic feature.

Holyrood soils occur on gently dissected, low lying terraces with level to gently undulating topography. These terraces are usually at about 6-10 meters above present river level. Holyrood soils are found mainly in the northern portion of the area surveyed constituting approximately 1½ per cent of the soils in the area. They often occur in association with soils of the Rasau and Lunas series being found on the same terrace in intermediate positions but being too small to outline as a separate entity at the scale of mapping used. A description of a typical Holyrood soil profile is given below (Field No. C9):

Ah—0 to 17 cm, yellowish brown (10YR5/4) fine loamy sand to fine sandy loam; weak; fine granular; very friable; abundant roots; many channels, abundant pores; boundary distinct.

AB—17 to 86 cm, brownish yellow (10YR6/6) fine loamy sand to fine sandy loam; weak, medium subangular blocky breaking easily to single grain; very friable; many roots; few channels and pores; boundary diffuse.

Bj—86 to 143 cm, brownish yellow (10YR6/6) fine sandy loam; weak, fine and medium subangular blocky; friable; few roots, channels and pores; weak; patchy clayskins; boundary diffuse.

C—143 to 185 cm, pale yellow (2.5Y7/4) fine sandy loam; weak; fine subangular blocky to single grain; friable; few roots and pores; weak, patchy clayskins.

**Fig. 45a Particle size distribution of 15 Holyrood soil profiles**

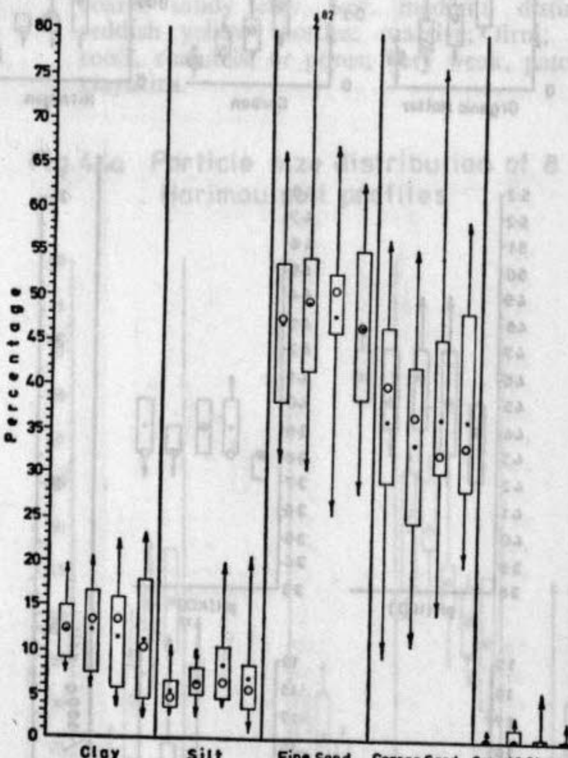
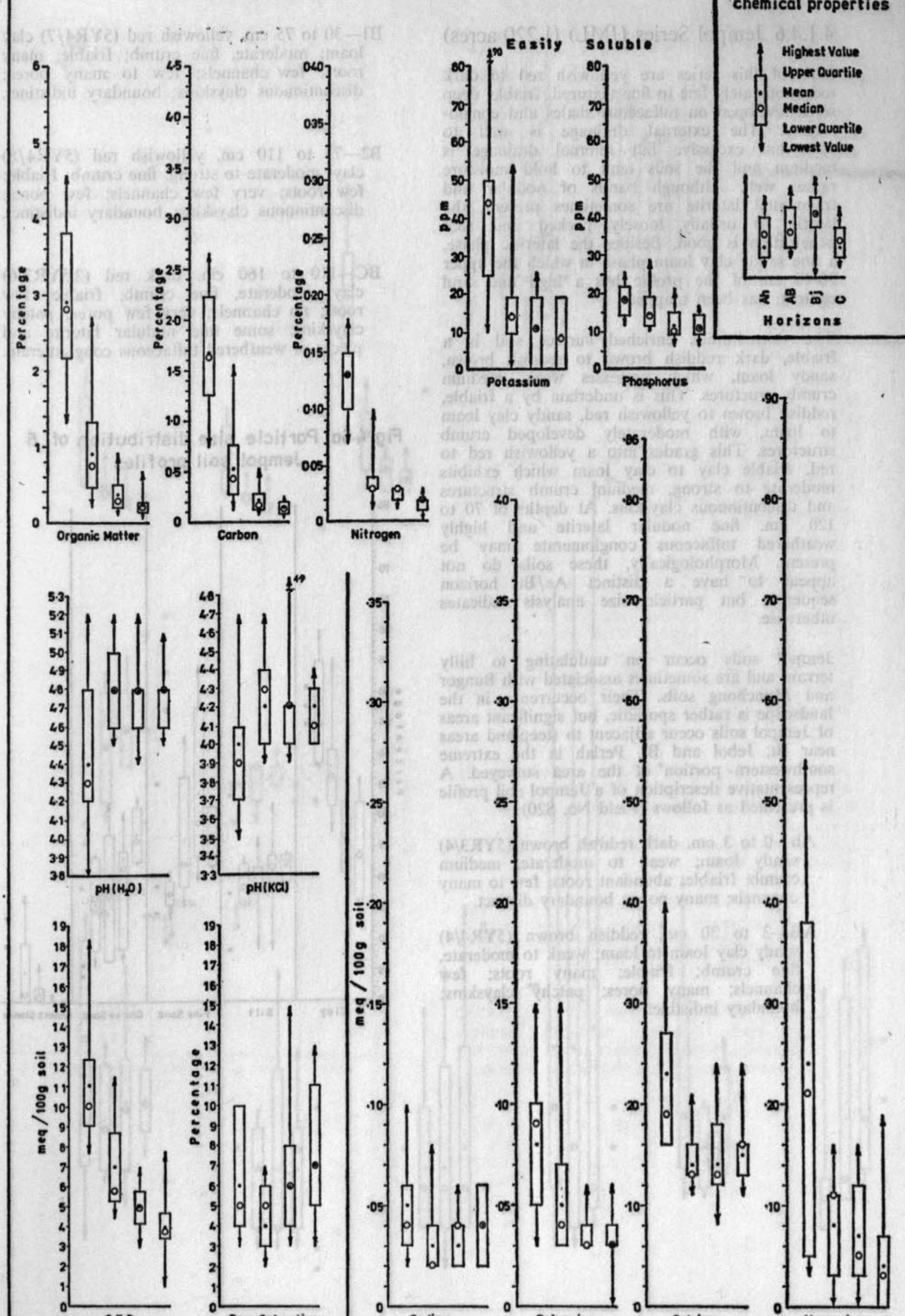


Fig. 45b Chemical properties of 15 Holyrood soil profiles



### 4.1.4.6 Jempol Series (JML) (1,220 acres)

Soils of this series are yellowish red to dark red, moderately fine to fine textured, friable, deep soils developed on tuffaceous shales and conglomerate. The external drainage is well to somewhat excessive but internal drainage is medium and the soils tend to hold moisture rather well. Although bands of nodular and fragmental laterite are sometimes present, the laterite is usually loosely packed and root penetration is good. Besides the lateritic phase, a fine sandy clay loam phase in which the upper 30-40 cm of the profile has a high fine sand content, has been mapped.

The thin humus enriched surface soil is a friable, dark reddish brown to reddish brown, sandy loam, which possesses weak, medium crumb structures. This is underlain by a friable, reddish brown to yellowish red, sandy clay loam to loam, with moderately developed crumb structures. This grades into a yellowish red to red, friable clay to clay loam which exhibits moderate to strong, medium crumb structures and discontinuous clayskins. At depths of 70 to 120 cm, fine nodular laterite and highly weathered tuffaceous conglomerate may be present. Morphologically, these soils do not appear to have a distinct Ae/Bt horizon sequence, but particle size analysis indicates otherwise.

Jempol soils occur on undulating to hilly terrain and are sometimes associated with Bungor and Munchong soils. Their occurrence in the landscape is rather sporadic, but significant areas of Jempol soils occur adjacent to steepland areas near Bt. Jebol and Bt. Perlah in the extreme southwestern portion of the area surveyed. A representative description of a Jempol soil profile is presented as follows (Field No. S20):

Ah—0 to 3 cm, dark reddish brown (5YR3/4) sandy loam; weak to moderate, medium crumb; friable; abundant roots; few to many channels; many pores; boundary distinct.

AB—3 to 30 cm, reddish brown (5YR4/4) sandy clay loam to loam; weak to moderate, fine crumb; friable; many roots; few channels; many pores; patchy clayskins; boundary indistinct.

B1—30 to 75 cm, yellowish red (5YR4/7) clay loam; moderate, fine crumb; friable; many roots; few channels; few to many pores; discontinuous clayskins; boundary indistinct.

B2—75 to 110 cm, yellowish red (5YR4/8) clay; moderate to strong, fine crumb; friable; few roots; very few channels; few pores; discontinuous clayskins; boundary indistinct.

BC—110 to 160 cm, dark red (2.5YR3/6) clay; moderate, fine crumb; friable; few roots; no channels; very few pores; patchy clayskins; some fine nodular laterite and pieces of weathered tuffaceous conglomerate.

**Fig. 4.6a Particle size distribution of 6 Jempol soil profiles**

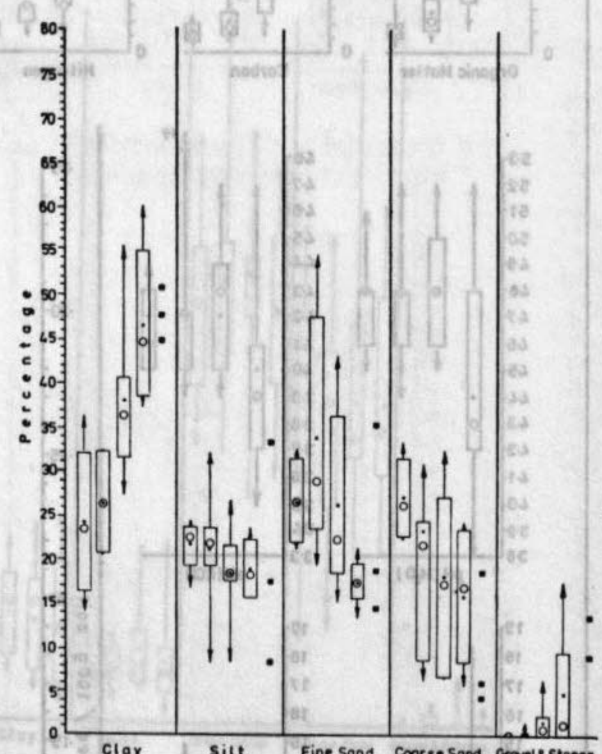
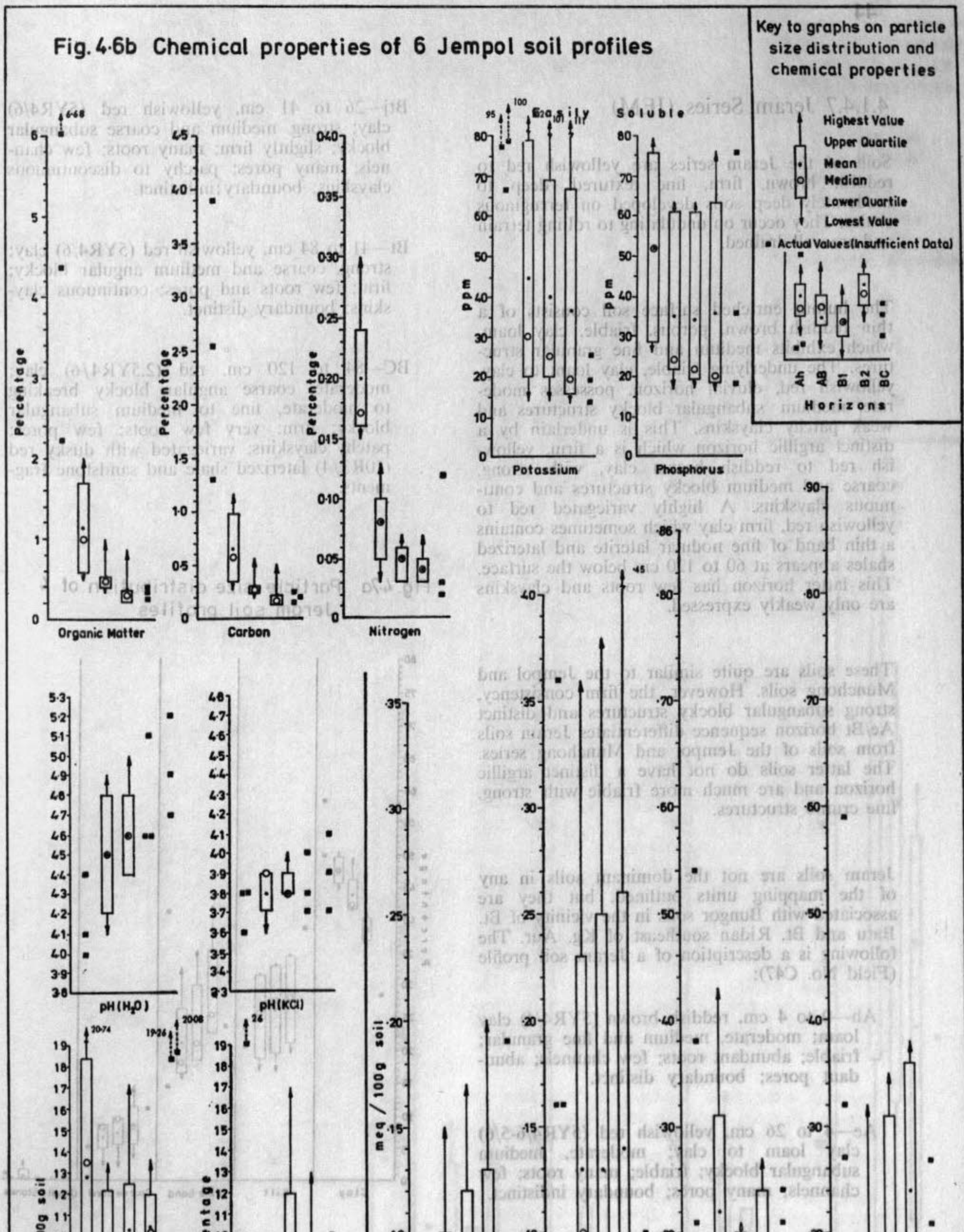


Fig. 4·6b Chemical properties of 6 Jempol soil profiles



### 4.1.4.7 Jeram Series (JEM)

Soils of the Jeram series are yellowish red to reddish brown, firm, fine textured, deep to moderately deep soils developed on ferruginous shales. They occur on undulating to rolling terrain and are well drained.

The humus enriched surface soil consists of a thin reddish brown, porous, friable, clay loam, which exhibits medium and fine granular structures. The underlying friable, clay loam to clay, yellowish red, eluvial horizon, possesses moderate, medium subangular blocky structures and weak patchy clayskins. This is underlain by a distinct argillic horizon which is a firm, yellowish red to reddish brown clay, with strong, coarse and medium blocky structures and continuous clayskins. A highly variegated red to yellowish red, firm clay which sometimes contains a thin band of fine nodular laterite and laterized shales appears at 60 to 120 cm below the surface. This latter horizon has few roots and clayskins are only weakly expressed.

These soils are quite similar to the Jempol and Munchong soils. However, the firm consistency, strong subangular blocky structures and distinct Ae/Bt horizon sequence differentiates Jeram soils from soils of the Jempol and Munchong series. The latter soils do not have a distinct argillic horizon and are much more friable with strong, fine crumb structures.

Jeram soils are not the dominant soils in any of the mapping units outlined, but they are associated with Bungor soils in the vicinity of Bt. Batu and Bt. Ridan southeast of Kg. Aur. The following is a description of a Jeram soil profile (Field No. C47):

Ah—0 to 4 cm, reddish brown (5YR4/4) clay loam; moderate, medium and fine granular; friable; abundant roots; few channels; abundant pores; boundary distinct.

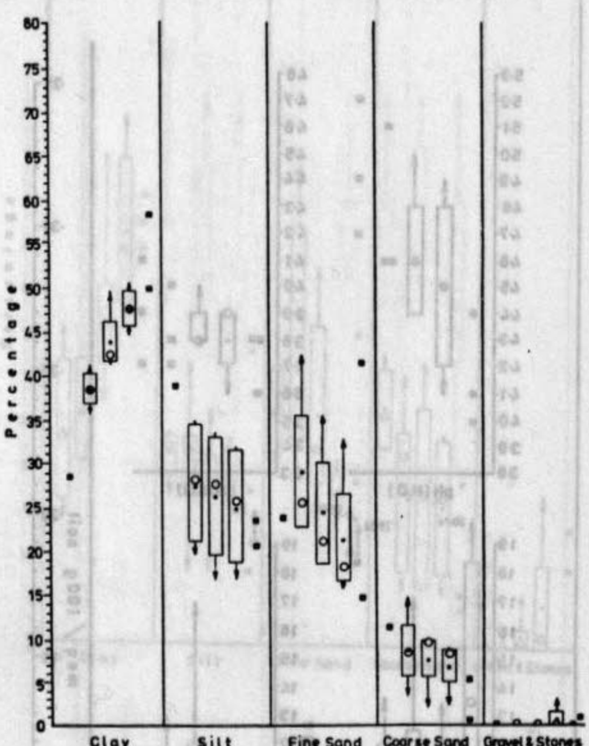
Ae—4 to 26 cm, yellowish red (5YR4/6-5/6) clay loam to clay; moderate, medium subangular blocky; friable; many roots; few channels; many pores; boundary indistinct.

Btj—26 to 41 cm, yellowish red (5YR4/6) clay; strong, medium and coarse subangular blocky; slightly firm; many roots; few channels; many pores; patchy to discontinuous clayskins; boundary indistinct.

Bt—41 to 84 cm, yellowish red (5YR4/6) clay; strong, coarse and medium angular blocky; firm; few roots and pores; continuous clayskins; boundary distinct.

BC—84 to 120 cm, red (2.5YR4/6) clay; moderate, coarse angular blocky breaking to moderate, fine to medium subangular blocky; firm; very few roots; few pores; patchy clayskins; variegated with dusky red (10R3/4) laterized shale and sandstone fragments.

Fig. 4·7a Particle size distribution of 4 Jeram soil profiles



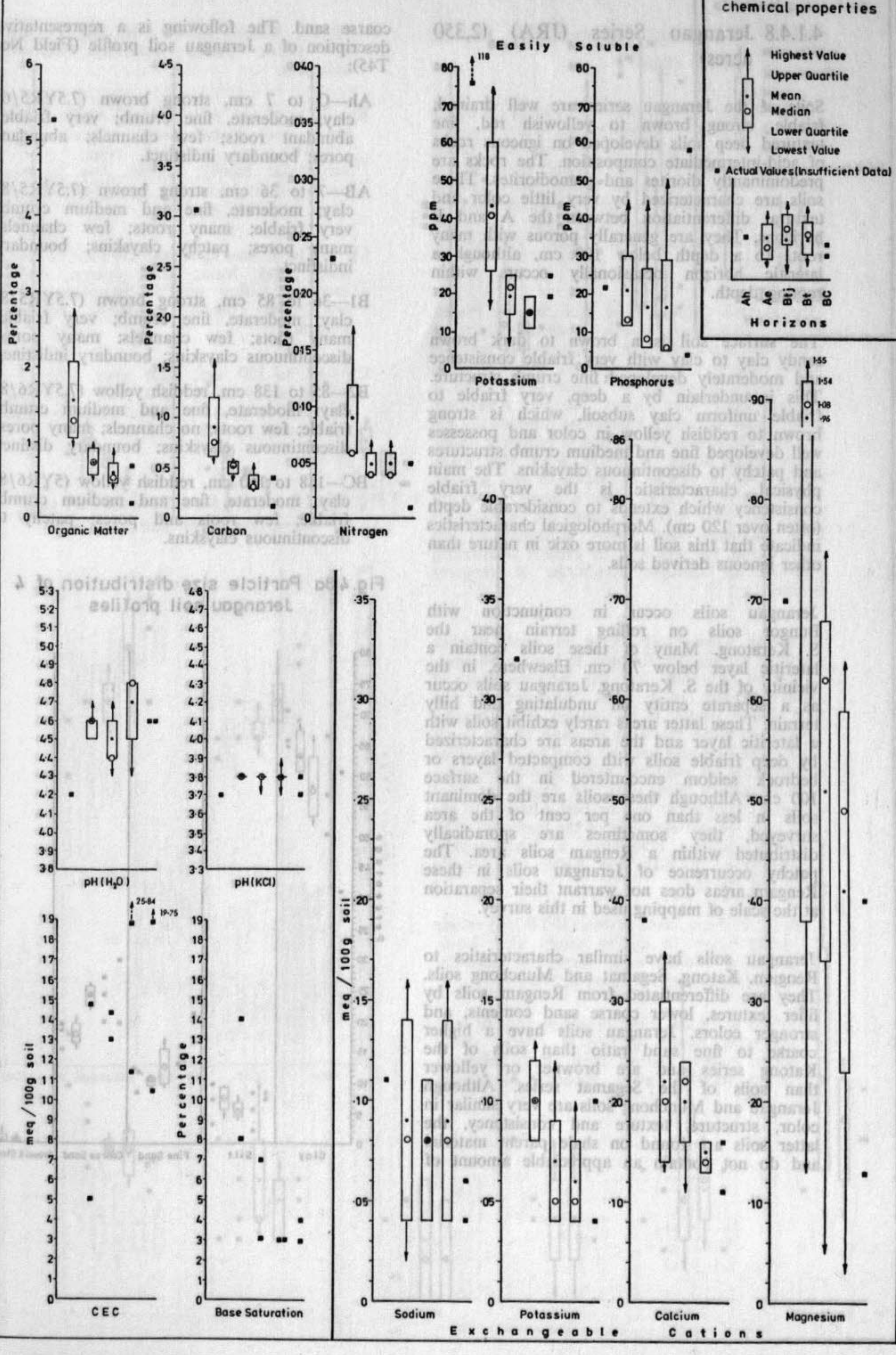



Fig. 4.7b Chemical properties of 4 Jeram soil profiles

### 4.1.4.8 Jerangau Series (JRA) (2,350 acres)

Soils of the Jerangau series are well drained, friable, strong brown to yellowish red, fine textured deep soils developed on igneous rocks of acid-intermediate composition. The rocks are predominantly diorites and granodiorites. These soils are characterized by very little color and textural differentiation between the A and B horizons. They are generally porous with many roots to a depth below 100 cm, although a lateritic horizon occasionally occurs within rooting depth.

The surface soil is a brown to dark brown sandy clay to clay with very friable consistence and moderately developed fine crumb structure. This is underlain by a deep, very friable to friable uniform clay subsoil, which is strong brown to reddish yellow in color and possesses well developed fine and medium crumb structures and patchy to discontinuous clayskins. The main physical characteristic is the very friable consistency which extends to considerable depth (often over 120 cm). Morphological characteristics indicate that this soil is more oxic in nature than other igneous derived soils.

Jerangau soils occur in conjunction with Bungor soils on rolling terrain near the S. Keratong. Many of these soils contain a lateritic layer below 70 cm. Elsewhere, in the vicinity of the S. Keratong, Jerangau soils occur as a separate entity on undulating and hilly terrain. These latter areas rarely exhibit soils with a lateritic layer and the areas are characterized by deep friable soils with compacted layers or bedrock seldom encountered in the surface 100 cm. Although these soils are the dominant soils in less than one per cent of the area surveyed, they sometimes are sporadically distributed within a Rengam soils area. The patchy occurrence of Jerangau soils in these Rengam areas does not warrant their separation at the scale of mapping used in this survey.

Jerangau soils have similar characteristics to Rengam, Katong, Segamat and Munchong soils. They are differentiated from Rengam soils by finer textures, lower coarse sand contents, and stronger colors. Jerangau soils have a higher coarse to fine sand ratio than soils of the Katong series and are browner or yellower than soils of the Segamat series. Although Jerangau and Munchong soils are very similar in color, structure, texture and consistency, the latter soils are found on shale parent material and do not contain an appreciable amount of coarse sand. The following is a representative description of a Jerangau soil profile (Field No. T45):

Ah—O to 7 cm, strong brown (7.5YR5/6) clay; moderate, fine crumb; very friable; abundant roots; few channels; abundant pores; boundary indistinct.

AB—7 to 36 cm, strong brown (7.5YR5/8) clay; moderate, fine and medium crumb; very friable; many roots; few channels; many pores; patchy clayskins; boundary indistinct.

B1—36 to 85 cm, strong brown (7.5YR5/8) clay; moderate, fine crumb; very friable; many roots; few channels; many pores; discontinuous clayskins; boundary indistinct.

B2—85 to 138 cm, reddish yellow (7.5YR6/8) clay; moderate, fine and medium crumb; friable; few roots; no channels; many pores; discontinuous clayskins; boundary distinct.

BC—138 to 160 cm, reddish yellow (5YR6/8) clay; moderate, fine and medium crumb; friable; few roots and pores; patchy to discontinuous clayskins.

Fig. 4·8a Particle size distribution of 4 Jerangau soil profiles

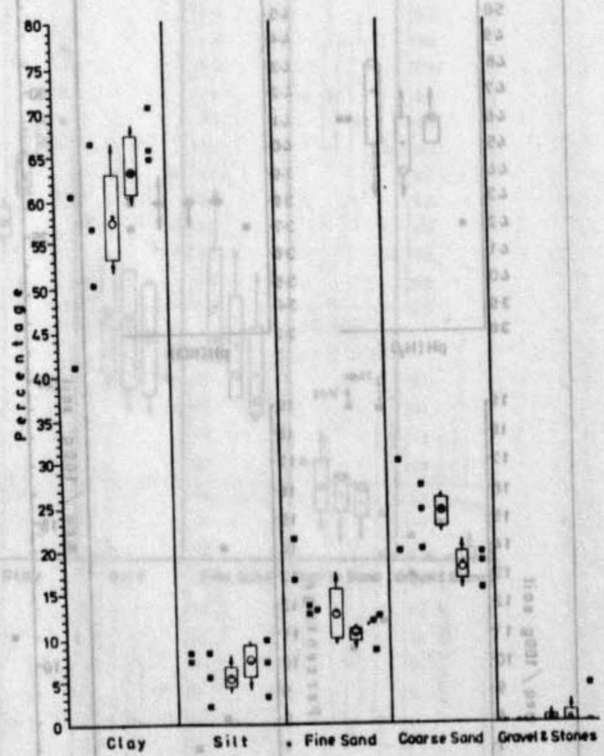
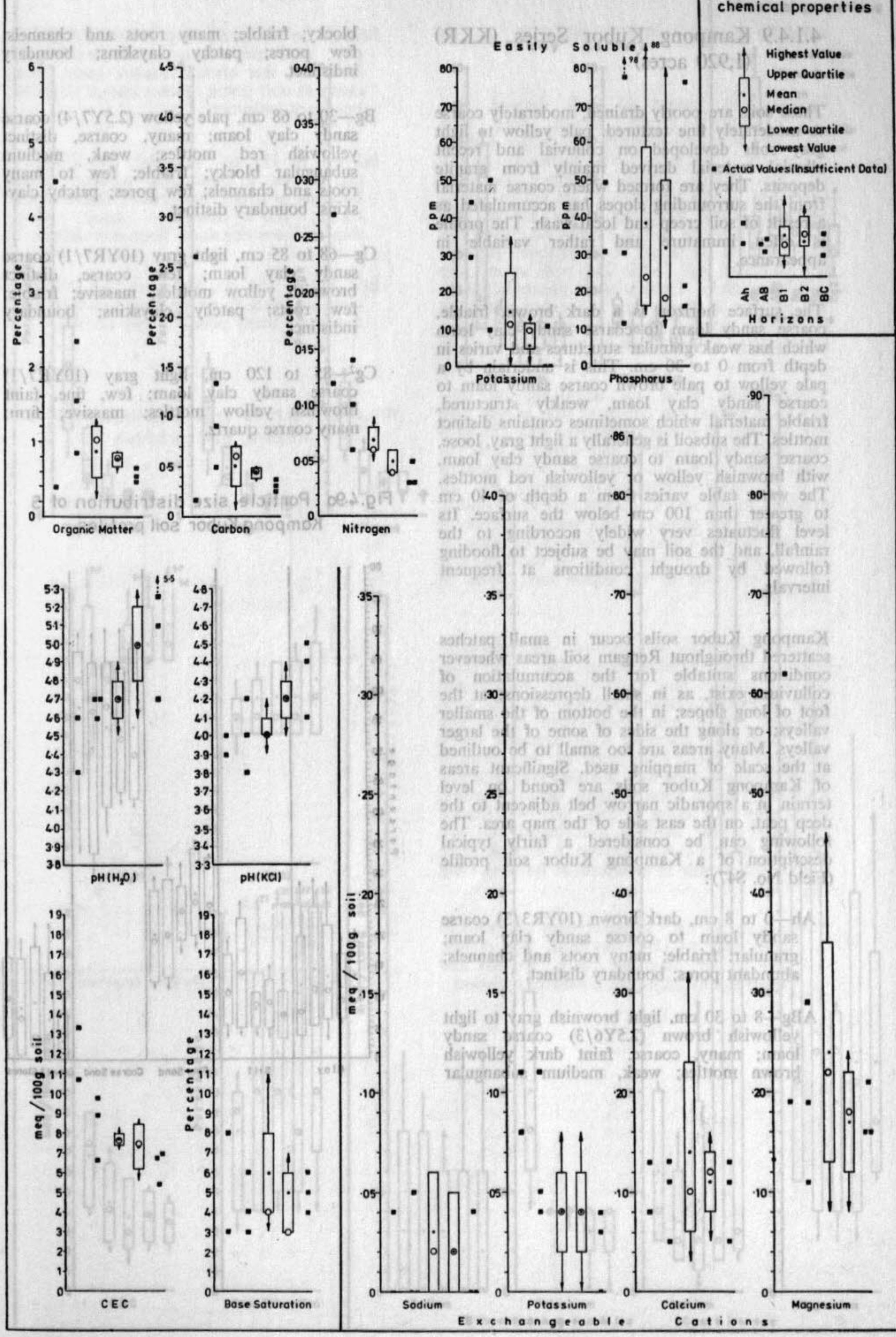


Fig. 4.8b Chemical properties of 4 Jerangau soil profiles



### 4.1.4.9 Kampong Kubor Series (KKR) (1,920 acres)

These soils are poorly drained, moderately coarse to moderately fine textured, pale yellow to light gray soils developed on colluvial and recent alluvial material derived mainly from granite deposits. They are formed where coarse material from the surrounding slopes has accumulated as a result of soil creep and local wash. The profile is often immature and rather variable in appearance.

The surface horizon is a dark brown, friable, coarse sandy loam to coarse sandy clay loam which has weak granular structures and varies in depth from 0 to 30 cm. This is underlain by a pale yellow to pale brown coarse sandy loam to coarse sandy clay loam, weakly structured, friable material which sometimes contains distinct mottles. The subsoil is generally a light gray, loose, coarse sandy loam to coarse sandy clay loam, with brownish yellow or yellowish red mottles. The water table varies from a depth of 40 cm to greater than 100 cm below the surface. Its level fluctuates very widely according to the rainfall, and the soil may be subject to flooding followed by drought conditions at frequent intervals.

Kampong Kubor soils occur in small patches scattered throughout Rengam soil areas wherever conditions suitable for the accumulation of colluvium exist, as in small depressions; at the foot of long slopes; in the bottom of the smaller valleys; or along the sides of some of the larger valleys. Many areas are too small to be outlined at the scale of mapping used. Significant areas of Kampong Kubor soils are found on level terrain in a sporadic narrow belt adjacent to the deep peat, on the east side of the map area. The following can be considered a fairly typical description of a Kampong Kubor soil profile (Field No. S47):

Ah—0 to 8 cm, dark brown (10YR3/3) coarse sandy loam to coarse sandy clay loam; granular; friable; many roots and channels; abundant pores; boundary distinct.

ABg—8 to 30 cm, light brownish gray to light yellowish brown (2.5Y6/3) coarse sandy loam; many, coarse, faint dark yellowish brown mottles; weak, medium subangular blocky; friable; many roots and channels; few pores; patchy clayskins; boundary indistinct.

Bg—30 to 68 cm, pale yellow (2.5Y7/4) coarse sandy clay loam; many, coarse, distinct yellowish red mottles; weak, medium subangular blocky; friable; few to many roots and channels; few pores; patchy clayskins; boundary distinct.

Cg—68 to 85 cm, light gray (10YR7/1) coarse sandy clay loam; few, coarse, distinct brownish yellow mottles; massive; friable; few roots; patchy clayskins; boundary indistinct.

Cg²—85 to 120 cm, light gray (10YR7/1) coarse sandy clay loam; few, fine, faint brownish yellow mottles; massive; firm; many coarse quartz.

Fig. 4.9a Particle size distribution of 5 Kampong Kubor soil profiles

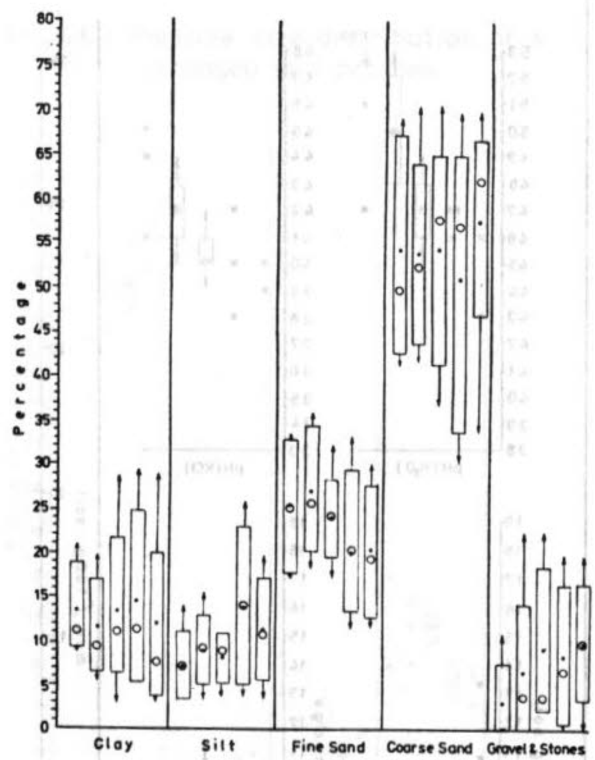
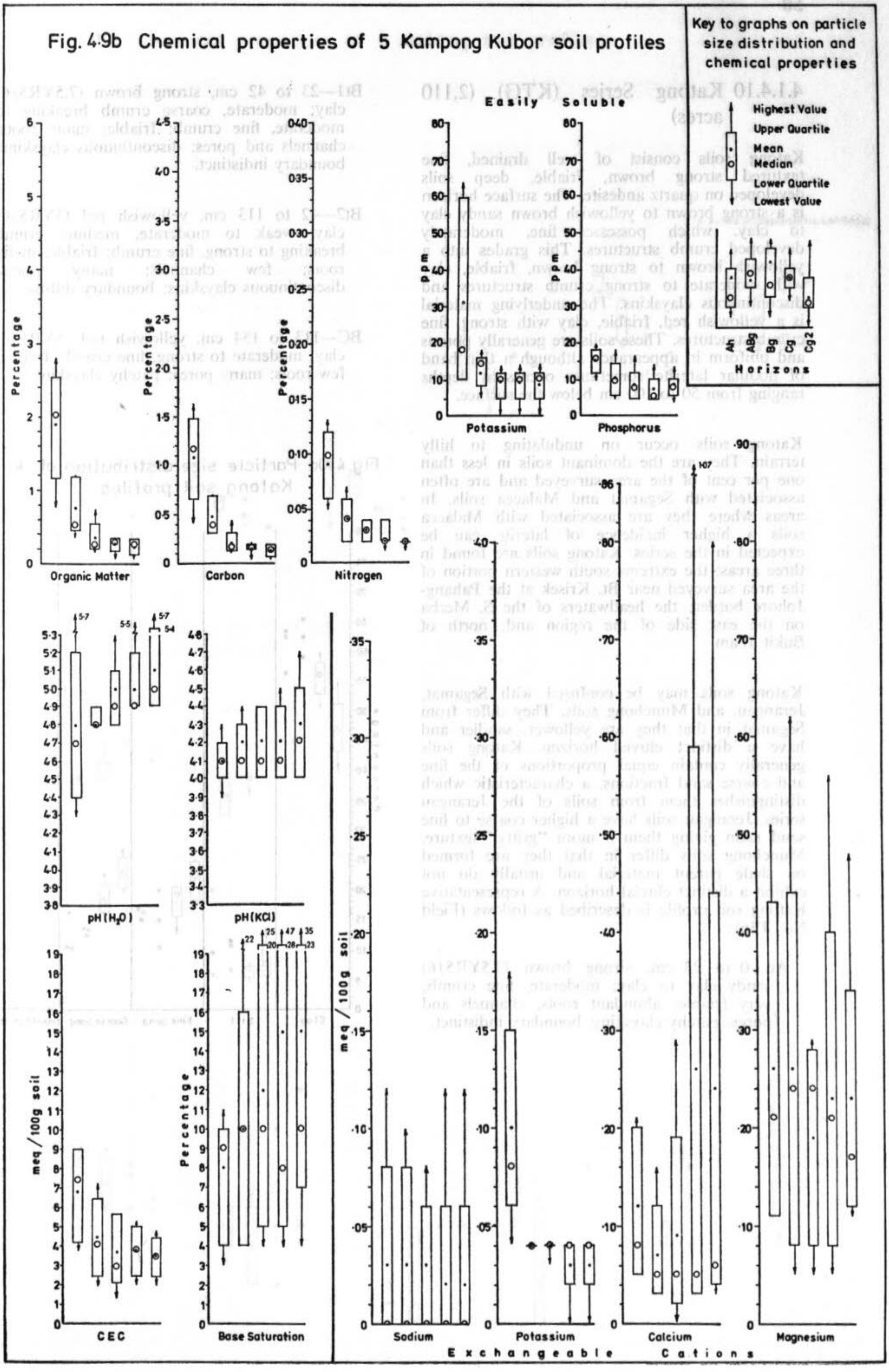


Fig. 4·9b Chemical properties of 5 Kampong Kubor soil profiles



### 4.1.4.10 Katong Series (KTG) (2,110 acres)

Katong soils consist of well drained, fine textured strong brown, friable, deep soils developed on quartz andesite. The surface horizon is a strong brown to yellowish brown sandy clay to clay, which possesses fine, moderately developed crumb structures. This grades into a yellowish brown to strong brown, friable, clay with moderate to strong crumb structures and discontinuous clayskins. The underlying material is a yellowish red, friable, clay with strong, fine crumb structures. These soils are generally porous and uniform in appearance although a thin band of nodular laterite sometimes occurs at depths ranging from 50 to 100 cm below the surface.

Katong soils occur on undulating to hilly terrain. They are the dominant soils in less than one per cent of the area surveyed and are often associated with Segamat and Malacca soils. In areas where they are associated with Malacca soils a higher incidence of laterite can be expected in the series. Katong soils are found in three areas; the extreme south western portion of the area surveyed near Bt. Krisek at the Pahang-Johore border; the headwaters of the S. Merba on the east side of the region and; north of Bukit Ibam.

Katong soils may be confused with Segamat, Jerangau, and Munchong soils. They differ from Segamat in that they are yellower, sandier and have a distinct eluvial horizon. Katong soils generally contain equal proportions of the fine and coarse sand fractions, a characteristic which distinguishes them from soils of the Jerangau series. Jerangau soils have a higher coarse to fine sand ratio giving them a more "gritty" texture. Munchong soils differ in that they are formed on shale parent material and usually do not exhibit a distinct eluvial horizon. A representative Katong soil profile is described as follows (Field No. T36):

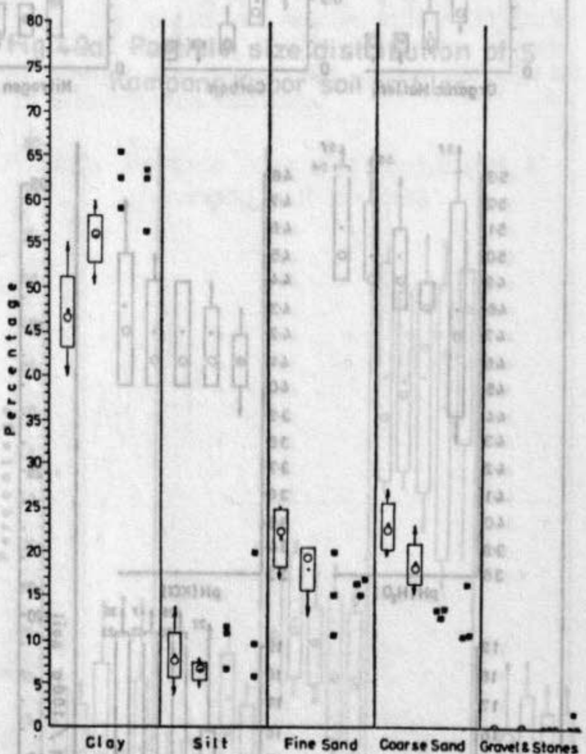
Ae—0 to 23 cm, strong brown (7.5YR5/6) sandy clay to clay; moderate, fine crumb; very friable; abundant roots, channels and pores; patchy clayskins; boundary indistinct.

Bt1—23 to 42 cm, strong brown (7.5YR5/6) clay; moderate, coarse crumb breaking to moderate, fine crumb; friable; many roots, channels and pores; discontinuous clayskins; boundary indistinct.

Bt2—42 to 113 cm, yellowish red (5YR5/6) clay; weak to moderate, medium crumb breaking to strong, fine crumb; friable; many roots; few channels; many pores; discontinuous clayskins; boundary diffuse.

BC—113 to 154 cm, yellowish red (5YR5/6) clay; moderate to strong, fine crumb; friable; few roots; many pores; patchy clayskins.

Fig. 4.10a Particle size distribution of 4 Katong soil profiles



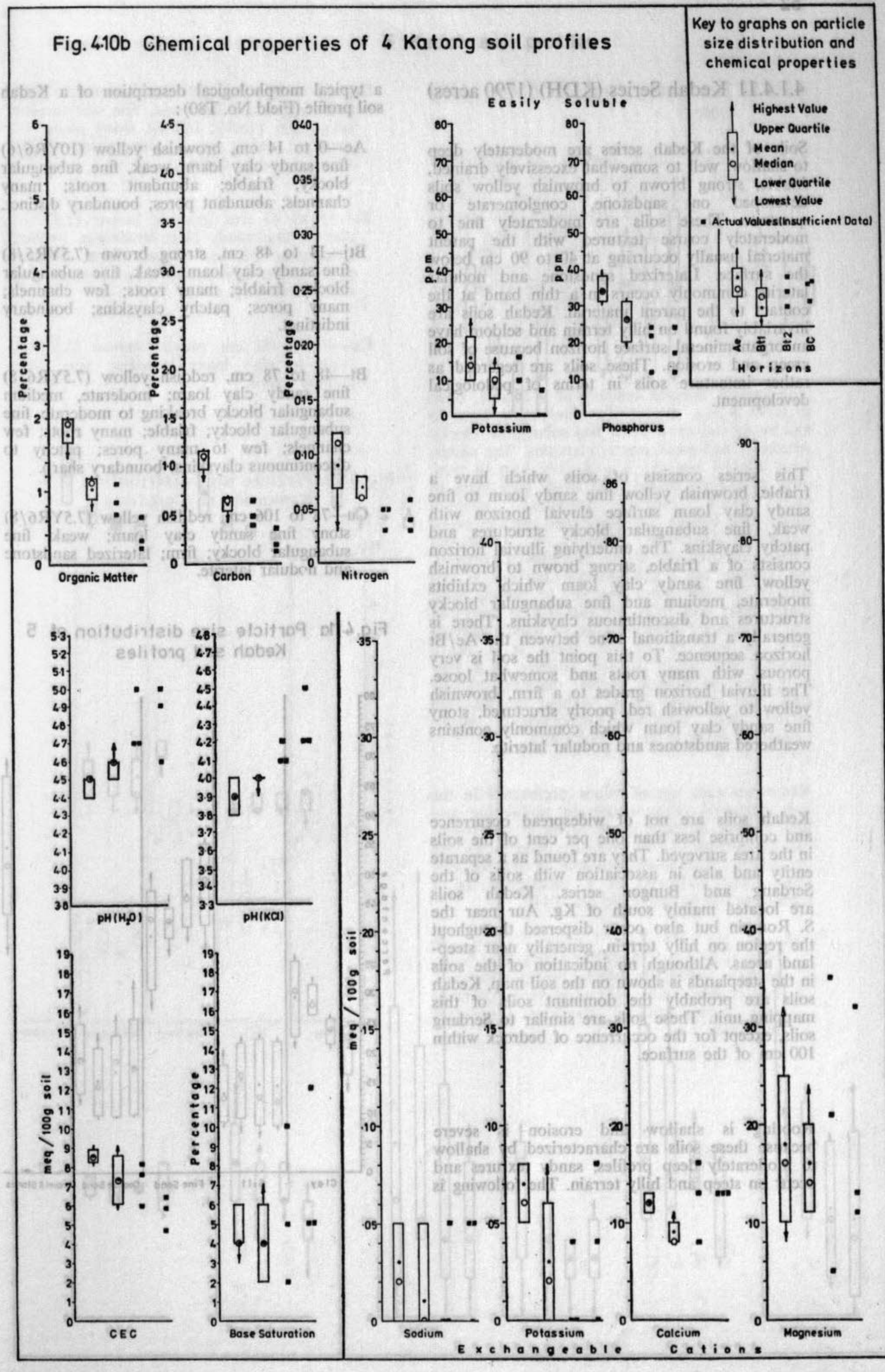



Fig. 4.10b Chemical properties of 4 Katong soil profiles

### 4.1.4.11 Kedah Series (KDH) (1790 acres)

Soils of the Kedah series are moderately deep to shallow, well to somewhat excessively drained, friable, strong brown to brownish yellow soils developed on sandstone, conglomerate or quartzite. These soils are moderately fine to moderately coarse textured with the parent material usually occurring at 40 to 90 cm below the surface. Laterized sandstone and nodular laterite commonly occurs in a thin band at the contact to the parent material. Kedah soils are invariably found on hilly terrain and seldom have an organomineral surface horizon because of soil creep and erosion. These soils are regarded as rather immature soils in terms of pedological development.

This series consists of soils which have a friable, brownish yellow fine sandy loam to fine sandy clay loam surface eluvial horizon with weak, fine subangular blocky structures and patchy clayskins. The underlying illuvial horizon consists of a friable, strong brown to brownish yellow, fine sandy clay loam which exhibits moderate, medium and fine subangular blocky structures and discontinuous clayskins. There is generally a transitional zone between the Ae/Bt horizon sequence. To this point the soil is very porous, with many roots and somewhat loose. The illuvial horizon grades to a firm, brownish yellow to yellowish red, poorly structured, stony fine sandy clay loam which commonly contains weathered sandstones and nodular laterite.

Kedah soils are not of widespread occurrence and comprise less than one per cent of the soils in the area surveyed. They are found as a separate entity and also in association with soils of the Serdang and Bungor series. Kedah soils are located mainly south of Kg. Aur near the S. Rompin but also occur dispersed throughout the region on hilly terrain, generally near steepland areas. Although no indication of the soils in the steeplands is shown on the soil map, Kedah soils are probably the dominant soils of this mapping unit. These soils are similar to Serdang soils, except for the occurrence of bedrock within 100 cm of the surface.

Rooting is shallow and erosion is severe because these soils are characterized by shallow to moderately deep profiles, sandy textures and occur on steep and hilly terrain. The following is a typical morphological description of a Kedah soil profile (Field No. T80):

Ae—0 to 14 cm, brownish yellow (10YR6/6) fine sandy clay loam; weak, fine subangular blocky; friable; abundant roots; many channels; abundant pores; boundary distinct.

Btj—14 to 48 cm, strong brown (7.5YR5/8) fine sandy clay loam; weak, fine subangular blocky; friable; many roots; few channels; many pores; patchy clayskins; boundary indistinct.

Bt—48 to 78 cm, reddish yellow (7.5YR6/8) fine sandy clay loam; moderate, medium subangular blocky breaking to moderate, fine subangular blocky; friable; many roots; few channels; few to many pores; patchy to discontinuous clayskins; boundary sharp.

Cu—78 to 106 cm, reddish yellow (7.5YR6/8) stony fine sandy clay loam; weak, fine subangular blocky; firm; laterized sandstone and nodular laterite.

Fig.4.11a Particle size distribution of 5 Kedah soil profiles

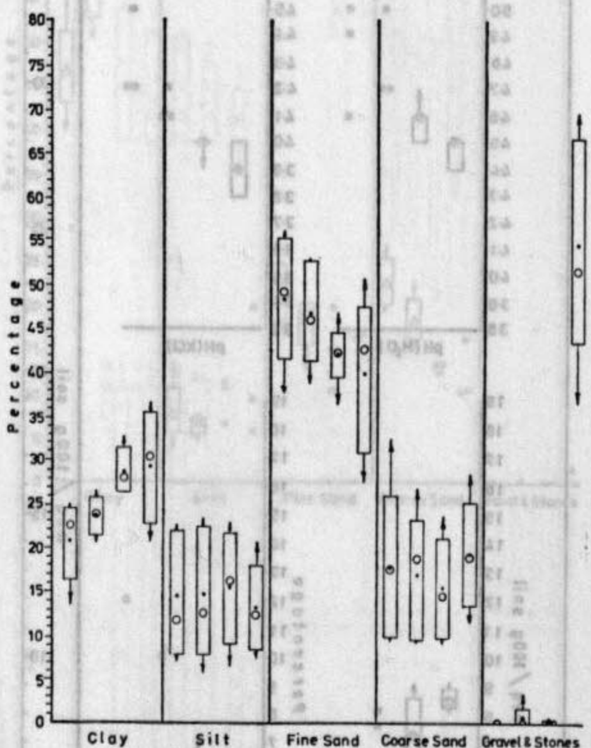
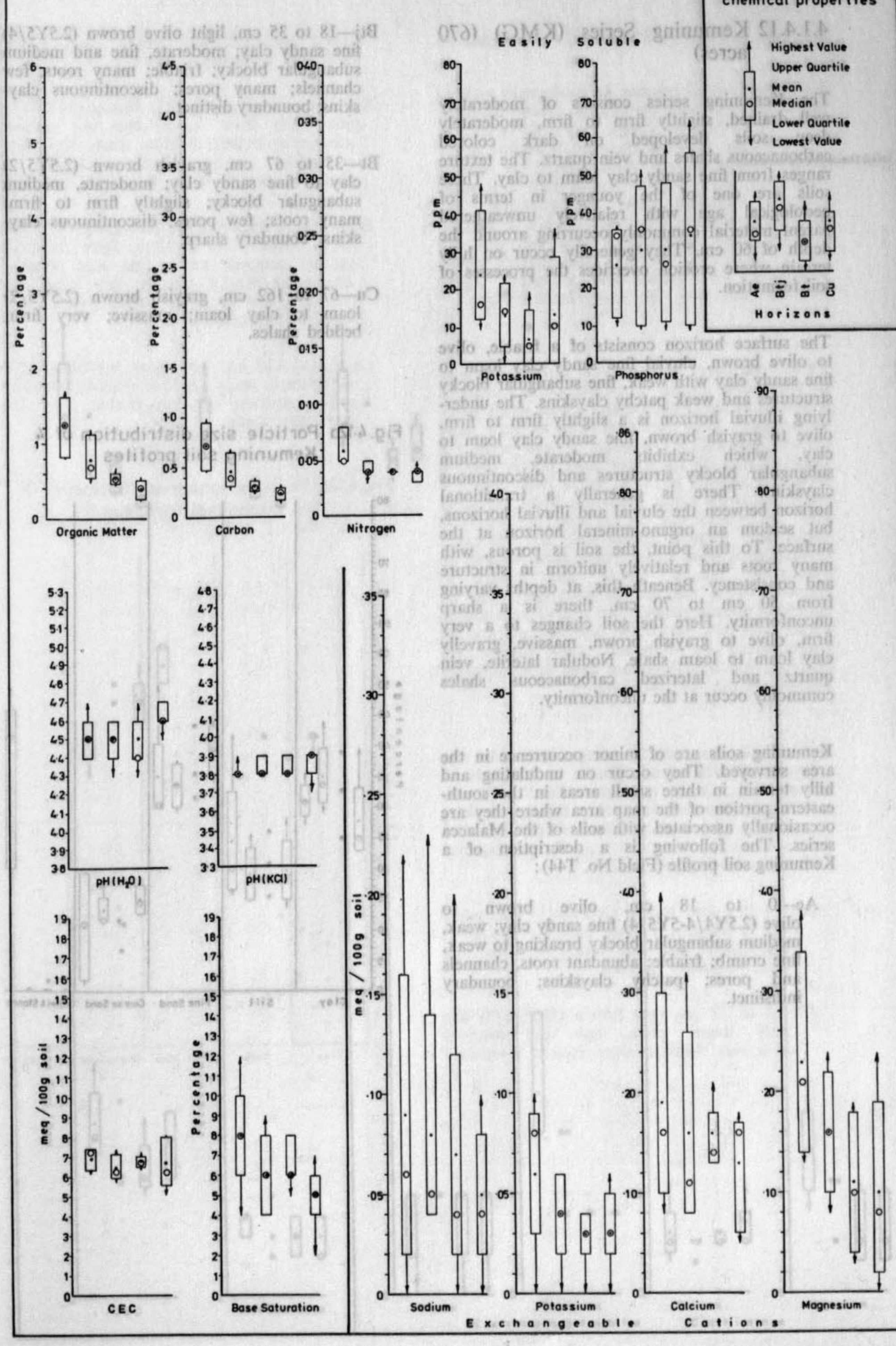


Fig. 4.11b Chemical properties of 5 Kedah soil profiles



## 4.1.4.12 Kemuning Series (KMG) (670 acres)

The Kemuning series consists of moderately well drained, slightly firm to firm, moderately deep soils developed on dark colored carbonaceous shales and vein quartz. The texture ranges from fine sandy clay loam to clay. These soils are one of the younger in terms of pedological age with relatively unweathered parent material commonly occurring around the depth of 60 cm. They generally occur on hilly terrain where erosion overrides the processes of soil formation.

The surface horizon consists of a friable, olive to olive brown, eluvial fine sandy clay loam to fine sandy clay with weak, fine subangular blocky structures and weak patchy clayskins. The underlying illuvial horizon is a slightly firm to firm, olive to grayish brown, fine sandy clay loam to clay, which exhibits moderate, medium subangular blocky structures and discontinuous clayskins. There is generally a transitional horizon between the eluvial and illuvial horizons, but seldom an organo-mineral horizon at the surface. To this point, the soil is porous, with many roots and relatively uniform in structure and consistency. Beneath this, at depths varying from 50 cm to 70 cm, there is a sharp unconformity. Here the soil changes to a very firm, olive to grayish brown, massive, gravelly clay loam to loam shale. Nodular laterite, vein quartz and laterized carbonaceous shales commonly occur at the unconformity.

Kemuning soils are of minor occurrence in the area surveyed. They occur on undulating and hilly terrain in three small areas in the south-eastern portion of the map area where they are occasionally associated with soils of the Malacca series. The following is a description of a Kemuning soil profile (Field No. T44):

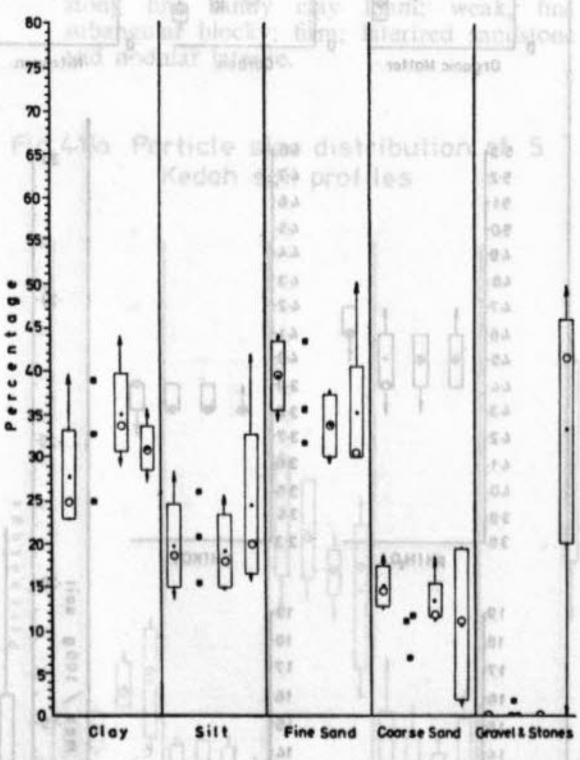
Ae—0 to 18 cm, olive brown to olive (2.5Y4/4-5Y5/4) fine sandy clay; weak, medium subangular blocky breaking to weak, fine crumb; friable; abundant roots, channels and pores; patchy clayskins; boundary indistinct.

Btj—18 to 35 cm, light olive brown (2.5Y5/4) fine sandy clay; moderate, fine and medium subangular blocky; friable; many roots; few channels; many pores; discontinuous clayskins; boundary distinct.

Bt—35 to 67 cm, grayish brown (2.5Y5/2) clay to fine sandy clay; moderate, medium subangular blocky; slightly firm to firm; many roots; few pores; discontinuous clayskins; boundary sharp.

Cu—67 to 162 cm, grayish brown (2.5Y5/2) loam to clay loam; massive; very firm; bedded shales.

Fig. 4·12a Particle size distribution of 4 Kemuning soil profiles



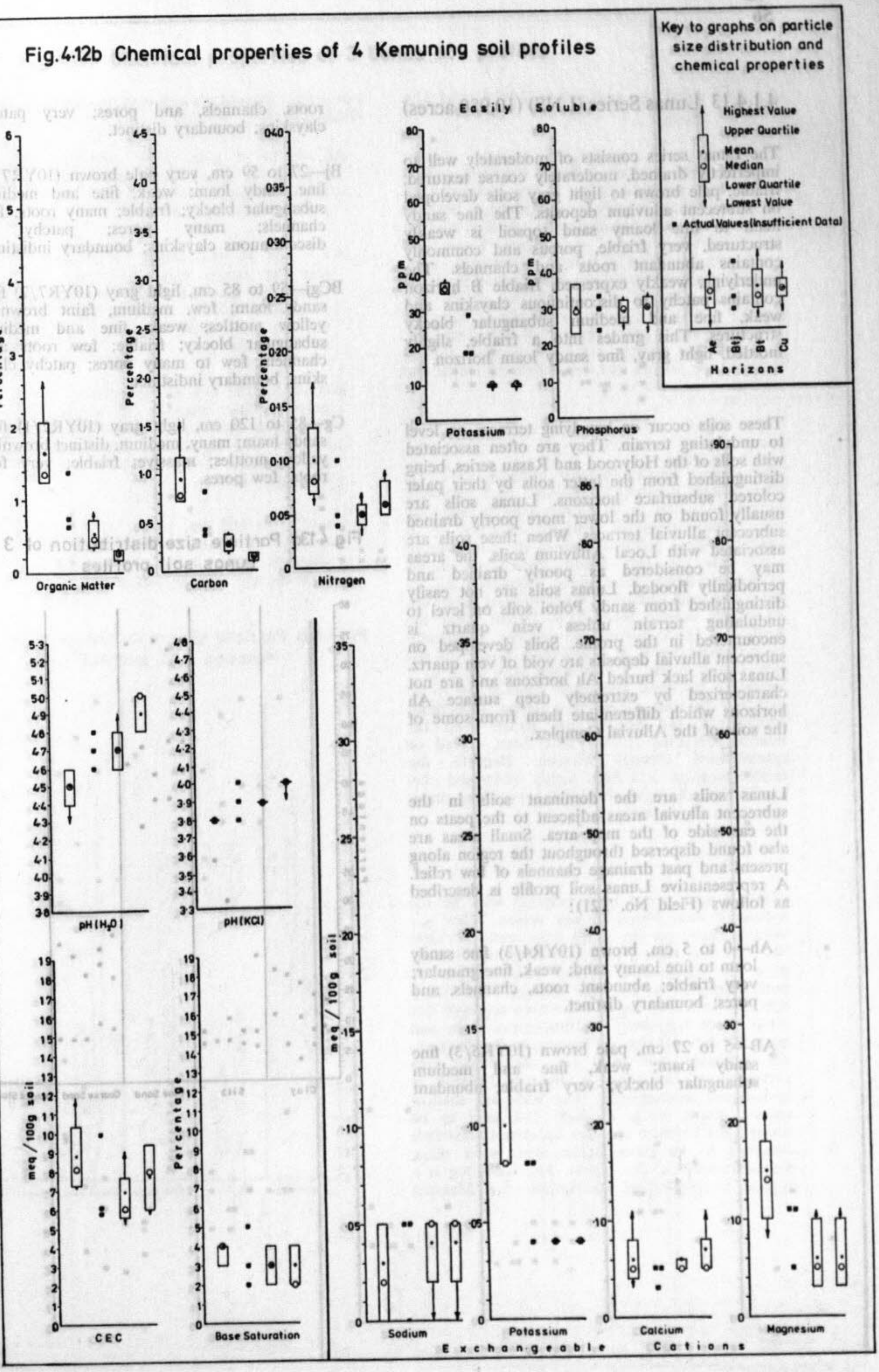



Fig.4.12b Chemical properties of 4 Kemuning soil profiles

### 4.1.4.13 Lunas Series (LNS) (10,980 acres)

The Lunas series consists of moderately well to imperfectly drained, moderately coarse textured, friable, pale brown to light gray soils developed on subrecent alluvium deposits. The fine sandy loam to fine loamy sand topsoil is weakly structured, very friable, porous and commonly contains abundant roots and channels. The underlying, weakly expressed, friable B horizon contains patchy to discontinuous clayskins and weak, fine and medium subangular blocky structures. This grades into a friable, slighly mottled, light gray, fine sandy loam horizon.

These soils occur on low lying terraces on level to undulating terrain. They are often associated with soils of the Holyrood and Rasau series, being distinguished from the latter soils by their paler colored subsurface horizons. Lunas soils are usually found on the lower more poorly drained subrecent alluvial terraces. When these soils are associated with Local Alluvium soils, the areas may be considered as poorly drained and periodically flooded. Lunas soils are not easily distinguished from sandy Pohoi soils on level to undulating terrain unless vein quartz is encountered in the profile. Soils developed on subrecent alluvial deposits are void of vein quartz. Lunas soils lack buried Ah horizons and are not characterized by extremely deep surface Ah horizons which differentiate them from some of the soils of the Alluvial Complex.

Lunas soils are the dominant soils in the subrecent alluvial areas adjacent to the peats on the east side of the map area. Small areas are also found dispersed throughout the region along present and past drainage channels of low relief. A representative Lunas soil profile is described as follows (Field No. T21):

Ah—0 to 5 cm, brown (10YR4/3) fine sandy loam to fine loamy sand; weak, fine granular; very friable; abundant roots, channels, and pores; boundary distinct.

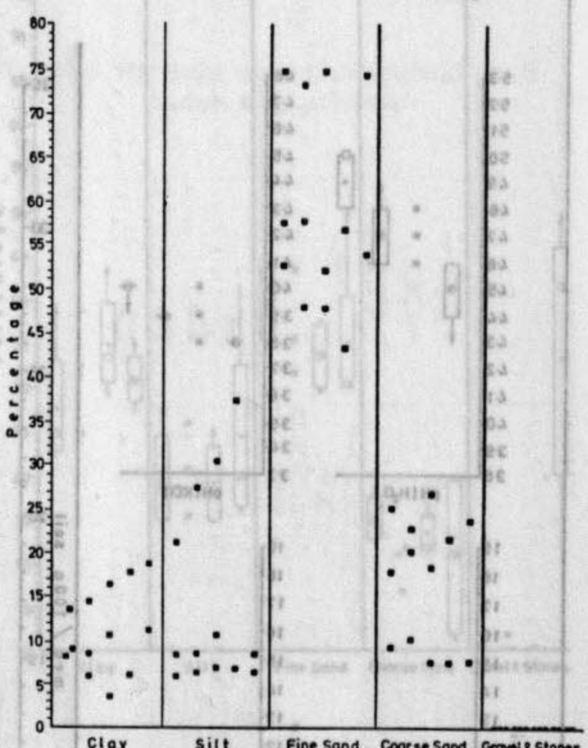
AB—5 to 27 cm, pale brown (10YR6/3) fine sandy loam; weak, fine and medium subangular blocky; very friable; abundant roots, channels, and pores; very patchy clayskins; boundary distinct.

Bj—27 to 59 cm, very pale brown (10YR7/3) fine sandy loam; weak, fine and medium subangular blocky; friable; many roots; few channels; many pores; patchy to discontinuous clayskins; boundary indistinct.

BCgj—59 to 85 cm, light gray (10YR7/2) fine sandy loam; few, medium, faint brownish yellow mottles; weak, fine and medium subangular blocky; friable; few roots and channels; few to many pores; patchy clayskins; boundary indistinct.

Cg—85 to 120 cm, light gray (10YR7/1) fine sandy loam; many, medium, distinct brownish yellow mottles; massive; friable; very few roots; few pores.

**Fig. 4·13a Particle size distribution of 3 Lunas soil profiles**



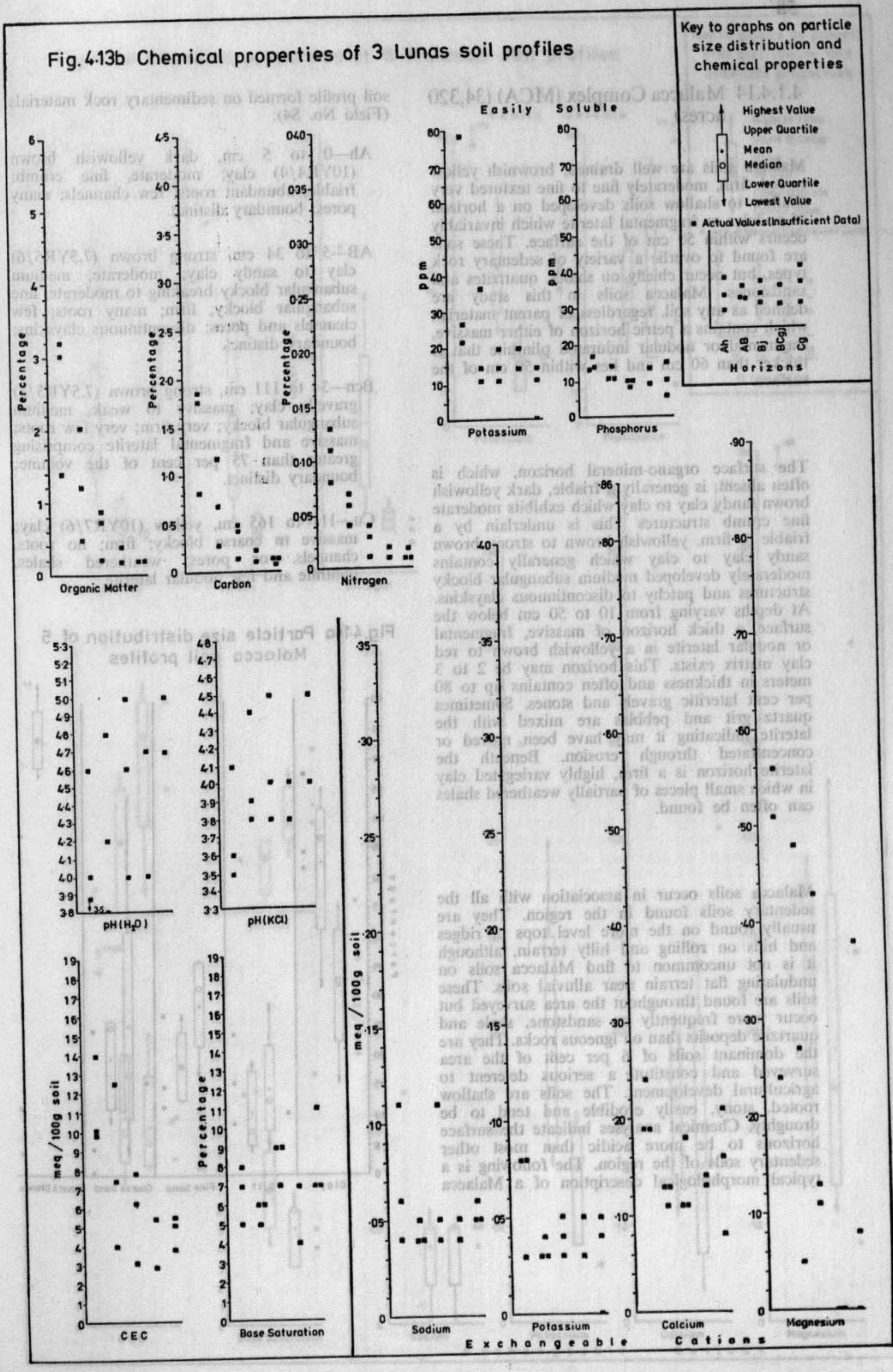



Fig. 4·13b Chemical properties of 3 Lunas soil profiles

### 4.1.4.14 Malacca Complex (MCA) (34,320 acres)

Malacca soils are well drained, brownish yellow to red, firm, moderately fine to fine textured very shallow to shallow soils developed on a horizon of nodular or fragmental laterite which invariably occurs within 50 cm of the surface. These soils are found to overlie a variety of sedentary rock types, but occur chiefly on shales, quartzites and sandstones. Malacca soils in this study are defined as any soil, regardless of parent material, which contains a petric horizon of either massive, fragmental or nodular indurated plinthite that is thicker than 60 cm and lies within 50 cm of the surface.

The surface organo-mineral horizon, which is often absent, is generally a friable, dark yellowish brown sandy clay to clay which exhibits moderate fine crumb structures This is underlain by a friable to firm, yellowish brown to strong brown sandy clay to clay which generally contains moderately developed medium subangular blocky structures and patchy to discontinuous clayskins. At depths varying from 10 to 50 cm below the surface, a thick horizon of massive, fragmental or nodular laterite in a yellowish brown to red clay matrix exists. This horizon may be 2 to 3 meters in thickness and often contains up to 80 per cent lateritic gravels and stones. Sometimes quartz grit and pebbles are mixed with the laterite indicating it may have been moved or concentrated through erosion. Beneath the laterite horizon is a firm, highly variegated clay in which small pieces of partially weathered shales can often be found.

Malacca soils occur in association with all the sedentary soils found in the region. They are usually found on the more level tops of ridges and hills on rolling and hilly terrain, although it is not uncommon to find Malacca soils on undulating flat terrain near alluvial soils. These soils are found throughout the area surveyed but occur more frequently on sandstone, shale and quartzite deposits than on igneous rocks. They are the dominant soils of 6 per cent of the area surveyed and constitute a serious deterent to agricultural development. The soils are shallow rooted, stony, easily erodible and tend to be droughty. Chemical analyses indicate the surface horizons to be more acidic than most other sedentary soils of the region. The following is a typical morphological description of a Malacca soil profile formed on sedimentary rock materials (Field No. S4):

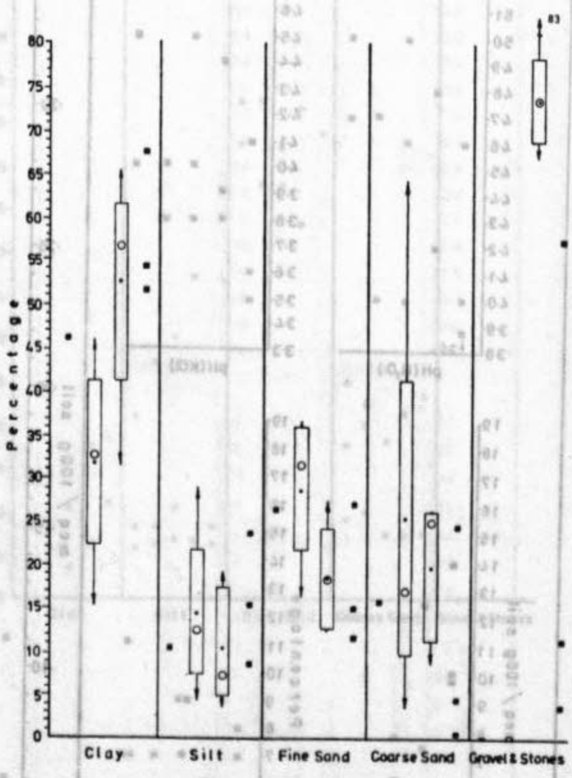
Ah—0 to 5 cm, dark yellowish brown (10YR4/4) clay; moderate, fine crumb; friable; abundant roots; few channels; many pores; boundary distinct.

AB—5 to 34 cm, strong brown (7.5YR5/6) clay to sandy clay; moderate, medium subangular blocky breaking to moderate, fine subangular blocky; firm; many roots; few channels and pores; discontinuous clayskins; boundary distinct.

Bcn—34 to 111 cm, strong brown (7.5YR5/8) gravelly clay; massive to weak, medium subangular blocky; very firm; very few roots; massive and fragmental laterite comprising greater than 75 per cent of the volume; boundary distinct.

Cu—111 to 165 cm, yellow (10YR7/6) clay; massive to coarse blocky; firm; no roots, channels, or pores; weathered shales, plinthite and few nodular laterite.

Fig.4.14a Particle size distribution of 5 Malacca soil profiles



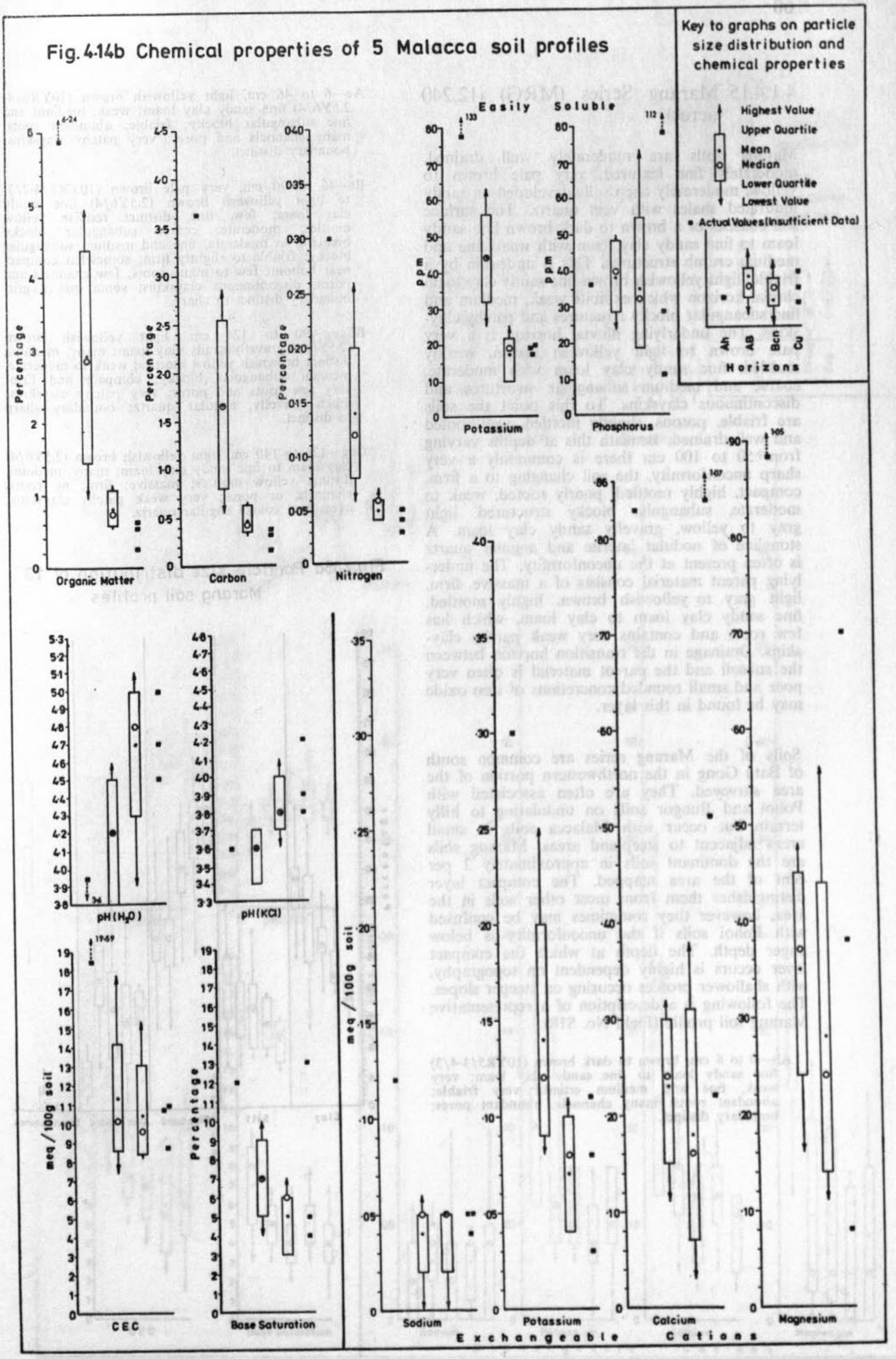



Fig. 4·14b Chemical properties of 5 Malacca soil profiles

### 4.1.4.15 Marang Series (MRG) (12,240 acres)

Marang soils are moderately well drained, moderately fine textured, very pale brown to yellow, moderately deep soils developed on sandy indurated shales with vein quartz. The surface soil consists of a brown to dark brown fine sandy loam to fine sandy clay loam with weak fine and medium crumb structures. This is underlain by a friable, light yellowish brown fine sandy clay loam eluvial horizon which exhibits weak, medium and fine subangular blocky structures and patchy clayskins. The underlying illuvial horizon is a very pale brown to light yellowish brown, weakly mottled, fine sandy clay loam with moderate, coarse and medium subangular structures and discontinuous clayskins. To this point the soils are friable, porous, slightly mottled, well rooted and well drained. Beneath this at depths varying from 50 to 100 cm there is commonly a very sharp unconformity, the soil changing to a firm, compact, highly mottled, poorly rooted, weak to moderate, subangular blocky structured, light gray to yellow, gravelly sandy clay loam. A stoneline of nodular laterite and angular quartz is often present at the unconformity. The underlying parent material consists of a massive, firm, light gray to yellowish brown, highly mottled, fine sandy clay loam to clay loam, which has few roots and contains very weak patchy clayskins. Drainage in the transition horizon between the subsoil and the parent material is often very poor and small rounded concretions of iron oxide may be found in this layer.

Soils of the Marang series are common south of Batu Gong in the northwestern portion of the area surveyed. They are often associated with Pohoi and Bungor soils on undulating to hilly terrain but occur with Malacca soils in small areas adjacent to steepland areas. Marang soils are the dominant soils in approximately 2 per cent of the area mapped. The compact layer distinguishes them from most other soils in the area, however they sometimes may be confused with Pohoi soils if the unconformity is below auger depth. The depth at which the compact layer occurs is highly dependent on topography, with shallower profiles occuring on steeper slopes. The following is a description of a representative Marang soil profile (Field No. S18):

**Ah—0 to 6 cm, brown to dark brown (10YR5/3-4/3) fine sandy loam to fine sandy clay loam; very weak, fine and medium crumb; very friable; abundant roots: many channels; abundant pores; boundary distinct.**

**Ae—6 to 46 cm, light yellowish brown (10YR6/4-2.5Y6/4) fine sandy clay loam; weak, medium and fine subangular blocky; friable; abundant roots; many channels and pores; very patchy clayskins; boundary distinct.**

**Bt—46 to 90 cm, very pale brown (10YR7/4-7/3) to light yellowish brown (2.5Y6/4) fine sandy clay loam; few, fine, distinct reddish yellow mottles; moderate, coarse subangular blocky breaking to moderate, fine and medium subangular blocky; friable to slightly firm; somewhat compact near bottom; few to many roots; few channels and pores; discontinuous clayskins; some quartz grit; boundary distinct to sharp.**

**BCcug—90 to 124 cm, light yellowish brown (2.5Y6/4) gravelly sandy clay loam; many, medium, distinct brownish yellow mottles; weak to moderate, medium subangular blocky; compact and firm; very few roots and pores; very patchy clayskins; much gravelly, angular quartz; boundary sharp to distinct.**

**Cug—124 to 140 cm, light yellowish brown (2.5Y6/4) clay loam to fine sandy clay loam; many, medium, distinct yellow mottles; massive; firm; no roots, channels, or pores; very weak patchy clayskins; occasional coarse angular quartz.**

**Fig.4.15a Particle size distribution of 13 Marang soil profiles**

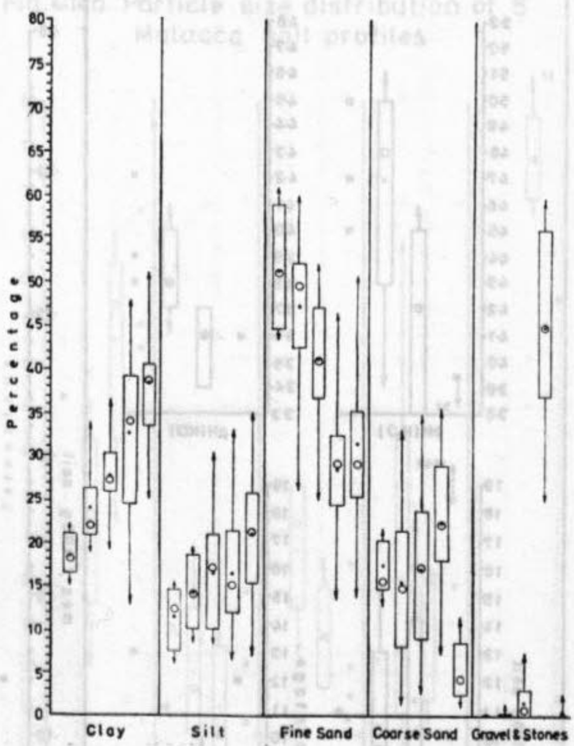
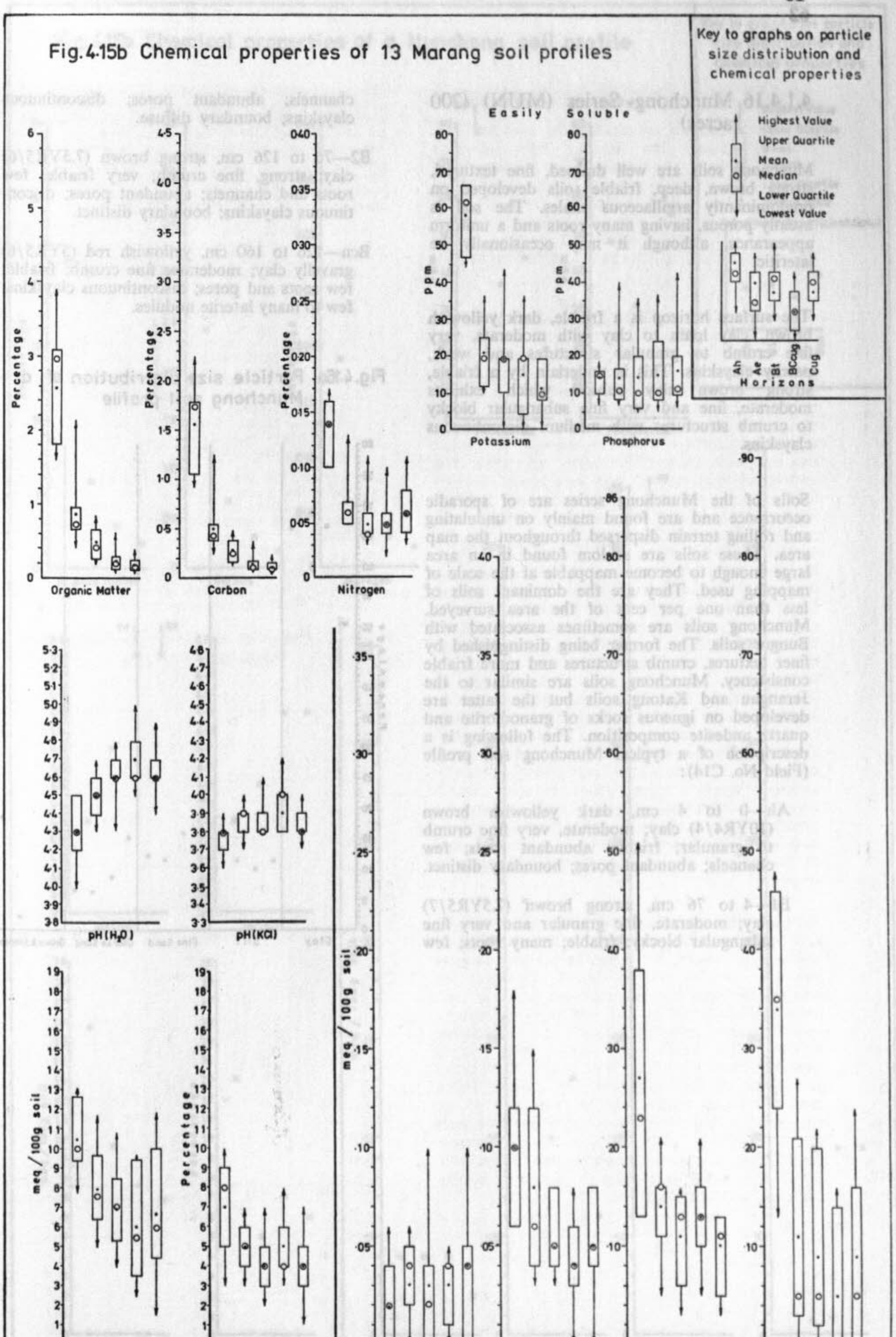


Fig. 4.15b Chemical properties of 13 Marang soil profiles



### 4.1.4.16 Munchong Series (MUN) (200 acres)

Munchong soils are well drained, fine textured, strong brown, deep, friable soils developed on predominantly argillaceous shales. The soil is usually porous, having many roots and a uniform appearance, although it may occasionally be lateritic.

The surface horizon is a friable, dark yellowish brown, clay loam to clay with moderate, very fine crumb to granular structures and weak, patchy clayskins. This is underlain by a friable, strong brown clay subsoil which exhibits moderate, fine and very fine subangular blocky to crumb structures with medium discontinuous clayskins.

Soils of the Munchong series are of sporadic occurrence and are found mainly on undulating and rolling terrain dispersed throughout the map area. These soils are seldom found in an area large enough to become mappable at the scale of mapping used. They are the dominant soils of less than one per cent of the area surveyed. Munchong soils are sometimes associated with Bungor soils. The former being distinguished by finer textures, crumb structures and more friable consistency. Munchong soils are similar to the Jerangau and Katong soils but the latter are developed on igneous rocks of granodiorite and quartz andesite composition. The following is a description of a typical Munchong soil profile (Field No. C14):

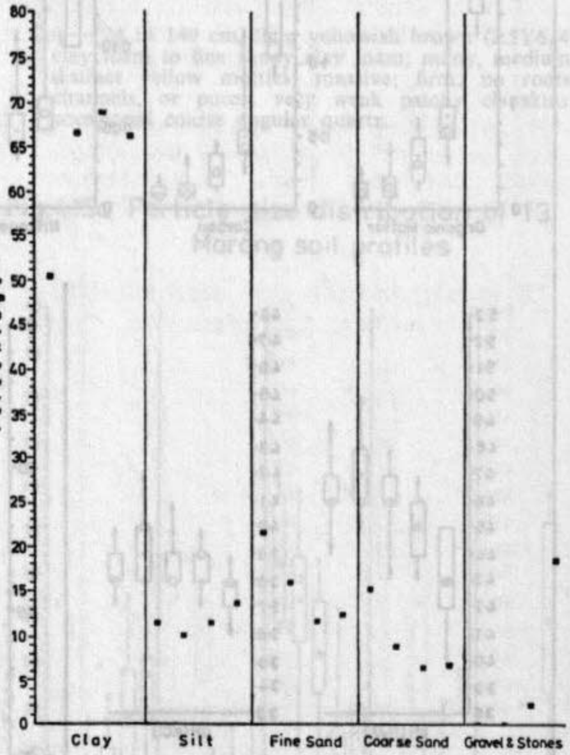
Ah—0 to 4 cm, dark yellowish brown (10YR4/4) clay; moderate, very fine crumb to granular; friable; abundant roots; few channels; abundant pores; boundary distinct.

B1—4 to 76 cm, strong brown (7.5YR5/7) clay; moderate, fine granular and very fine subangular blocky; friable; many roots; few channels; abundant pores; discontinuous clayskins; boundary diffuse.

B2—76 to 126 cm, strong brown (7.5YR5/6) clay; strong, fine crumb; very friable; few roots and channels; abundant pores; discontinuous clayskins; boundary distinct.

Bcn—126 to 160 cm, yellowish red (5YR5/6) gravelly clay; moderate; fine crumb; friable; few roots and pores; discontinuous clayskins; few to many laterite nodules.

**Fig.4.16a Particle size distribution of a Munchong soil profile**



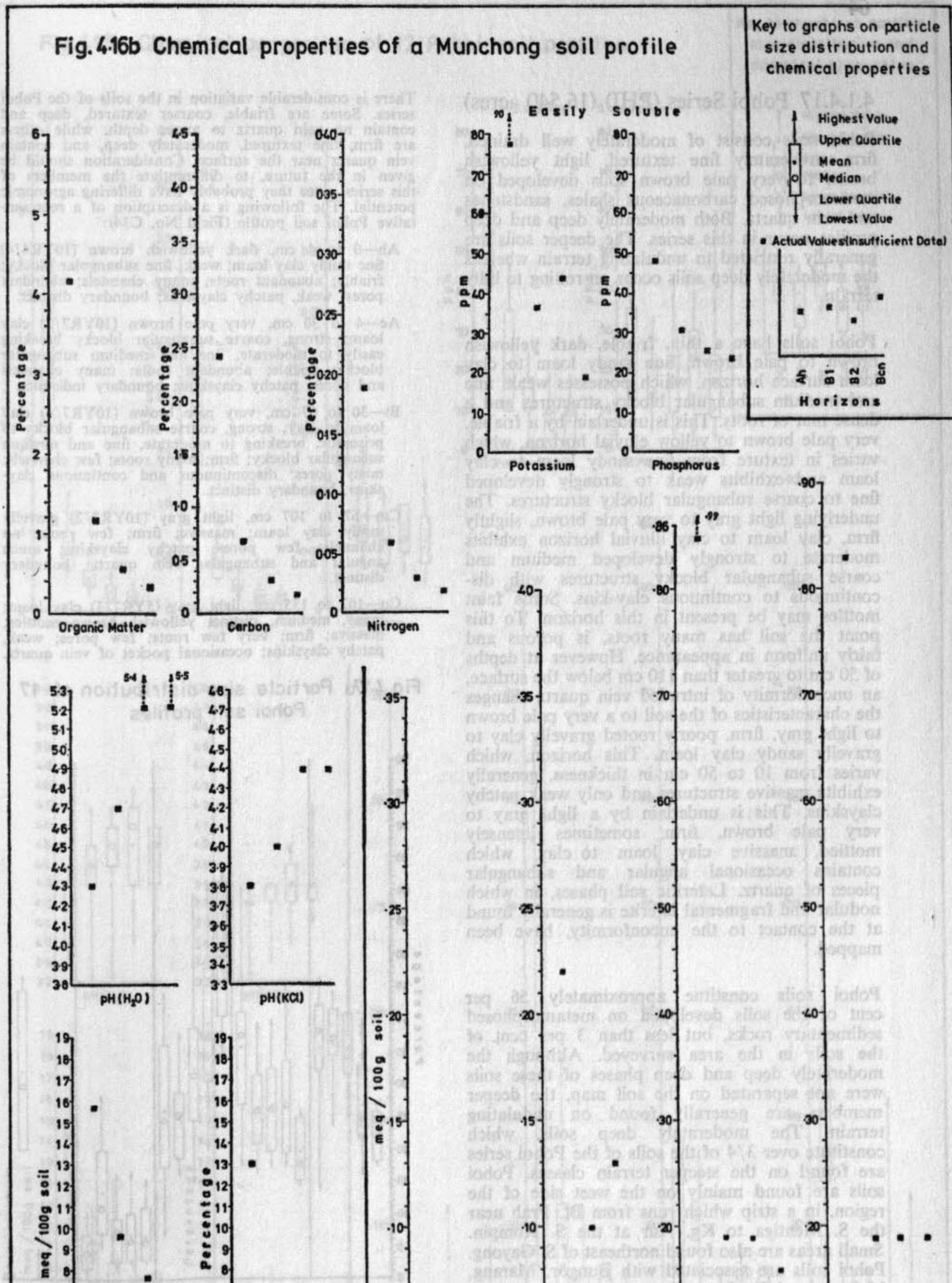



Fig. 4·16b Chemical properties of a Munchong soil profile

### 4.1.4.17 Pohoi Series (PHI) (16,540 acres)

Pohoi soils consist of moderately well drained, firm, moderately fine textured, light yellowish brown to very pale brown soils developed on metamorphosed carbonaceous shales, sandstones and vein quartz. Both moderately deep and deep profiles occur in this series. The deeper soils are generally restricted to undulating terrain whereas the moderately deep soils occur on rolling to hilly terrain.

Pohoi soils have a thin, friable, dark yellowish brown to pale brown, fine sandy loam to clay loam surface horizon, which possesses weak, fine and medium subangular blocky structures and a dense mat of roots. This is underlain by a friable, very pale brown to yellow eluvial horizon, which varies in texture from fine sandy loam to clay loam and exhibits weak to strongly developed fine to coarse subangular blocky structures. The underlying light gray to very pale brown, slightly firm, clay loam to clay illuvial horizon exhibits moderate to strongly developed medium and coarse subangular blocky structures with discontinuous to continuous clayskins. Some faint mottles may be present in this horizon. To this point the soil has many roots, is porous and fairly uniform in appearance. However at depths of 50 cm to greater than 110 cm below the surface, an unconformity of intruded vein quartz changes the characteristics of the soil to a very pale brown to light gray, firm, poorly rooted gravelly clay to gravelly sandy clay loam. This horizon, which varies from 10 to 50 cm in thickness, generally exhibits massive structures and only weak patchy clayskins. This is underlain by a light gray to very pale brown, firm, sometimes intensely mottled, massive clay loam to clay, which contains occasional angular and subangular pieces of quartz. Lateritic soil phases, in which nodular and fragmental laterite is generally found at the contact to the unconformity, have been mapped.

Pohoi soils constitue approximately 56 per cent of the soils developed on metamorphosed sedimentary rocks, but less than 3 per cent of the soils in the area surveyed. Although the moderately deep and deep phases of these soils were not separated on the soil map, the deeper members are generally found on undulating terrain. The moderately deep soils, which constitute over 3/4 of the soils of the Pohoi series are found on the steeper terrain classes. Pohoi soils are found mainly on the west side of the region, in a strip which runs from Bt. Prah near the S. Mentiga to Kg. Aur at the S. Rompin. Small areas are also found northeast of S. Gayong. Pohoi soils are associated with Bungor, Marang, Malacca and Durian soils.

There is considerable variation in the soils of the Pohoi series. Some are friable, coarser textured, deep and contain no vein quartz to auger depth, while others are firm, fine textured, moderately deep, and contain vein quartz near the surface. Consideration should be given in the future, to differentiate the members of this series, since they probably have differing agronomic potential. The following is a description of a representative Pohoi soil profile (Field No. C34):

Ah—0 to 4 cm, dark yellowish brown (10YR4/4) fine sandy clay loam; weak, fine subangular blocky; friable; abundant roots; many channels; abundant pores; weak, patchy clayskins; boundary distinct.

Ae—4 to 30 cm, very pale brown (10YR7/3) clay loam; strong, coarse subangular blocky breaking easily to moderate, fine and medium subangular blocky; friable; abundant roots; many channels and pores; patchy clayskins; boundary indistinct.

Bt—30 to 67 cm, very pale brown (10YR7/4) clay loam to clay; strong, coarse subangular blocky to prismatic, breaking to moderate, fine and medium subangular blocky; firm; many roots; few channels; many pores; discontinuous and continuous clayskins; boundary distinct.

Cm—67 to 107 cm, light gray (10YR7/2) gravelly sandy clay loam; massive; firm; few roots; no channels; few pores; patchy clayskins; much angular and subangular vein quartz; boundary distinct.

Cu—107 to 135 cm, light gray (5YR7/1) clay loam; many, medium, distinct yellowish brown mottles; massive; firm; very few roots; few pores; weak, patchy clayskins; occasional pocket of vein quartz.

**Fig. 4.17a Particle size distribution of 17 Pohoi soil profiles**

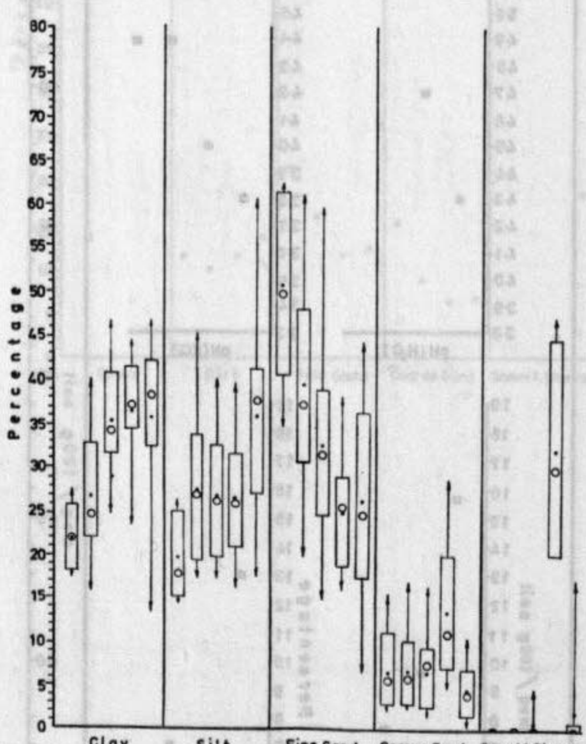
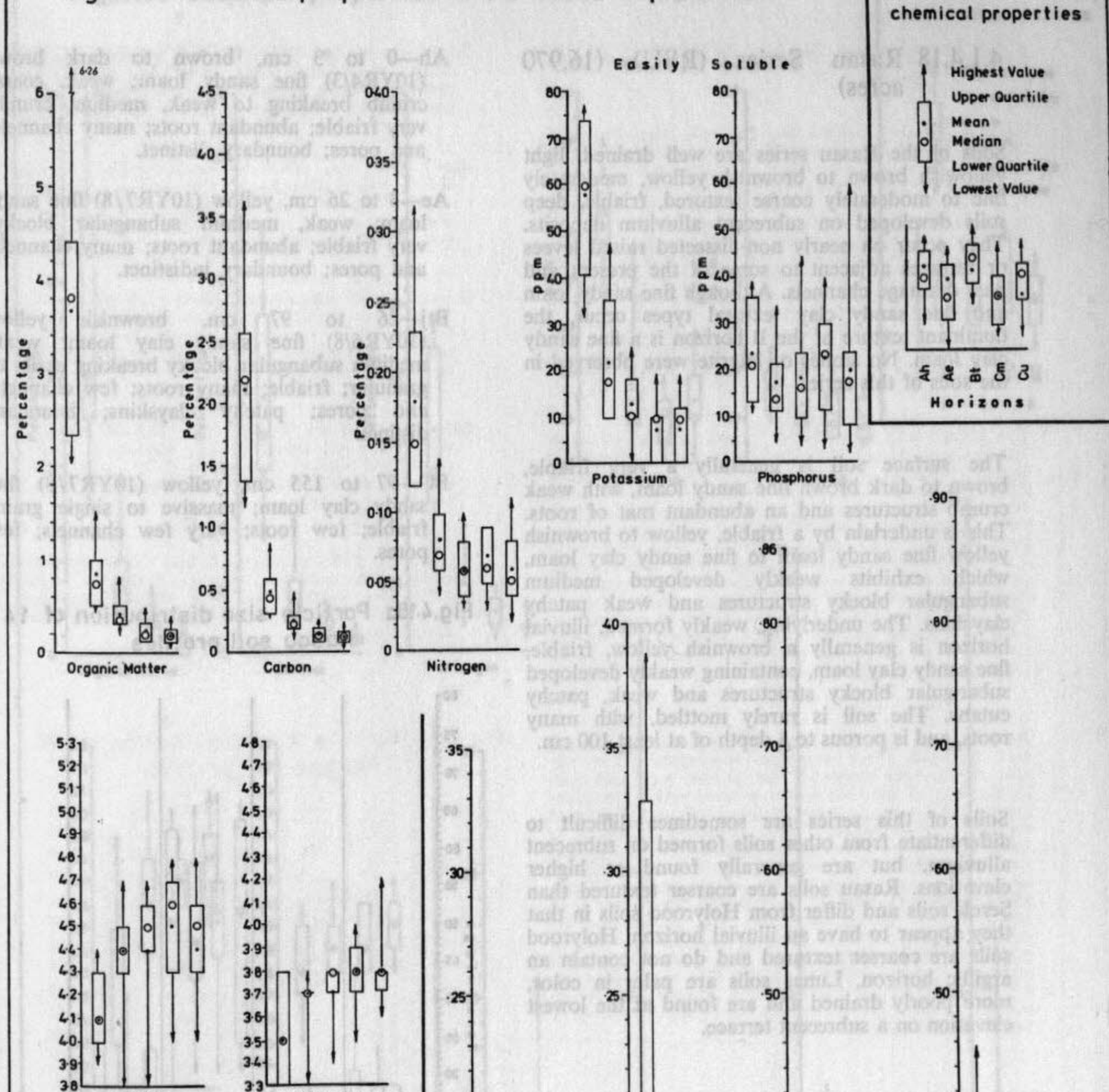


Fig. 4.17b Chemical properties of 17 Pohoi soil profiles



### 4.1.4.18 Rasau Series (RSU) (16,970 acres)

Soils of the Rasau series are well drained, light yellowish brown to brownish yellow, moderately fine to moderately coarse textured, friable, deep soils developed on subrecent alluvium deposits. They occur on nearly non-dissected raised levees or terraces adjacent to some of the present and past drainage channels. Although fine sandy loam and fine sandy clay textural types occur, the dominant texture of the B horizon is a fine sandy clay loam. No stones or laterite were observed in the soils of this series.

The surface soil is generally a very friable, brown to dark brown fine sandy loam, with weak crumb structures and an abundant mat of roots. This is underlain by a friable, yellow to brownish yellow fine sandy loam to fine sandy clay loam, which exhibits weakly developed medium subangular blocky structures and weak patchy clayskins. The underlying, weakly formed, illuvial horizon is generally a brownish yellow, friable, fine sandy clay loam, containing weakly developed subangular blocky structures and weak, patchy cutans. The soil is rarely mottled, with many roots, and is porous to a depth of at least 100 cm.

Soils of this series are sometimes difficult to differentiate from other soils formed on subrecent alluvium, but are generally found at higher elevations. Rasau soils are coarser textured than Serok soils and differ from Holyrood soils in that they appear to have an illuvial horizon. Holyrood soils are coarser textured and do not contain an argillic horizon. Lunas soils are paler in color, more poorly drained and are found at the lowest elevation on a subrecent terrace.

Rasau soils are found on level to undulating terrain, sometimes in association with Holyrood, Lunas, Riverine Alluvium and Local Alluvium soils. They constitute approximately 3 per cent of the soils in the area surveyed, being found mainly adjacent to the major rivers of the area as well as along present and past drainage channels of low relief. A representative description of a Rasau soil profile is as follows (Field No. S10):

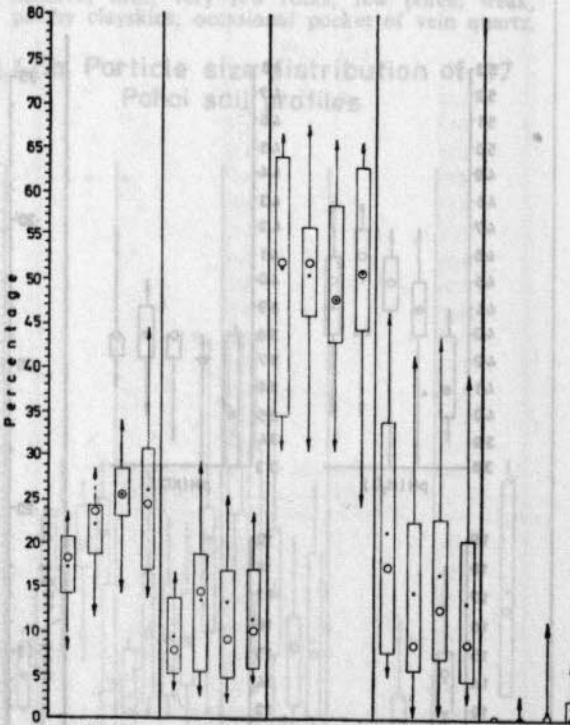
Ah—0 to 3 cm, brown to dark brown (10YR4/3) fine sandy loam; weak, coarse crumb breaking to weak, medium crumb; very friable; abundant roots; many channels; and pores; boundary distinct.

Ae—3 to 26 cm, yellow (10YR7/8) fine sandy loam; weak, medium subangular blocky; very friable; abundant roots; many channels, and pores; boundary indistinct.

Btj—26 to 97 cm, brownish yellow (10YR6/8) fine sandy clay loam; weak, medium subangular blocky breaking easily to granular; friable; many roots; few channels, and pores; patchy clayskins; boundary distinct.

BC—97 to 155 cm, yellow (10YR7/8) fine sandy clay loam; massive to single grain; friable; few roots; very few channels; few pores.

Fig.4.18a Particle size distribution of 14 Rasau soil profiles



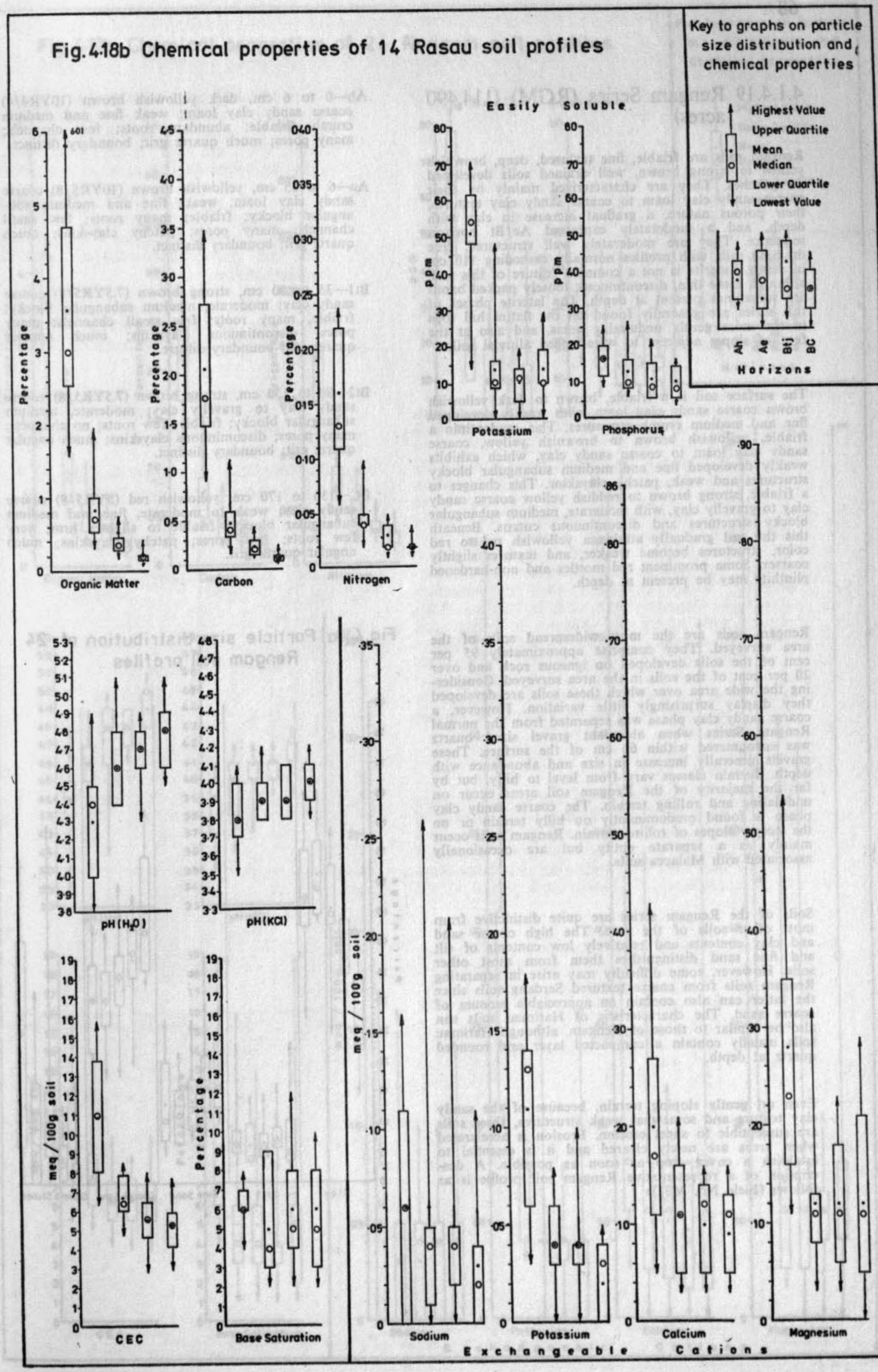



Fig. 4.18b Chemical properties of 14 Rasau soil profiles

### 4.1.4.19 Rengam Series (RGM) (114,490 acres)

Rengam soils are friable, fine textured, deep, brownish yellow to strong brown, well drained soils developed on granites. They are characterized mainly by their coarse sandy clay loam to coarse sandy clay textures, their porous nature, a gradual increase in clay with depth, and a moderately expressed Ae/Bt horizon sequence. They are moderately well structured, free draining soils with profiles normally exceeding 110 cm in depth. Laterite is not a common feature of this soil, although some thin, discontinuous, loosely packed bands are sometimes present at depth. The laterite phases of this series are generally found on the flatter hill tops in the more gently undulating areas, and also at the foot of slopes adjacent to waterlogged alluvial soils.

The surface soil is a friable, brown to dark yellowish brown coarse sandy clay loam, with weakly developed fine and medium crumb structures. This grades into a friable, yellowish brown to brownish yellow, coarse sandy clay loam to coarse sandy clay, which exhibits weakly developed fine and medium subangular blocky structures and weak, patchy clayskins. This changes to a friable, strong brown to reddish yellow coarse sandy clay to gravelly clay, with moderate, medium subangular blocky structures and discontinuous cutans. Beneath this the soil gradually attains a yellowish red to red color, structures become weaker, and textures slightly coarser. Some prominent red mottles and non-hardened plinthite may be present at depth.

Rengam soils are the most widespread soils of the area surveyed. They comprise approximately 95 per cent of the soils developed on igneous rock and over 20 per cent of the soils in the area surveyed. Considering the wide area over which these soils are developed they display surprisingly little variation. However, a coarse sandy clay phase was separated from the normal Rengam Series when abundant gravel sized quartz was encountered within 60 cm of the surface. These gravels generally increase in size and abundance with depth. Terrain classes vary from level to hilly, but by far the majority of the Rengam soil areas occur on undulating and rolling terrain. The coarse sandy clay phase is found predominantly on hilly terrain or on the steeper slopes of rolling terrain. Rengam soils occur mainly as a separate entity but are occasionally associated with Malacca soils.

Soils of the Rengam series are quite distinctive from most other soils of the area. The high coarse sand and clay contents and relatively low contents of silt and fine sand distinguishes them from most other soils. However, some difficulty may arise in separating Rengam soils from coarse textured Serdang soils since the latter can also contain an appreciable amount of coarse sand. The characteristic of Harimau soils can also be similar to those of Rengam, although Harimau soils usually contain a compacted layer and rounded quartz at depth.

Even on gently sloping terrain, because of the sandy clay texture and somewhat weak structures, these soils are susceptible to sheet erosion. Erosion is accelerated when areas are newly cleared and it is essential to establish a cover crop as soon as possible. A description of a representative Rengam soil profile is as follows (Field No. M31):

Ah—0 to 6 cm, dark yellowish brown (10YR4/4) coarse sandy clay loam; weak fine and medium crumb; friable; abundant roots; few channels; many pores; much quartz grit; boundary distinct.

Ae—6 to 35 cm, yellowish brown (10YR5/8) coarse sandy clay loam; weak; fine and medium subangular blocky; friable; many roots; few small channels; many pores; patchy clayskins; much quartz grit; boundary distinct.

Bt1—35 to 80 cm, strong brown (7.5YR5/8) coarse sandy clay; moderate, medium subangular blocky; friable; many roots; few small channels; many pores; discontinuous clayskins; much angular quartz grit; boundary diffuse.

Bt2—80 to 130 cm, strong brown (7.5YR5/8) coarse sandy clay to gravelly clay; moderate, medium subangular blocky; friable; few roots; no channels; many pores; discontinuous clayskins; much angular quartz grit; boundary distinct.

BC—130 to 170 cm, yellowish red (5YR5/8) coarse sandy clay; weak to moderate, fine and medium subangular blocky; friable to slightly firm; very few roots; few pores; patchy clayskins; much angular quartz grit.

Fig. 4.19a Particle size distribution of 24 Rengam soil profiles

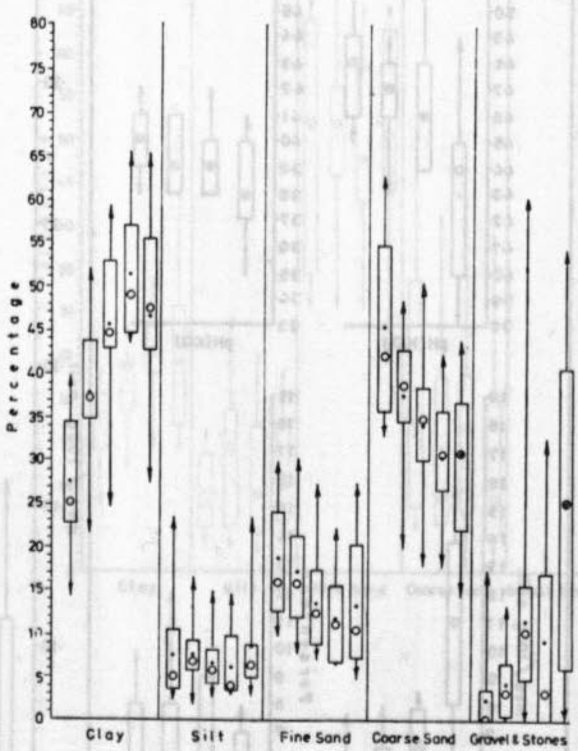
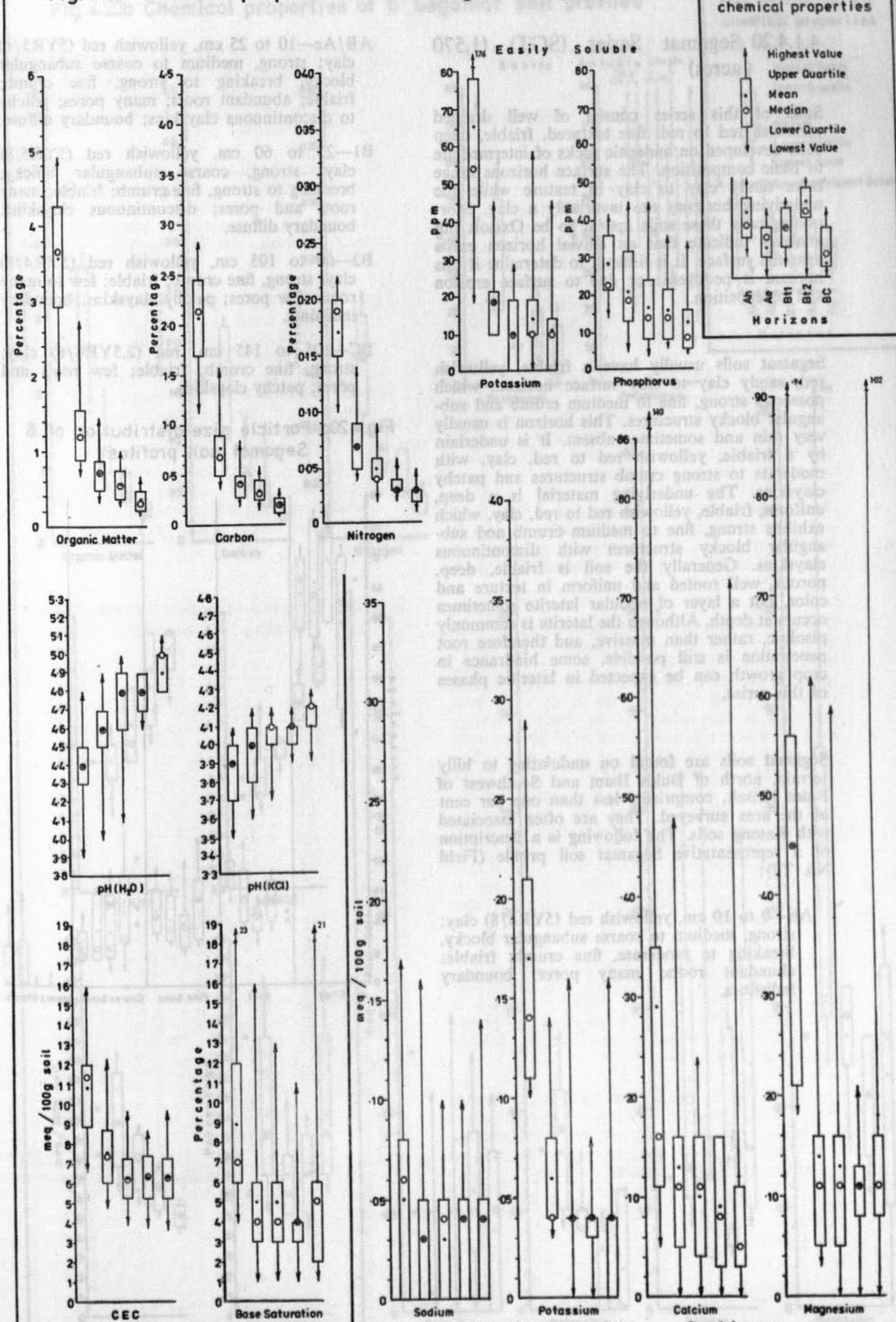


Fig. 4·19b Chemical properties of 24 Rengam soil profiles



### 4.1.4.20 Segamat Series (SGT) (1,570 acres)

Soils of this series consist of well drained yellowish red to red, fine textured, friable, deep soils developed on andesitic rocks of intermediate to basic composition. The surface horizons range from sandy clay to clay in texture while the underlying horizons are invariably a clay. Morphologically these soils appear to be Oxisols but analyses indicate that an eluvial horizon exists near the surface. It is difficult to determine if this horizon is pedogenic or due to surface erosion and redeposition.

Segamat soils usually have a friable, yellowish red, sandy clay to clay surface horizon, which possesses strong, fine to medium crumb and subangular blocky structures. This horizon is usually very thin and sometimes absent. It is underlain by a friable, yellowish red to red, clay, with moderate to strong crumb structures and patchy clayskins. The underlying material is a deep, uniform, friable, yellowish red to red, clay, which exhibits strong, fine to medium crumb and subangular blocky structures with discontinuous clayskins. Generally the soil is friable, deep, porous, well rooted and uniform in texture and color, but a layer of nodular laterite sometimes occurs at depth. Although the laterite is commonly pisolitic, rather than massive, and therefore root penetration is still possible, some hindrance in crop growth can be expected in lateritic phases of this series.

Segamat soils are found on undulating to hilly terrain, north of Bukit Ibam and Southwest of Bukit Krisek, comprising less than one per cent of the area surveyed. They are often associated with Katong soils. The following is a description of a representative Segamat soil profile (Field No. T2):

Ah—0 to 10 cm, yellowish red (5YR4/8) clay; strong, medium to coarse subangular blocky, breaking to moderate, fine crumb; friable; abundant roots; many pores; boundary indistinct.

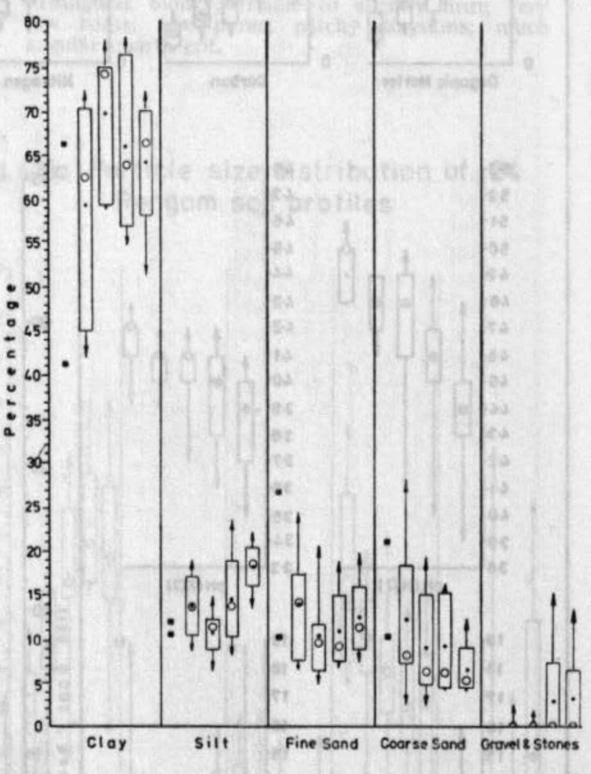
AB/Ae—10 to 25 cm, yellowish red (5YR5/6) clay; strong, medium to coarse subangular blocky, breaking to strong, fine crumb; friable; abundant roots; many pores; patchy to discontinuous clayskins; boundary diffuse.

B1—25 to 60 cm, yellowish red (5YR5/8) clay; strong, coarse subangular blocky; breaking to strong, fine crumb; friable; many roots and pores; discontinuous clayskins; boundary diffuse.

B2—60 to 105 cm, yellowish red (5YR4/8) clay; strong, fine crumb; friable; few to many roots; few pores; patchy clayskins; boundary indistinct.

BC—105 to 145 cm, red (2.5YR4/6) clay; strong, fine crumb; friable; few roots and pores; patchy clayskins.

Fig.4.20a Particle size distribution of 6 Segamat soil profiles



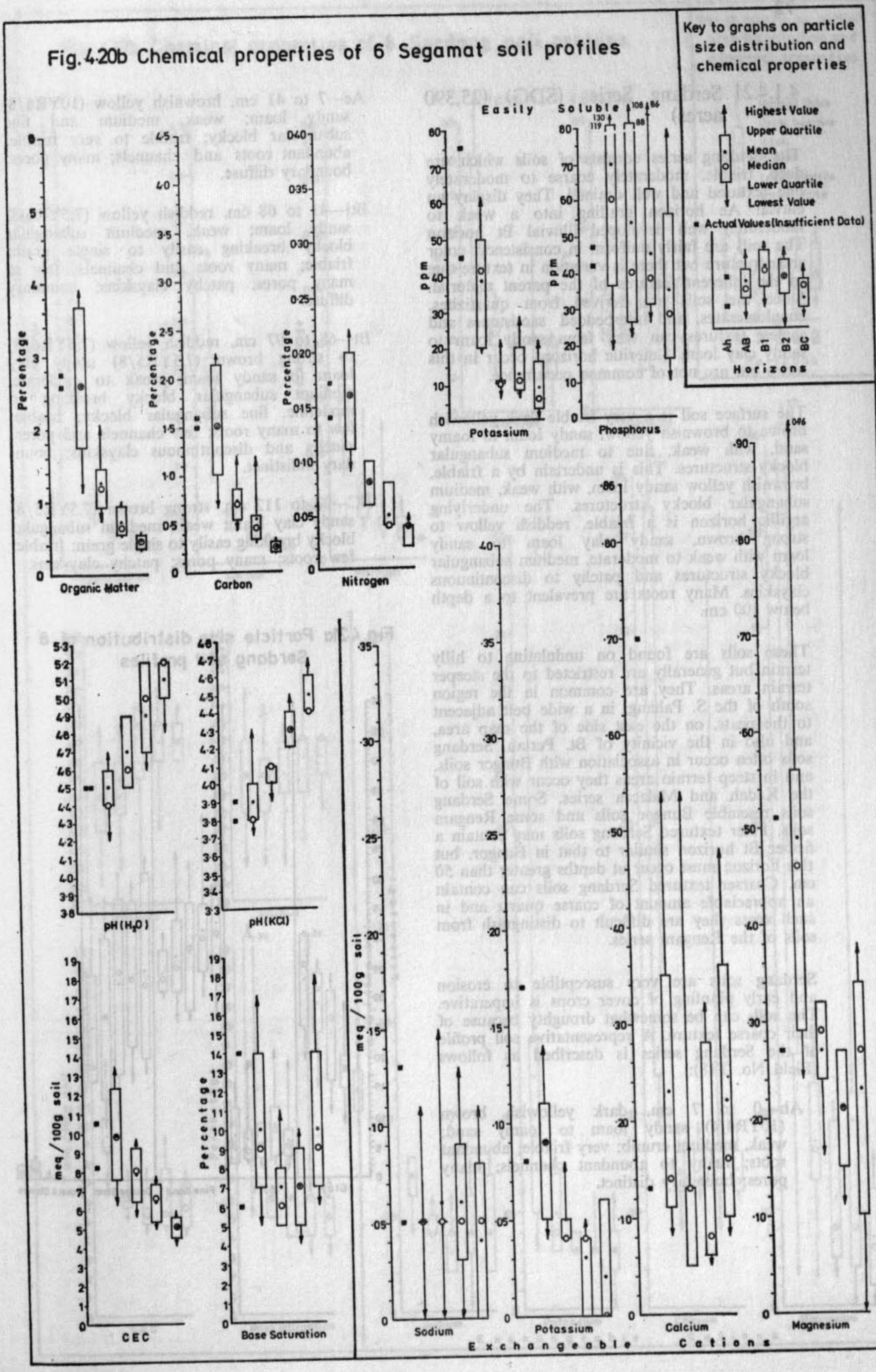



Fig. 4.20b Chemical properties of 6 Segamat soil profiles

### 4.1.4.21 Serdang Series (SDG) (25,390 acres)

The Serdang series consists of soils which are deep, friable, moderately coarse to moderately fine textured and well drained. They display an eluvial Ae horizon grading into a weak to moderately well developed illuvial Bt horizon The soils are fairly uniform in consistency, color and structure but there is variation in texture due to the inherent features of the parent material. Since the soils are derived from quartzites, conglomerates, and interbedded sandstones and shales, textures can vary from sandy loam to sandy clay loam. Lateritic horizons occur in this series but are not of common occurrence.

The surface soil is a very friable dark yellowish brown to brownish yellow, sandy loam to loamy sand, with weak, fine to medium subangular blocky structures. This is underlain by a friable, brownish yellow sandy loam, with weak, medium subangular blocky structures. The underlying argillic horizon is a friable, reddish yellow to strong brown, sandy clay loam to sandy loam with weak to moderate, medium subangular blocky structures and patchy to discontinuous clayskins. Many roots are prevalent to a depth below 100 cm.

These soils are found on undulating to hilly terrain but generally are restricted to the steeper terrain areas. They are common in the region south of the S. Pahang, in a wide belt adjacent to the peats, on the east side of the map area, and also in the vicinity of Bt. Perlah. Serdang soils often occur in association with Bungor soils, and in steep terrain areas they occur with soil of the Kedah and Malacca series. Some Serdang soils resemble Bungor soils and some Rengam soils. Finer textured Serdang soils may contain a firmer Bt horizon similar to that in Bungor, but this horizon must occur at depths greater than 50 cm. Coarser textured Serdang soils can contain an appreciable amount of coarse quartz and in such cases they are difficult to distinguish from soils of the Rengam series.

Serdang soils are very susceptible to erosion and early planting of cover crops is imperative. The soils can be somewhat droughty because of their coarse texture. A representative soil profile of the Serdang series is described as follows (Field No. T18):

Ah—0 to 7 cm, dark yellowish brown (10YR4/4) sandy loam to loamy sand; weak, medium crumb; very friable; abundant roots; many to abundant channels; many pores; boundary distinct.

Ae—7 to 41 cm, brownish yellow (10YR6/8) sandy loam; weak, medium and fine subangular blocky; friable to very friable; abundant roots and channels; many pores; boundary diffuse.

Btj—41 to 68 cm, reddish yellow (7.5YR6/8) sandy loam; weak, medium subangular blocky breaking easily to single grain; friable; many roots and channels; few to many pores; patchy clayskins; boundary diffuse.

Bt—68 to 97 cm, reddish yellow (7.5YR6/8) to strong brown (7.5YR5/8) sandy clay loam to sandy loam; weak to moderate, medium subangular blocky breaking to moderate, fine subangular blocky; friable; few to many roots; few channels and pores; patchy and discontinuous clayskins; boundary indistinct.

BC—97 to 112 cm, strong brown (7.5YR5/8) sandy clay loam; weak, medium subangular blocky breaking easily to single grain; friable; few roots; many pores; patchy clayskins.

Fig.4.21a Particle size distribution of 8 Serdang soil profiles

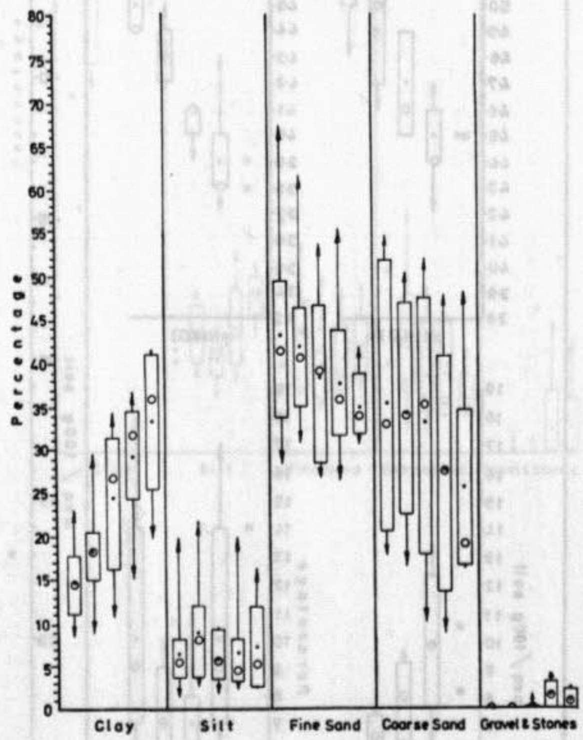
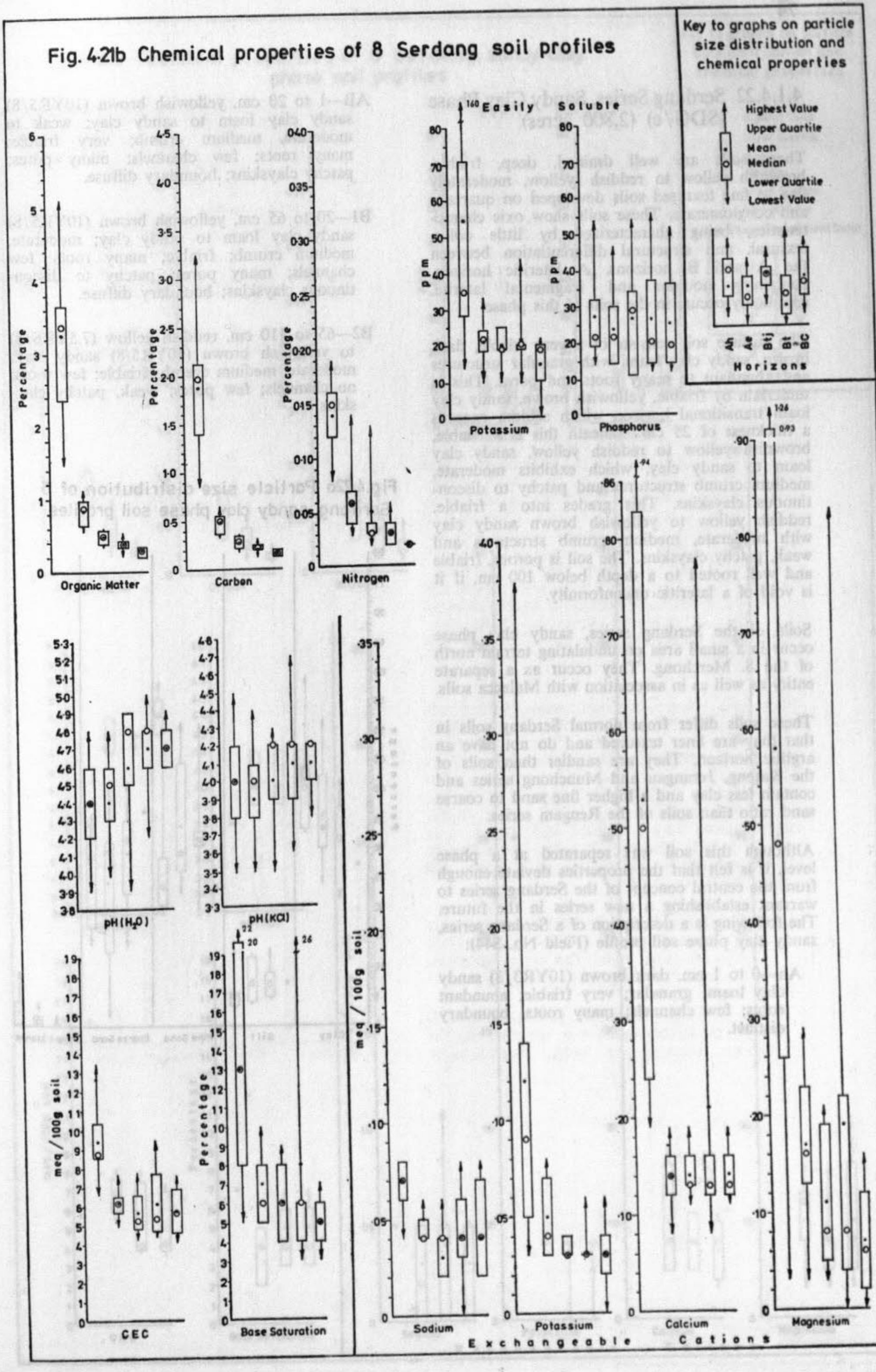


Fig. 4·21b Chemical properties of 8 Serdang soil profiles



### 4.1.4.22 Serdang Series, Sandy Clay Phase (SDG/c) (2,800 acres)

These soils are well drained, deep, friable, brownish yellow to reddish yellow, moderately fine to fine textured soils developed on quartzite and conglomerate. These soils show oxic characteristics, being characterized by little color, textural, and structural differentiation between the A and B horizons. A lateritic horizon, containing nodular and fragmental laterite, commonly occurs in the soils of this phase.

The surface soil consists of a very friable, dark brown, sandy clay loam, with granular structures and abundant to many roots and pores. This is underlain by friable, yellowish brown, sandy clay loam transitional horizon which seldom exceeds a thickness of 25 cm. Beneath this is a friable, brownish yellow to reddish yellow, sandy clay loam to sandy clay, which exhibits moderate, medium crumb structures and patchy to discontinuous clayskins. This grades into a friable, reddish yellow to yellowish brown sandy clay with moderate, medium crumb structures and weak, patchy clayskins. The soil is porous, friable and well rooted to a depth below 100 cm, if it is void of a lateritic unconformity.

Soils of the Serdang series, sandy clay phase occur in a small area on undulating terrain north of the S. Merchong. They occur as a separate entity as well as in association with Malacca soils.

These soils differ from normal Serdang soils in that thay are finer textured and do not have an argillic horizon. They are sandier than soils of the Katong, Jerangau and Munchong series and contain less clay and a higher fine sand to coarse sand ratio than soils of the Rengam series.

Although this soil was separated at a phase level, it is felt that the properties deviate enough from the central concept of the Serdang series to warrant establishing a new series in the future. The following is a description of a Serdang series, sandy clay phase soil profile (Field No. S44):

Ah—0 to 1 cm, dark brown (10YR3/3) sandy clay loam; granular; very friable; abundant roots; few channels; many roots; boundary distinct.

AB—1 to 20 cm, yellowish brown (10YR5/8) sandy clay loam to sandy clay; weak to moderate, medium crumb; very friable; many roots; few channels; many pores; patchy clayskins; boundary diffuse.

B1—20 to 65 cm, yellowish brown (10YR5/8) sandy clay loam to sandy clay; moderate, medium crumb; friable; many roots; few channels; many pores; patchy to discontinuous clayskins; boundary diffuse.

B2—65 to 110 cm, reddish yellow (7.5YR6/8) to yellowish brown (10YR5/8) sandy clay; moderate, medium crumb; friable; few roots; no channels; few pores; weak, patchy clayskins.

Fig.4.22a Particle size distribution of 6 Serdang, sandy clay phase soil profiles

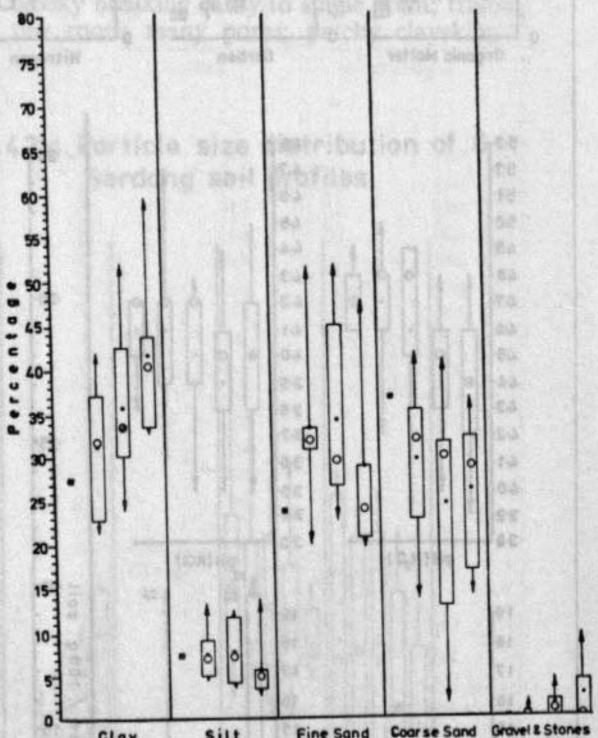
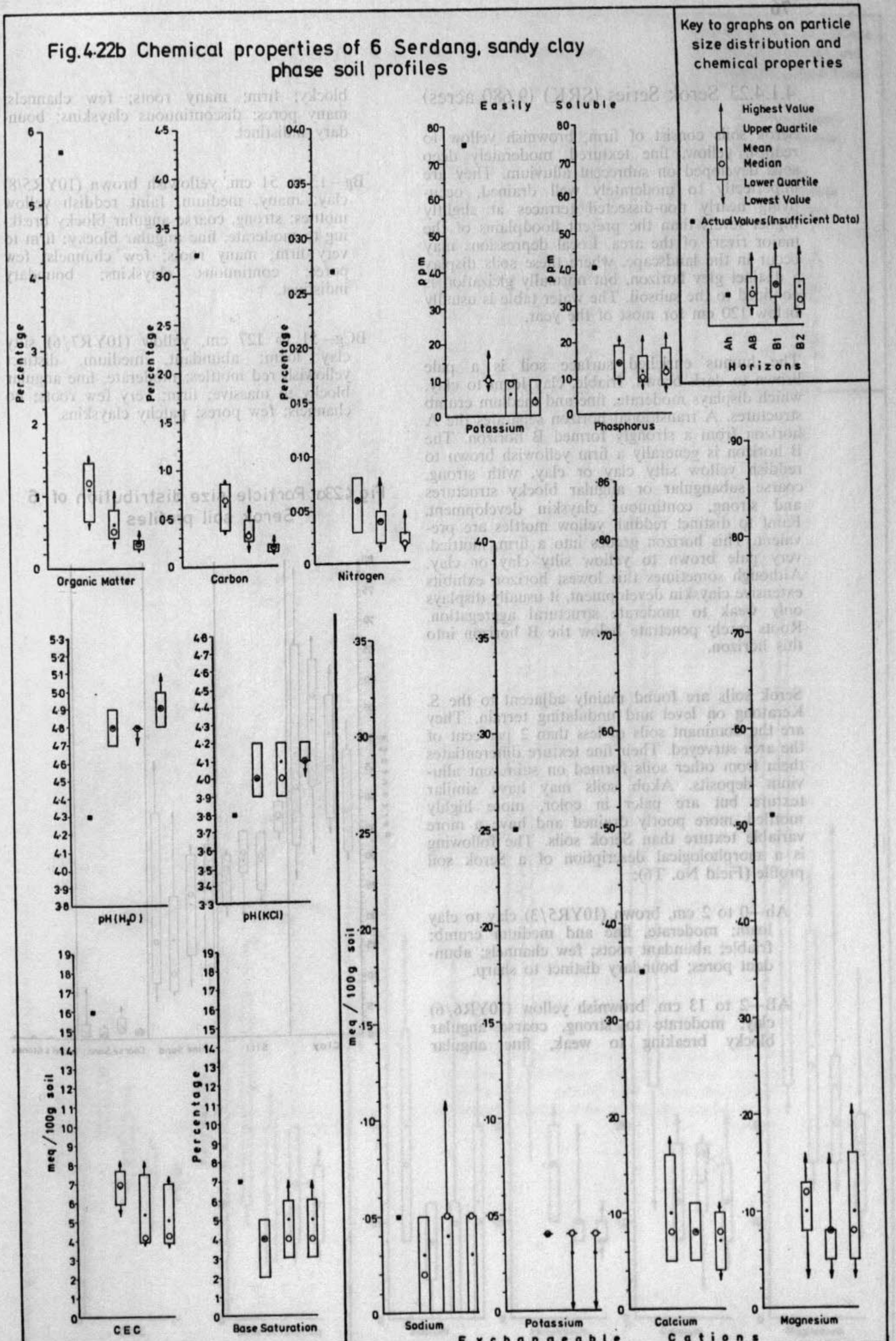


Fig.4.22b Chemical properties of 6 Serdang, sandy clay phase soil profiles



### 4.1.4.23 Serok Series (SRK) (9,680 acres)

Serok soils consist of firm, brownish yellow to reddish yellow, fine textured, moderately deep soils developed on subrecent alluvium. They are imperfectly to moderately well drained, occupying nearly non-dissected terraces at slightly higher levels than the present floodplains of the major rivers of the area. Local depressions may occur in the landscape, where these soils display a distinct gley horizon, but normally gleization is confined to the subsoil. The water table is usually below 120 cm for most of the year.

The humus enriched surface soil is a pale brown to dark brown, friable, clay loam to clay, which displays moderate, fine and medium crumb structures. A transitional horizon separates the A horizon from a strongly formed B horizon. The B horizon is generally a firm yellowish brown to reddish yellow silty clay or clay, with strong, coarse subangular or angular blocky structures and strong, continuous clayskin development. Faint to distinct reddish yellow mottles are prevalent. This horizon grades into a firm, mottled, very pale brown to yellow silty clay or clay. Although sometimes this lowest horizon exhibits extensive clayskin development, it usually displays only weak to moderate structural aggregation. Roots rarely penetrate below the B horizon into this horizon.

Serok soils are found mainly adjacent to the S. Keratong on level and undulating terrain. They are the dominant soils of less than 2 per cent of the area surveyed. Their fine texture differentiates them from other soils formed on subrecent alluvium deposits. Akob soils may have similar texture but are paler in color, more highly mottled, more poorly drained and have a more variable texture than Serok soils. The following is a morphological description of a Serok soil profile (Field No. T6):

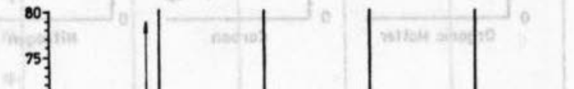
Ah—0 to 2 cm, brown (10YR5/3) clay to clay loam; moderate, fine and medium crumb; friable; abundant roots; few channels; abundant pores; boundary distinct to sharp.

AB—2 to 13 cm, brownish yellow (10YR6/6) clay; moderate to strong, coarse angular blocky breaking to weak, fine angular blocky; firm; many roots; few channels; many pores; discontinuous clayskins; boundary indistinct.

Bg—13 to 51 cm, yellowish brown (10YR5/8) clay; many, medium, faint reddish yellow mottles; strong, coarse angular blocky breaking to moderate, fine angular blocky; firm to very firm; many roots; few channels; few pores; continuous clayskins; boundary indistinct.

BCg—51 to 127 cm, yellow (10YR7/6) silty clay loam; abundant, medium, distinct yellowish red mottles; moderate, fine angular blocky to massive; firm; very few roots; no channels; few pores; patchy clayskins.

Fig.4.23a Particle size distribution of 6 Serok soil profiles



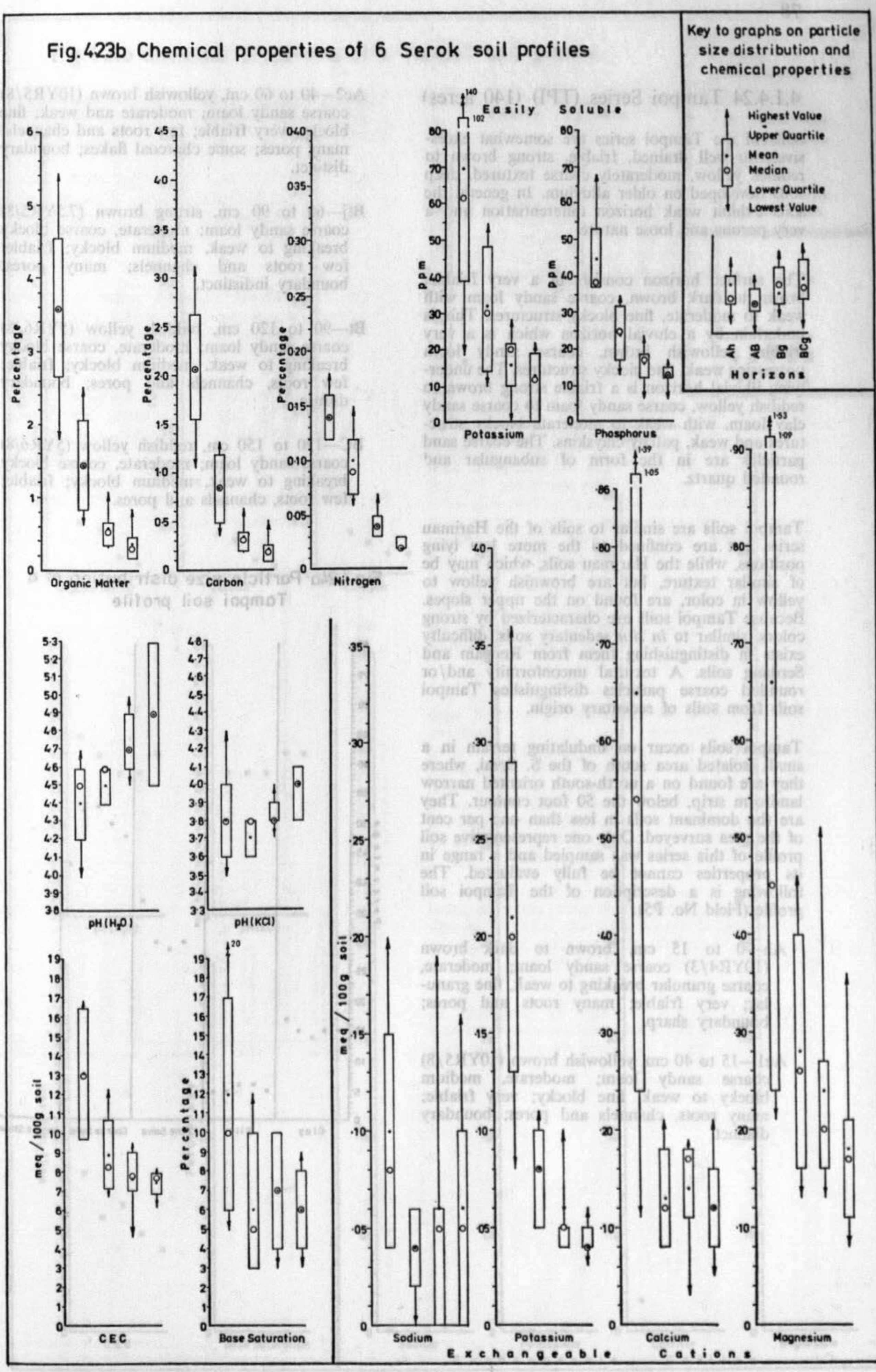



Fig.423b Chemical properties of 6 Serok soil profiles

## 4.1.4.24 Tampoi Series (TPI) (140 acres)

Soils of the Tampoi series are somewhat excessively to well drained, friable, strong brown to reddish yellow, moderately coarse textured, deep soils developed on older alluvium. In general the soils exhibit weak horizon differentiation and a very porous and loose nature.

The surface horizon consists of a very friable, brown to dark brown, coarse sandy loam with weak to moderate, fine blocky structures. This is underlain by a eluvial horizon which is a very friable, yellowish brown, coarse sandy loam possessing weak, fine blocky structures. The underlying illuvial horizon is a friable strong brown to reddish yellow, coarse sandy loam to coarse sandy clay loam, with weak to moderate blocky structures and weak, patchy clayskins. The coarse sand particles are in the form of subangular and rounded quartz.

Tampoi soils are similar to soils of the Harimau series but are confined to the more low lying positions, while the Harimau soils, which may be of similar texture, but are brownish yellow to yellow in color, are found on the upper slopes. Because Tampoi soils are characterized by strong colors, similar to *in situ* sedentary soils, difficulty exists in distinguishing them from Rengam and Serdang soils. A textural unconformity and/or rounded coarse particles distinguishes Tampoi soils from soils of sedentary origin.

Tampoi soils occur on undulating terrain in a small isolated area south of the S. Serai, where they are found on a north-south oriented narrow landform strip, below the 50 foot contour. They are the dominant soils in less than one per cent of the area surveyed. Only one representative soil profile of this series was sampled and a range in its properties cannot be fully evaluated. The following is a description of the Tampoi soil profile (Field No. P5):

Ah—0 to 15 cm, brown to dark brown (10YR4/3) coarse sandy loam; moderate, coarse granular breaking to weak, fine granular; very friable; many roots and pores; boundary sharp.

Ae1—15 to 40 cm, yellowish brown (10YR5/8) coarse sandy loam; moderate, medium blocky to weak, fine blocky; very friable; many roots, channels and pores; boundary distinct.

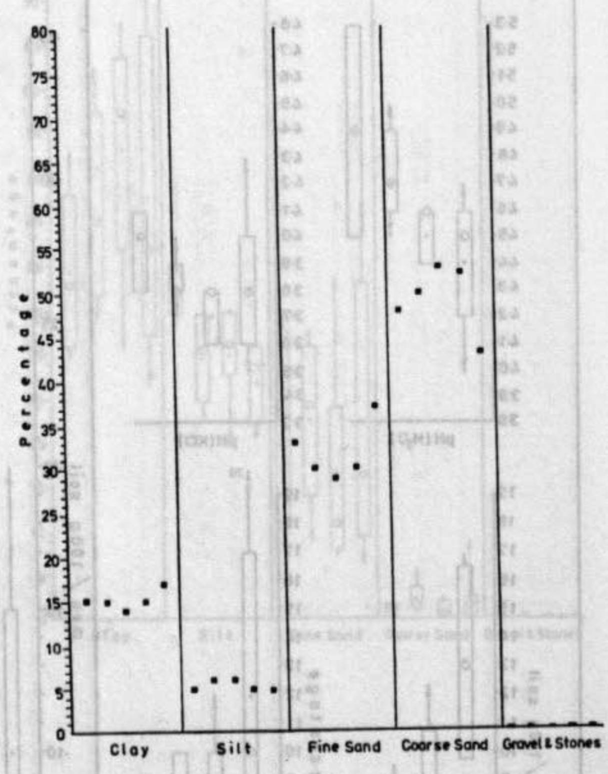
Ae2—40 to 60 cm, yellowish brown (10YR5/8) coarse sandy loam; moderate and weak; fine blocky; very friable; few roots and channels; many pores; some charcoal flakes; boundary distinct.

Btj—60 to 90 cm, strong brown (7.5YR5/8) coarse sandy loam; moderate, coarse blocky breaking to weak, medium blocky; friable; few roots and channels; many pores; boundary indistinct.

Bt—90 to 120 cm, reddish yellow (5YR6/8) coarse sandy loam; moderate, coarse blocky breaking to weak, medium blocky; friable; few roots, channels and pores; boundary diffuse.

BC—120 to 150 cm, reddish yellow (5YR6/8) coarse sandy loam; moderate, coarse blocky breaking to weak, medium blocky; friable; few roots, channels and pores.

Fig.4.24a Particle size distribution of a Tampoi soil profile



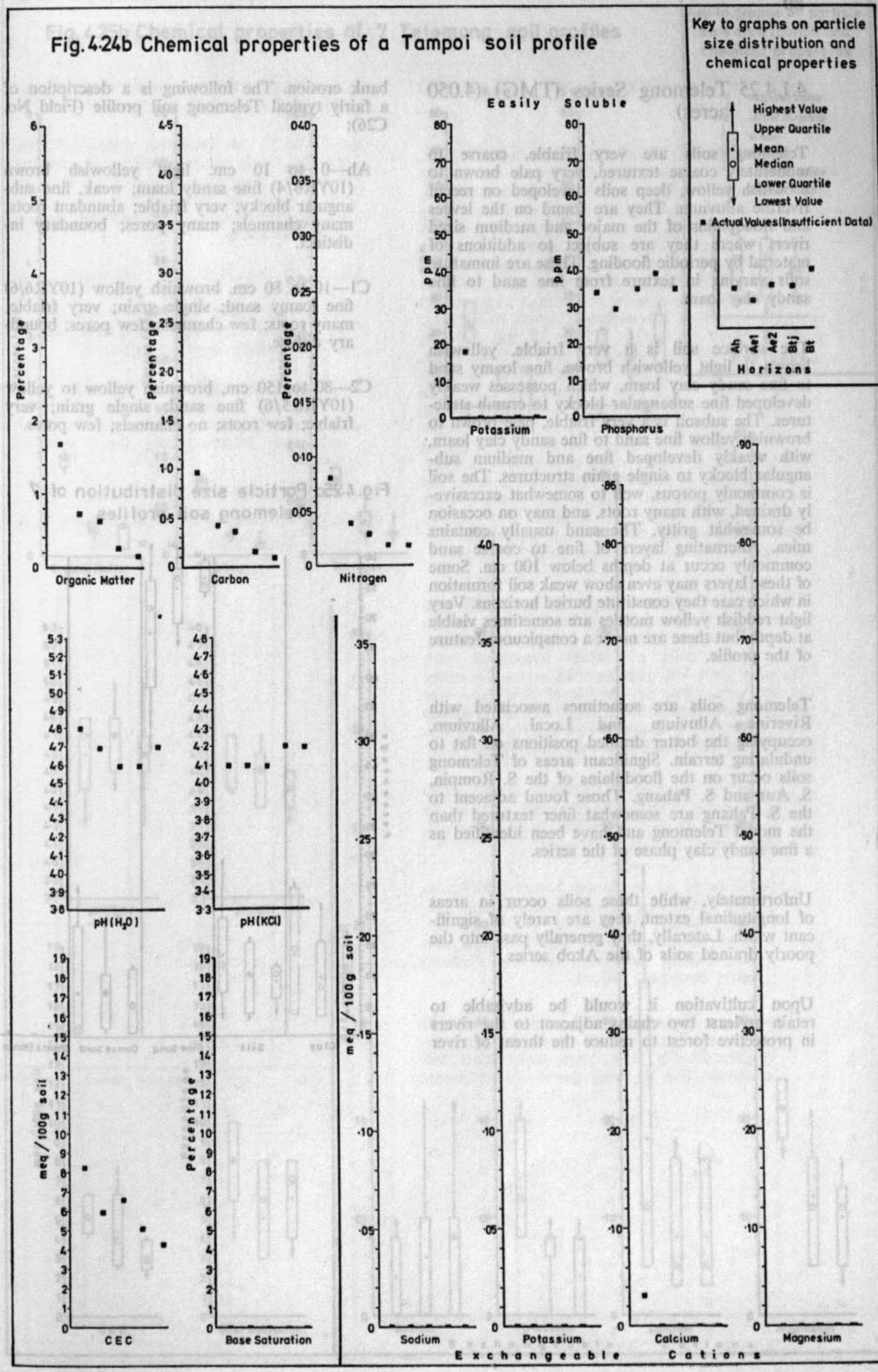



Fig. 4.24b Chemical properties of a Tampoi soil profile

### 4.1.4.25 Telemong Series (TMG) (4.050 acres)

Telemong soils are very friable, coarse to moderately coarse textured, very pale brown to brownish yellow, deep soils developed on recent riverine alluvium. They are found on the levees and floodplains of the major and medium sized rivers where they are subject to additions of material by periodic flooding. These are immature soils varying in texture from fine sand to fine sandy clay loam.

The surface soil is a very friable, yellowish brown to light yellowish brown, fine loamy sand to fine sandy clay loam, which possesses weakly developed fine subangular blocky to crumb structures. The subsoil is a very friable, pale brown to brownish yellow fine sand to fine sandy clay loam, with weakly developed fine and medium subangular blocky to single grain structures. The soil is commonly porous, well to somewhat excessively drained, with many roots, and may on occasion be somewhat gritty. The sand usually contains mica. Alternating layers of fine to coarse sand commonly occur at depths below 100 cm. Some of these layers may even show weak soil formation in which case they constitute buried horizons. Very light reddish yellow mottles are sometimes visible at depth, but these are never a conspicuous feature of the profile.

Telemong soils are sometimes associated with Riverine Alluvium and Local Alluvium, occupying the better drained positions on flat to undulating terrain. Significant areas of Telemong soils occur on the floodplains of the S. Rompin, S. Aur and S. Pahang. Those found adjacent to the S. Pahang are somewhat finer textured than the modal Telemong and have been identified as a fine sandy clay phase of the series.

Unfortunately, while these soils occur in areas of longitudinal extent, they are rarely of significant width. Laterally, they generally pass into the poorly drained soils of the Akob series

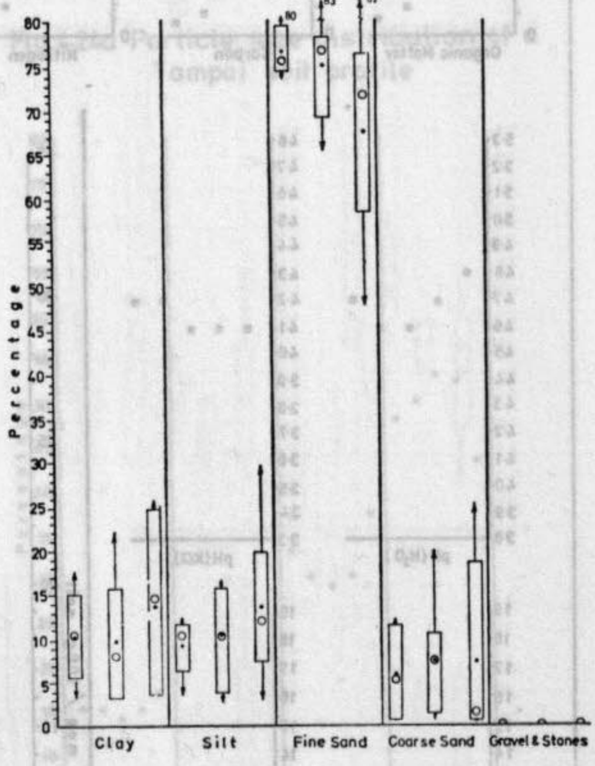
Upon cultivation it would be advisable to retain at least two chains adjacent to the rivers in protective forest to reduce the threat of river bank erosion. The following is a description of a fairly typical Telemong soil profile (Field No. C26):

Ah—0 to 10 cm, light yellowish brown (10YR6/4) fine sandy loam; weak, fine subangular blocky; very friable; abundant roots; many channels; many pores; boundary indistinct.

C1—10 to 80 cm, brownish yellow (10YR6/6) fine loamy sand; single grain; very friable; many roots; few channels; few pores; boundary diffuse.

C2—80 to 150 cm, brownish yellow to yellow (10YR6.5/6) fine sand; single grain; very friable; few roots; no channels; few pores.

Fig. 4.25a Particle size distribution of 7 Telemong soil profiles



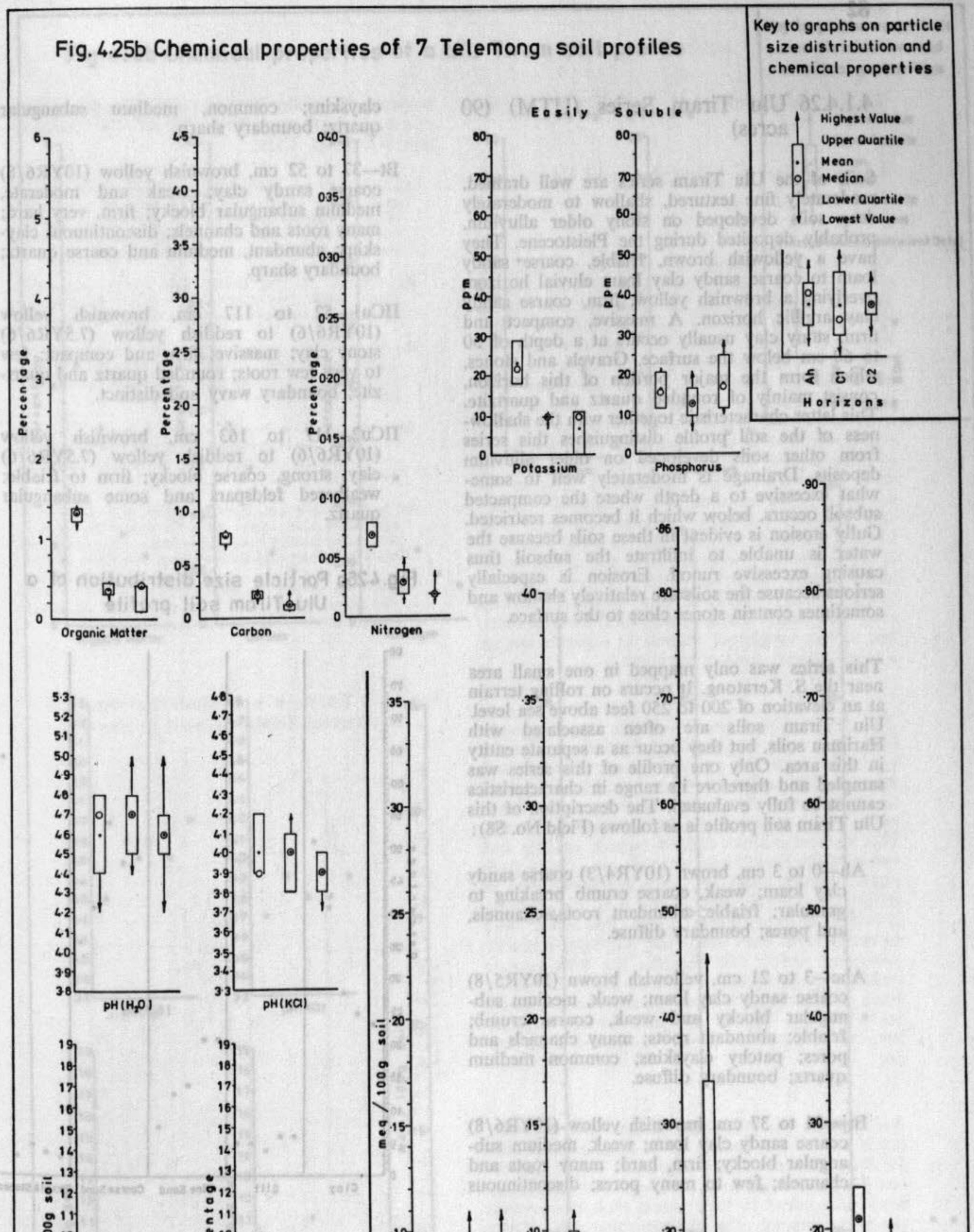



Fig. 4.25b Chemical properties of 7 Telemong soil profiles

### 4.1.4.26 Ulu Tiram Series (UTM) (90 acres)

Soils of the Ulu Tiram series are well drained, moderately fine textured, shallow to moderately deep soils developed on stony older alluvium, probably deposited during the Pleistocene. They have a yellowish brown, friable, coarse sandy loam to coarse sandy clay loam eluvial horizon, overlying a brownish yellow, firm, coarse sandy clay argillic horizon. A massive, compact and firm, stony clay usually occurs at a depth of 50 to 60 cm below the surface. Gravels and stones, which form the major portion of this horizon, consist mainly of rounded quartz and quartzite. This latter characteristic together with the shallowness of the soil profile distinguishes this series from other soils developed on older alluvium deposits. Drainage is moderately well to somewhat excessive to a depth where the compacted subsoil occurs, below which it becomes restricted. Gully erosion is evident in these soils because the water is unable to infiltrate the subsoil thus causing excessive runoff. Erosion is especially serious because the soils are relatively shallow and sometimes contain stones close to the surface.

This series was only mapped in one small area near the S. Keratong. It occurs on rolling terrain at an elevation of 200 to 250 feet above sea level. Ulu Tiram soils are often associated with Harimau soils, but they occur as a separate entity in this area. Only one profile of this series was sampled and therefore its range in characteristics cannot be fully evaluated. The description of this Ulu Tiram soil profile is as follows (Field No. S8):

Ah—0 to 3 cm, brown (10YR4/3) coarse sandy clay loam; weak, coarse crumb breaking to granular; friable; abundant roots, channels, and pores; boundary diffuse.

Ahe—3 to 21 cm, yellowish brown (10YR5/8) coarse sandy clay loam; weak, medium subangular blocky and weak, coarse crumb; friable; abundant roots; many channels and pores; patchy clayskins; common medium quartz; boundary diffuse.

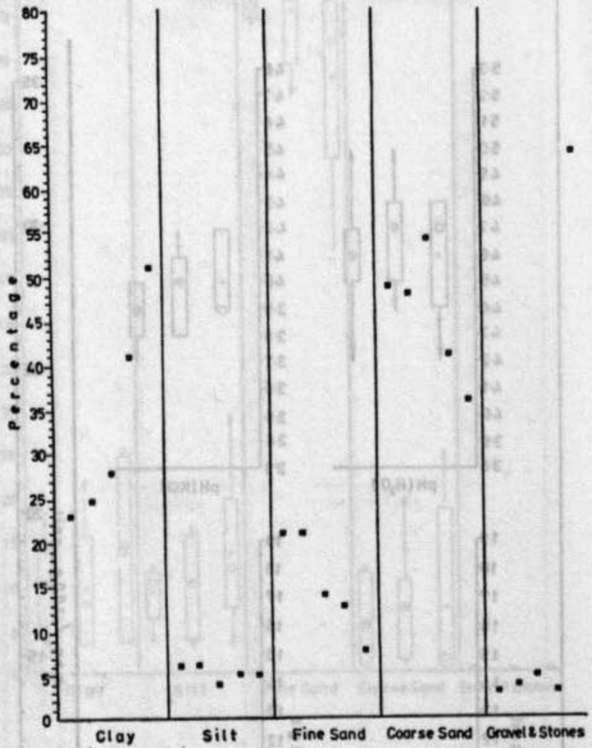
Btj—21 to 37 cm, brownish yellow (10YR6/8) coarse sandy clay loam; weak, medium subangular blocky; firm, hard; many roots and channels; few to many pores; discontinuous clayskins; common, medium subangular quartz; boundary sharp.

Bt—37 to 52 cm, brownish yellow (10YR6/8) coarse sandy clay; weak and moderate, medium subangular blocky; firm, very hard; many roots and channels; discontinuous clayskins; abundant, medium and coarse quartz; boundary sharp.

IICu1—52 to 117 cm, brownish yellow (10YR6/6) to reddish yellow (7.5YR6/6) stony clay; massive; firm and compact; few to very few roots; rounded quartz and quartzite; boundary wavy and distinct.

IICu2—117 to 163 cm, brownish yellow (10YR6/6) to reddish yellow (7.5YR6/6) clay; strong, coarse blocky; firm to friable; weathered feldspars and some subangular quartz.

**Fig. 4.26a Particle size distribution of a Ulu Tiram soil profile**



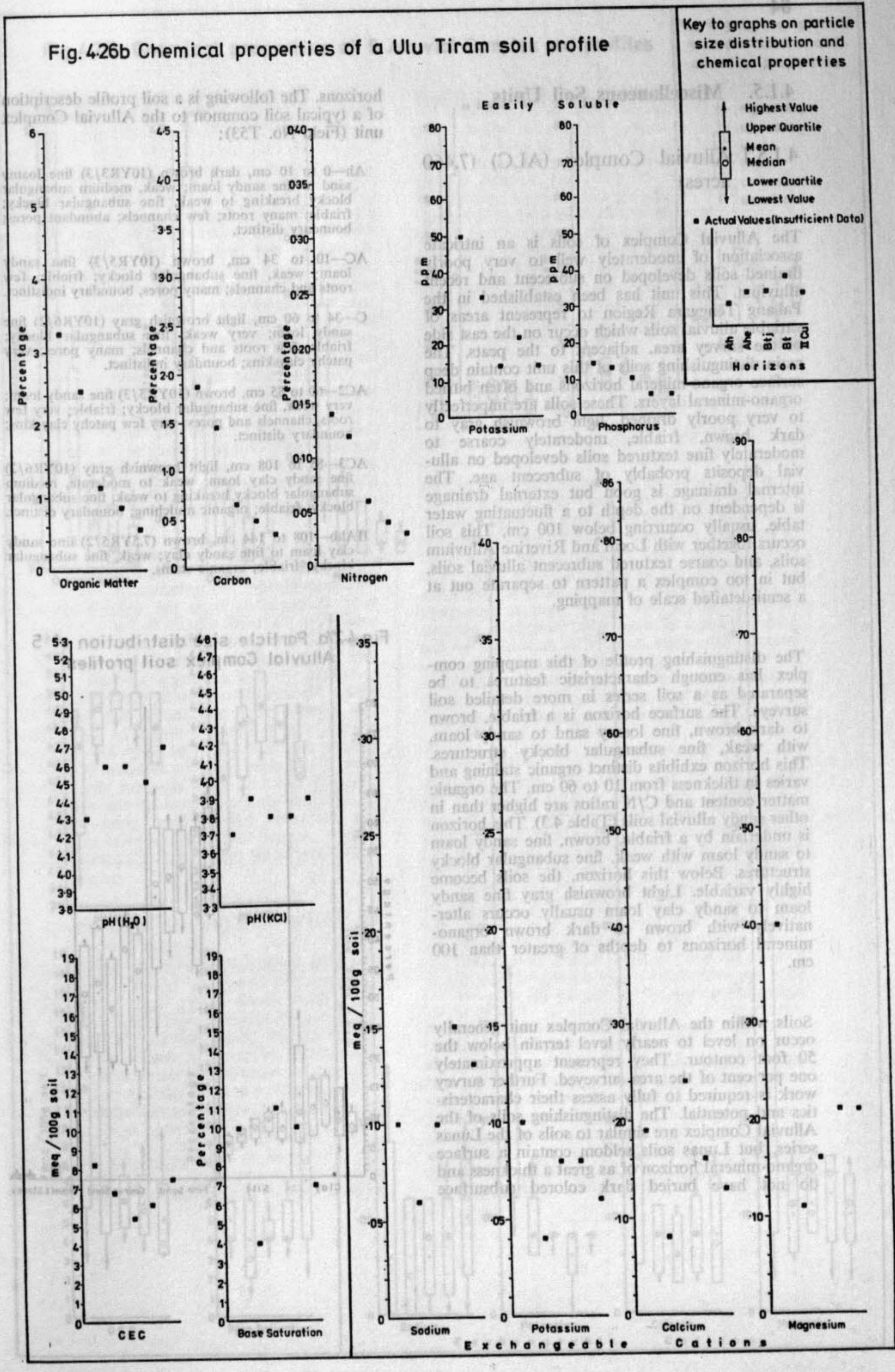



Fig. 4.26b Chemical properties of a Ulu Tiram soil profile

### 4.1.5. **Miscellaneous Soil Units**

#### 4.1.5.1 Alluvial Complex (ALC) (7,460 acres)

The Alluvial Complex of soils is an intricate association of moderately well to very poorly drained soils developed on subrecent and recent alluvium. This unit has been established in the Pahang Tenggara Region to represent areas of variable alluvial soils which occur on the east side of the survey area, adjacent to the peats. The main distinguishing soils of this unit contain deep surface organo-mineral horizons and often buried organo-mineral layers. These soils are imperfectly to very poorly drained, light brownish gray to dark brown, friable, moderately coarse to moderately fine textured soils developed on alluvial deposits probably of subrecent age. The internal drainage is good but external drainage is dependent on the depth to a fluctuating water table, usually occurring below 100 cm, This soil occurs together with Local and Riverine Alluvium soils, and coarse textured subrecent alluvial soils, but in too complex a pattern to separate out at a semi-detailed scale of mapping.

The distinguishing profile of this mapping complex has enough characteristic features to be separated as a soil series in more detailed soil surveys. The surface horizon is a friable, brown to dark brown, fine loamy sand to sandy loam, with weak, fine subangular blocky structures. This horizon exhibits distinct organic staining and varies in thickness from 10 to 60 cm. The organic matter content and C/N ratios are higher than in other sandy alluvial soils (Table 4.3). This horizon is underlain by a friable, brown, fine sandy loam to sandy loam with weak, fine subangular blocky structures. Below this horizon, the soils become highly variable. Light brownish gray fine sandy loam to sandy clay loam usually occurs alternatively with brown to dark brown organo-mineral horizons to depths of greater than 100 cm.

Soils within the Alluvial Complex unit generally occur on level to nearly level terrain below the 50 foot contour. They represent approximately one per cent of the area surveyed. Further survey work is required to fully assess their characteristics and potential. The distinguishing soils of the Alluvial Complex are similar to soils of the Lunas series, but Lunas soils seldom contain a surface organo-mineral horizon of as great a thickness and do not have buried dark colored subsurface horizons. The following is a soil profile description of a typical soil common to the Alluvial Complex unit (Field No. T53):

Ah—0 to 10 cm, dark brown (10YR3/3) fine loamy sand to fine sandy loam; weak, medium subangular blocky breaking to weak, fine subangular blocky; friable; many roots; few channels; abundant pores; boundary distinct.

AC—10 to 34 cm, brown (10YR5/3) fine sandy loam; weak, fine subangular blocky; friable; few roots and channels; many pores, boundary indistinct.

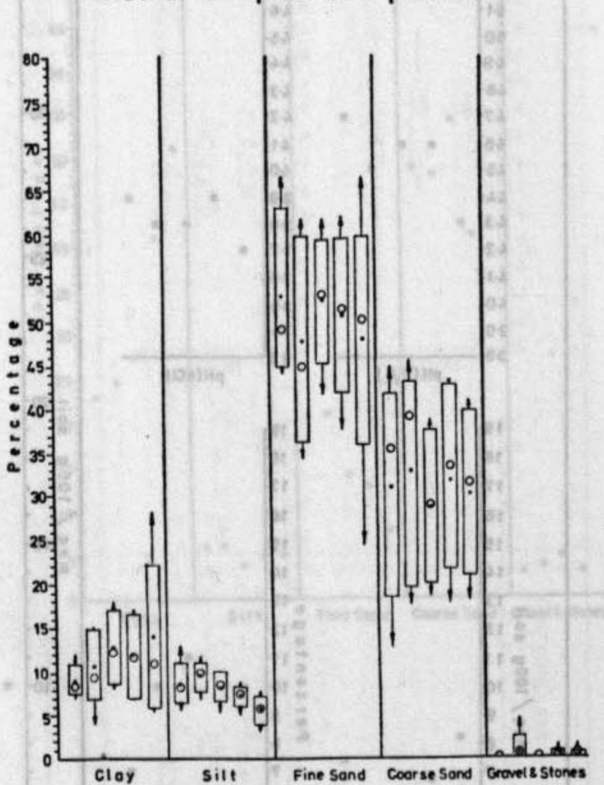
C—34 to 60 cm, light brownish gray (10YR6/2) fine sandy loam; very weak, fine subangular blocky; friable; few roots and channels; many pores; very patchy clayskins; boundary indistinct.

AC2—60 to 85 cm, brown (10YR5/3) fine sandy loam; very weak, fine subangular blocky; friable; very few roots, channels and pores; very few patchy clayskins; boundary distinct.

AC3—85 to 108 cm, light brownish gray (10YR6/2) fine sandy clay loam; weak to moderate, medium subangular blocky breaking to weak, fine subangular blocky; friable; organic mulching; boundary distinct.

IIAhb—108 to 144 cm, brown (7.5YR5/2) fine sandy clay loam to fine sandy clay; weak, fine subangular blocky; friable; organic stains.

**Fig.4.27a Particle size distribution of 5 Alluvial Complex soil profiles**



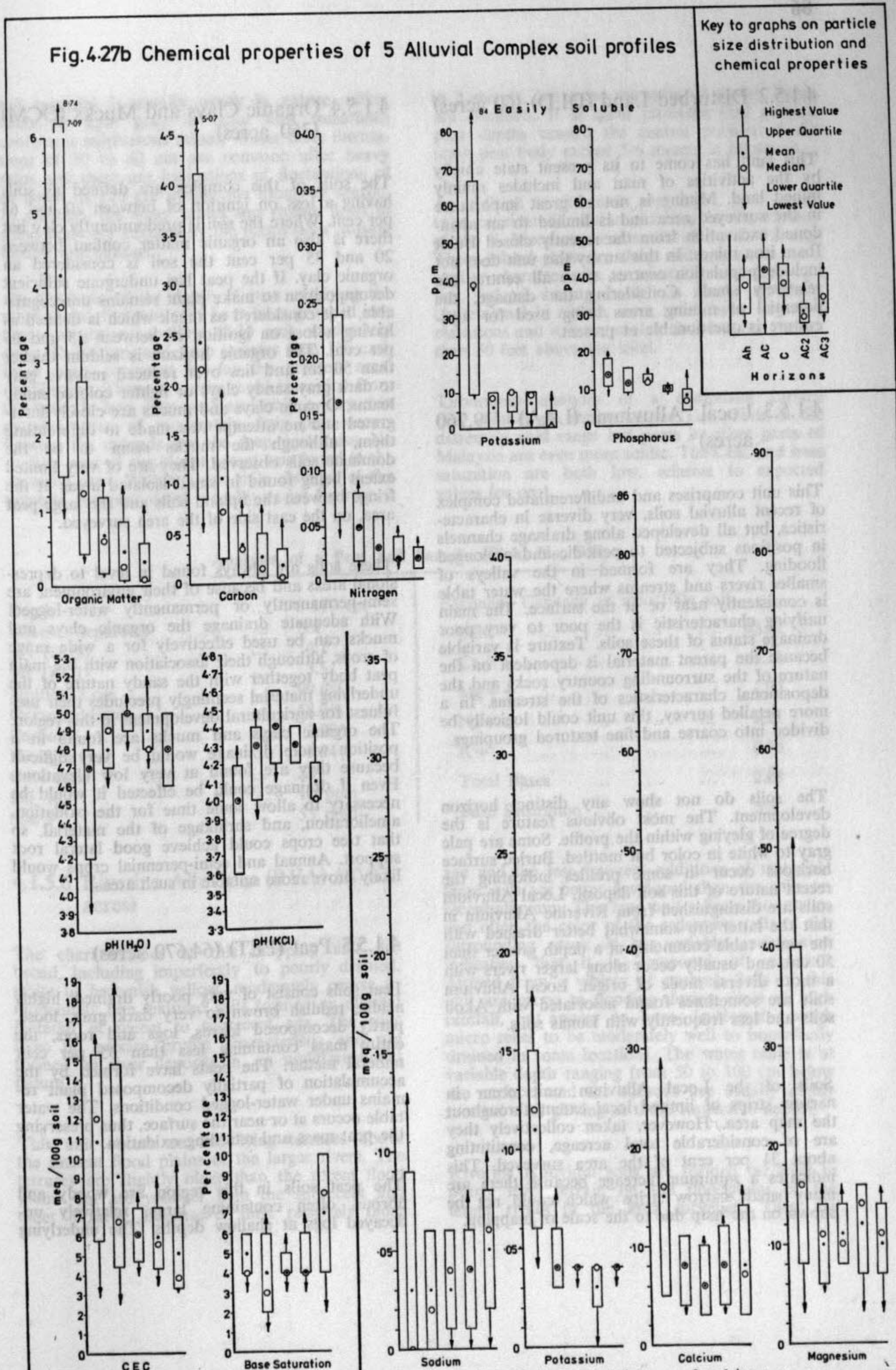


Fig.4·27b Chemical properties of 5 Alluvial Complex soil profiles

### 4.1.5.2 Disturbed Land (DLD) (60 acres)

This land has come to its present state chiefly by the activities of man and includes mainly mined land. Mining is not of great importance in the surveyed area and is limited to an abandoned excavation from the recently closed Bukit Ibam iron mines. In this survey this unit does not include population centres, since all centres are relatively small. Considering the damage, the potential of mining areas being used for agriculture is questionable at present.

### 4.1.5.3 Local Alluvium (LAA) (19,760 acres)

This unit comprises and undifferentiated complex of recent alluvial soils, very diverse in characteristics, but all developed along drainage channels in positions subjected to periodic and prolonged flooding. They are formed in the valleys of smaller rivers and streams where the water table is consistently near or at the surface. The main unifying characteristic is the poor to very poor drainage status of these soils. Texture is variable because the parent material is dependent on the nature of the surrounding country rocks and the depositional characteristics of the streams. In a more detailed survey, this unit could logically be divided into coarse and fine textured groupings.

The soils do not show any distinct horizon development. The most obvious feature is the degree of gleying within the profile. Some are pale gray to white in color but mottled. Buried surface horizons occur in some profiles indicating the recent nature of this soil deposit. Local Alluvium soils are distinguished from Riverine Alluvium in that the latter are somewhat better drained with the water table commonly at a depth greater than 50 cm, and usually occur along larger rivers with a more diverse mode of origin. Local Alluvium soils are sometimes found associated with Akob soils and less frequently with Lunas soils.

Soils of the Local Alluvium unit occur in narrow strips of limited local extent throughout the map area. However, taken collectively they are of considerable total acreage, constituting about 3½ per cent of the area surveyed. This indicates a minimum acreage because there are many small narrow strips which could not be shown on the map due to the scale of mapping.

### 4.1.5.4 Organic Clays and Mucks (OCM) (360 acres)

The soils of this complex are defined as soils having a loss on ignition of between 20 and 65 per cent. Where the soil is predominantly clay but there is also an organic matter content between 20 and 35 per cent the soil is considered an organic clay. If the peat has undergone sufficient decomposition to make plant remains unrecognizable, it is considered as muck which is defined as having a loss on ignition of between 35 and 65 per cent. The organic horizon is seldom thicker than 50 cm and lies over reduced massive gray to dark gray sandy clays or lighter colored sandy loams. Organic clays and mucks are closely intergrated and no attempt was made to differentiate them, although the mucks seem to be the dominate soils observed. They are of very limited extent being found in small isolated areas at the fringe between the upland soils and the large peat area, on the east side of the area surveyed.

These soils are always found in level to depressional areas and because of their environment are semi-permanently or permanently water-logged. With adequate drainage the organic clays and mucks can be used effectively for a wide range of crops, although their association with the main peat body together with the sandy nature of the underlying material seemingly precludes their usefulness for agricultural development in this region. The organic clays and mucks are found in a position where drainage would be very difficult because they are found at very low elevations. Even if drainage could be effected it would be necessary to allow some time for the oxidation, amelioration, and shrinkage of the material, so that tree crops could achieve good lateral root support. Annual and semi-perennial crops would likely prove more suitable in such areas.

### 4.1.5.5 Peat (PET) (64,670 acres)

Peat soils consist of very poorly drained, highly acidic, reddish brown to very dark gray, loose, partly decomposed leaves, logs and roots, the entire mass containing less than 35 per cent mineral matter. The peats have formed by the accumulation of partially decomposed plant remains under water-logged conditions. The water table occurs at or near the surface, thus preserving the peat mass and retarding oxidation.

The peat soils in this region are woody and fibrous, often containing large, relatively undecayed logs at shallow depths. The underlying soil material is usually sandy in nature, either white or light gray in color and sometimes contains a sulphurous odour. Water table fluctuations of 30 to 60 cm are common after heavy rains and there are indications of fluctuations of as much as 120 cm during the monsoon season. In addition, the water tables and stream flows in some areas are affected by the ocean tides causing further fluctuations.

On the basis of the depth of peat overlying the mineral soil, the peat soils have been grouped into three categories: shallow (0-50 cm), moderately deep (50-100 cm) and deep (greater than 100 cm). Deep peats represent by far the greatest areal distribution. There is a very rapid transition from the uplands into deep peat and only a very thin marginal area of moderately deep peat occurs between the uplands and the deep peat areas. No shallow peat of significant extent was found in the surveyed area. Within a one mile distance of the uplands, the peat depth usually varies between 2 to 3 meters, but areas exceeding 5 meters depth are common. It is quite probable that average peat depths toward the central portion of the main peat body exceed 5-6 meters in thickness.

In addition to the main peat body, peat occurs to a considerable distance inland in the vicinity of the S. Merchong and south of the S. Pahang. These inland peats are deep and appear to have similar characteristics to coastal peats. Although the "inland swamp basin" is rarely distinctly depressional in nature, most areas have very low elevations and it is unusual to find heights greater than 50 feet above sea level.

Laboratory analyses of a composite surface peat sample are shown below. The pH is in the extremely acid range but peats in other parts of Malaysia are even more acidic. The CEC and base saturation are both low, relative to expected values for peat.

**Analyses of a Peat Soil Sample (Field No. S48)**

| | |
|---|---|
| Depth ... ... | 0-110 cm |
| Mineral Separates ... ... | Nil |
| pH ($H_2O$) ... ... | 4.1 |
| pH (KC1) ... ... ... | 3.5 |
| Ignition Loss ... ... ... | 99.6% |
| Organic Matter ... ... ... | 58.2% |
| Carbon ... ... ... | 33.78% |
| Nitrogen ... ... ... | 1.54% |
| C/N ratio ... ... ... | 22 |
| Sol. K. ... ... ... | 10 ppm |
| Sol. P. ... ... ... | 53 ppm |

| Exchange Capacity in meq/100g soil: | |
|---|---|
| CEC ... ... ... | 43.62 |
| Ca++ ... ... ... | 0.29 |
| Mg++ ... ... ... | 1.02 |
| Na+ ... ... ... | 0.21 |
| K+ ... ... ... | 0.56 |
| Total Bases ... ... ... | 2.08 |
| Base Saturation ... ... ... | 5% |

## 4.1.5.6 Riverine Alluvium (RVA) (10,070 acres)

The characteristics of this mapping unit are broad, including imperfectly to poorly drained, white to brownish yellow, moderately coarse to moderately fine textured soils formed on alluvial material of recent to subrecent age. The soils have no precise profile characteristic and are formed on river deposits in an undifferentiated nature.

This unit occurs on low lying terraces above the present flood plains of the larger rivers. The terraces are slightly older than the recent flood plains but are younger than the subrecent and older terraces. Because of their relatively older age and the less frequent additions of materials these soils are better developed than the soils on recent alluvium. This land unit reflects the texture and often the color of the sedentary soils of the surrounding areas. It has variable composition indicating that it is composed of materials derived from a variety of sources. Soils of this unit are prone to flooding during times of high rainfall, but appear to have developed enough micro relief to be moderately well to imperfectly drained in some locations. The water table is at variable depth ranging from 50 to 100 cm below the surface, and the subsoils are usually highly mottled with gleying at these respective depths.

Riverine Alluvium soils are formed on level to nearly level terrain on the floodplains of the larger rivers in the area surveyed. They are sometimes associated with soils of the Akob series but usually occur as a seperate entity. Although many of the Riverine Alluvium areas are relatively narrow and occur as narrow ribbons along the major rivers, they collectively comprise approximately 2 per cent of the area surveyed. With proper drainage and flood control, they are suited for a variety of crops.

#### 4.1.5.7 Steepland (STP) (46,970 acres)

This unit includes land which has an average slope of greater than 20°. The steepland boundary generally occurs at a height of 250 feet above sea level; however the elevation of the land is not to be confused with its steepness as there are areas which are above the 250 foot contour which exhibit undulating to rolling terrain.

Although soil units were not designated on steepland, soils are developed mainly on granites, quartzites, shales or sandstones with Kedah, Kuala Brang, Malacca, Bukit Temiang and Rengam coarse soils being the dominant soils observed. The soils are generally shallow and possess weak horizon development, however, where the parent material is granitic the profile may be still quite deep and show distinct horizonation. Many of the soil profiles are truncated and outcrops of bedrock are commonly encountered. On very steep slopes, generally greater than 35°, the wasting process is usually ahead of the rate of soil formation and the soil profiles exhibit AC horizonation.

In the steepland, soil erosion can be very severe and rapid under the influence of high and intensive rainfall, especially when such areas are exposed by intensive logging or cleared for planting. The steepland comprises greater than 8 per cent of the area surveyed and virtually all of it is under virgin forest. Every effort should be made to maintain these areas under permanent virgin or managed forests.

### 4.1.6 **Physical and Chemical Soil Properties**

Previously, use and interpretation of chemical and physical laboratory analyses for the soils in Malaysia has been limited because of the reconnaissance nature of many of the surveys and consequently the sporadic nature of soil sampling. This study carried out a fairly extensive sampling program in which sufficient soil profiles were sampled for most of the major soils to give statistically reliable results. Comprehensive explanations and interpretations are presented to make the results more useful to not only those familiar with soil science but also those interested in imroving farm management or initiating agricultural development. The results also indicate areas where more research is necessary. In addition, they have been used, where possible, in recommending the crops, crop rotations and management techniques outlined in the Agriculture Section of the main report.

#### 4.1.6.1 Comparative soil textural properties

Soil texture is important to plant growth because it affects the soil's potential to provide a suitable rooting medium and its capacity to supply adequate nutrients and water. The range of suitable soil textures is considerable for most crops, providing proper agronomic practices are adhered to. However, some crops, especially root crops, are more restricted and only grow well on a narrow range of textures. In addition, the effect of texture on management practices and crop rotational programs can be considerable.

Particle size distributions of the soils in the semi-detailed soil survey area are presented on an equivalent depth basis to allow comparisons between different soils (Table 4.3). Soil textural properties are used to a large extent in distinguishing different soil types and therefore comparison between soils is important.

In all sedentary and older alluvium derived soils except the Kemuning series, the clay content increases with depth, reflecting intense leaching and weathering, and probably downward translocation of clay minerals. Decrease in the clay content in the lowest horizon of the Kemuning soils is probably because these soils are only moderately deep, therefore the lowest horizon represents parent material where weathering is still minimal. Alluvial soils are usually at least weakly stratified, therefore clay contents are more variable, but still show some trend to increasing clay content with depth.

Igneous derived soils are clay or sandy clay in texture, especially at depth. Soils with more acidic rock parent materials usually have clay contents less than 60 per cent while soils derived

## Table 4.3—Particle Size Distribution of Soils in the Semi-Detailed Soil Survey Area

| Soil series | Depth (cm) | Clay* | Silt* | Fine sand* | Coarse sand* | Gravel and stones† |
|---|---|---|---|---|---|---|
| *Soils developed on igneous rocks:* | | | | | | |
| Jerangau (4)‡ | 0–30 | 54.5 ± 7.0 | 6.3 ± 2.9 | 14.7 ± 2.1 | 24.4 ± 3.1 | nil |
| | 30–60 | 61.1 ± 4.2 | 5.7 ± 3.3 | 11.1 ± 1.9 | 22.6 ± 5.0 | 0.4 ± 0.8 |
| | 60–100 | 62.7 ± 7.7 | 6.2 ± 3.0 | 12.2 ± 3.6 | 18.1 ± 2.2 | 0.6 ± 1.2 |
| Katong (4) | 0–30 | 48.3 ± 4.4 | 7.4 ± 3.0 | 21.4 ± 3.8 | 22.6 ± 3.4 | nil |
| | 30–60 | 56.8 ± 3.0 | 6.2 ± 2.0 | 17.6 ± 3.4 | 19.2 ± 3.6 | nil |
| | 60–100 | 59.5 ± 3.0 | 7.1 ± 3.0 | 16.6 ± 3.2 | 16.6 ± 4.8 | nil |
| Rengam (24) | 0–30 | 33.3 ± 8.6 | 8.1 ± 4.4 | 17.7 ± 6.8 | 40.5 ± 8.9 | 4.4 ± 5.5 |
| | 30–60 | 44.6 ± 8.1 | 7.0 ± 3.2 | 15.0 ± 6.4 | 34.2 ± 5.8 | 11.4 ± 11.8 |
| | 60–100 | 46.5 ± 8.4 | 7.0 ± 3.4 | 12.9 ± 5.7 | 33.4 ± 7.6 | 17.3 ± 18.3 |
| Segamat (6) | 0–30 | 58.6 ± 12.6 | 14.3 ± 3.7 | 14.4 ± 6.9 | 12.6 ± 9.5 | 0.4 ± 1.0 |
| | 30–60 | 69.9 ± 8.6 | 10.9 ± 3.0 | 10.6 ± 5.6 | 9.1 ± 6.7 | 0.4 ± 0.9 |
| | 60–100 | 68.2 ± 10.6 | 14.2 ± 5.2 | 9.8 ± 5.0 | 8.2 ± 5.6 | 3.0 ± 6.8 |
| *Soils developed on sedimentary rocks:* | | | | | | |
| Bungor (34) | 0–30 | 28.2 ± 7.0 | 12.8 ± 10.3 | 40.9 ± 11.4 | 18.6 ± 13.2 | 0.1 ± 0.4 |
| | 30–60 | 36.9 ± 7.0 | 12.8 ± 9.4 | 34.3 ± 9.4 | 16.9 ± 10.9 | 0.6 ± 1.8 |
| | 60–100 | 43.0 ± 7.0 | 11.9 ± 8.3 | 29.6 ± 8.8 | 15.7 ± 9.6 | 0.7 ± 1.7 |
| Durian (12) | 0–30 | 33.5 ± 9.2 | 26.1 ± 11.8 | 30.2 ± 12.6 | 12.0 ± 6.8 | 0.1 ± 0.2 |
| | 30–60 | 49.2 ± 9.8 | 21.2 ± 7.7 | 21.6 ± 10.1 | 9.5 ± 5.1 | 1.4 ± 1.5 |
| | 60–100 | 52.7 ± 11.2 | 20.5 ± 6.6 | 18.0 ± 8.0 | 9.7 ± 5.4 | 18.6 ± 22.4 |
| Jempol (6) | 0–30 | 26.0 ± 6.8 | 21.6 ± 6.9 | 34.7 ± 15.9 | 20.0 ± 9.6 | 0.2 ± 0.5 |
| | 30–60 | 32.8 ± 4.8 | 19.3 ± 6.2 | 29.6 ± 13.9 | 19.7 ± 10.6 | 1.8 ± 2.6 |
| | 60–100 | 46.0 ± 5.9 | 16.3 ± 4.8 | 24.4 ± 12.0 | 12.3  6.0 | 10.9 ± 10.4 |
| Jeram (4) | 0–30 | 38.1 ± 3.0 | 28.4 ± 8.4 | 28.6 ± 9.3 | 8.5 ± 3.9 | nil |
| | 30–60 | 43.7 ± 4.6 | 26.6 ± 7.4 | 24.2 ± 12.0 | 7.8 ± 3.2 | nil |
| | 60–100 | 50.4 ± 6.8 | 24.2 ± 8.1 | 20.6 ± 11.0 | 6.4 ± 3.1 | nil |
| Kedah (5) | 0–30 | 20.4 ± 4.7 | 14.2 ± 7.1 | 48.4 ± 7.3 | 18.4 ± 9.2 | 0.2 ± 0.5 |
| | 30–60 | 26.4 ± 4.4 | 14.5 ± 6.9 | 44.8 ± 5.9 | 16.4  6.6 | 0.1 ± 0.1 |
| | 60–100 | 29.4 ± 7.1 | 12.8 ± 5.5 | 40.1 ± 8.9 | 19.3 ± 6.6 | 54.2 ± 12.8 |
| Serdang (8) | 0–30 | 16.6 ± 5.5 | 7.5 ± 5.9 | 42.7 ± 11.1 | 34.6 ± 14.1 | nil |
| | 30–60 | 25.8 ± 9.3 | 7.6 ± 5.7 | 37.6 ± 9.2 | 30.6 ± 17.8 | 0.2 ± 0.6 |
| | 60–100 | 28.7 ± 9.2 | 7.2 ± 5.8 | 38.3 ± 9.4 | 27.2 ± 14.6 | 1.2 ± 1.7 |
| Serdang (sandy clay phase) (6) | 0–30 | 31.0 ± 8.0 | 7.4 ± 3.4 | 32.8 ± 10.4 | 29.3 ± 9.9 | 0.6 ± 1.3 |
| | 30–60 | 34.4 ± 8.1 | 8.0 ± 3.9 | 32.7 ± 11.1 | 23.7 ± 14.2 | 1.7 ± 2.7 |
| | 60–100 | 38.9 ± 9.8 | 6.6 ± 4.4 | 31.2 ± 12.0 | 26.3 ± 9.0 | 3.0 ± 4.9 |
| *Soils developed on metamorphosed sedimentary rocks:* | | | | | | |
| Kemuning (4) | 0–30 | 28.7 ± 7.6 | 19.6 ± 5.7 | 38.7 ± 5.2 | 13.5 ± 3.7 | 0.2 ± 0.4 |
| | 30–60 | 34.9 ± 6.5 | 19.0 ± 5.3 | 33.7 ± 4.2 | 13.3 ± 3.5 | nil |
| | 60–100 | 30.8 ± 3.6 | 24.4 ± 12.2 | 35.2 ± 10.0 | 10.7 ± 10.1 | 33.1 ± 22.5 |
| Marang (13) | 0–30 | 23.3 ± 5.1 | 16.1 ± 6.3 | 46.2 ± 8.9 | 15.2 ± 7.8 | 0.1 ± 0.2 |
| | 30–60 | 29.1 ± 6.5 | 15.7 ± 6.0 | 40.9 ± 11.8 | 18.4 ± 15.6 | 1.5 ± 2.2 |
| | 60–100 | 32.2 ± 8.6 | 16.2 ± 5.8 | 34.8 ± 10.5 | 16.7 ± 8.3 | 18.9 ± 23.0 |
| Pohoi (17) | 0–30 | 27.3 ± 5.4 | 27.4 ± 8.5 | 39.2 ± 11.7 | 7.2 ± 4.2 | nil |
| | 30–60 | 35.8 ± 5.8 | 26.7 ± 7.1 | 32.1 ± 10.6 | 6.9 ± 4.2 | 3.1 ± 11.3 |
| | 60–100 | 37.4 ± 6.1 | 29.6 ± 10.1 | 27.9 ± 9.4 | 7.8 ± 7.8 | 8.4 ± 12.9 |

* Expressed as a percentage of oven-dry mineral weight of the < 2mm fraction ± standard deviation.

† Expressed as a percentage of the total sample weight ± standard deviation.

‡ Number of profiles analysed.

**Table 4.3—Particle Size Distribution of Soils in the Semi-Detailed Soil Survey Area—(*cont.*)**

| Soil series | Depth (cm) | Clay* | Silt* | Fine sand* | Coarse sand* | Gravel and stones† |
|---|---|---|---|---|---|---|
| *Soils developed on older alluvium:* | | | | | | |
| Harimau (8) | 0–30 | 18.4 ± 4.3 | 6.1 ± 2.2 | 27.0 ± 4.1 | 51.2 ± 5.9 | 4.7 ± 7.0 |
| | 30–60 | 32.3 ± 7.1 | 5.8 ± 2.9 | 21.3 ± 2.6 | 43.6 ± 6.7 | 13.6 ± 17.6 |
| | 60–100 | 39.2 ± 4.7 | 5.6 ± 2.9 | 15.9 ± 5.0 | 40.6 ± 5.5 | 18.4 ± 16.2 |
| *Soils developed on subrecent alluvium:* | | | | | | |
| Holyrood (15) | 0–30 | 12.2 ± 3.7 | 5.3 ± 2.0 | 47.3 ± 10.3 | 35.9 ± 12.9 | 0.2 ± 0.4 |
| | 30–60 | 11.6 ± 5.6 | 6.8 ± 3.4 | 49.4 ± 13.9 | 34.0 ± 12.8 | 0.5 ± 1.0 |
| | 60–100 | 11.1 ± 6.3 | 7.8 ± 4.9 | 49.8 ± 13.6 | 32.4 ± 11.4 | 0.9 ± 1.6 |
| Lunas (3) | 0–30 | 10.3 ± 3.1 | 11.8 ± 8.1 | 61.7 ± 11.6 | 17.1 ± 7.3 | nil |
| | 30–60 | 10.1 ± 5.4 | 14.3 ± 11.4 | 57.8 ± 13.6 | 19.1 ± 8.3 | nil |
| | 60–100 | 10.7 ± 7.5 | 15.9 ± 12.7 | 59.3 ± 13.9 | 16.3 ± 7.7 | nil |
| Rasau (14) | 0–30 | 19.8 ± 4.6 | 12.2 ± 7.0 | 51.1 ± 11.6 | 17.6 ± 15.2 | 0.1 ± 0.3 |
| | 30–60 | 23.6 ± 6.3 | 12.0 ± 7.2 | 49.2 ± 11.2 | 17.1 ± 14.0 | 0.4 ± 1.0 |
| | 60–100 | 25.2 ± 5.6 | 10.4 ± 7.0 | 49.8 ± 11.7 | 16.2 ± 13.7 | 1.1 ± 3.1 |
| Serok (6) | 0–30 | 46.6 ± 12.9 | 32.6 ± 6.7 | 18.8 ± 10.7 | 1.8 ± 1.9 | nil |
| | 30–60 | 51.9 ± 12.6 | 31.3 ± 6.4 | 17.4 ± 9.7 | 0.9 ± 0.8 | nil |
| | 60–100 | 49.8 ± 16.4 | 27.5 ± 5.0 | 19.9 ± 12.5 | 2.6 ± 3.3 | nil |
| *Soils developed on recent alluvium:* | | | | | | |
| Akob (12) | 0–30 | 39.5 ± 13.8 | 27.4 ± 10.7 | 28.4 ± 16.8 | 5.1 ± 6.3 | nil |
| | 30–60 | 46.2 ± 14.6 | 24.2 ± 11.8 | 26.0 ± 15.3 | 5.6 ± 9.5 | nil |
| | 60–100 | 47.9 ± 14.1 | 23.8 ± 12.3 | 23.1 ± 16.6 | 5.6 ± 8.8 | nil |
| Telemong (7) | 0–30 | 8.6 ± 5.1 | 7.7 ± 3.7 | 71.4 ± 14.1 | 13.5 ± 19.7 | nil |
| | 30–60 | 11.2 ± 6.4 | 14.4 ± 10.2 | 70.2 ± 11.7 | 6.3 ± 7.0 | nil |
| | 60–100 | 14.2 ± 9.4 | 13.6 ± 8.8 | 66.9 ± 11.2 | 7.4 ± 10.2 | nil |
| Kampong Kubor (5) | 0–30 | 12.8 ± 5.7 | 7.5 ± 4.7 | 25.8 ± 8.1 | 54.7 ± 12.3 | 3.8 ± 4.6 |
| | 30–60 | 13.4 ± 9.6 | 8.4 ± 3.1 | 24.2 ± 5.5 | 54.1 ± 13.2 | 9.1 ± 8.9 |
| | 60–100 | 14.1 ± 10.6 | 14.1 ± 9.2 | 19.5 ± 8.3 | 53.0 ± 18.6 | 7.8 ± 8.5 |
| *Soils developed on variable parent materials:* | | | | | | |
| Alluvial Complex (5) | 0–30 | 9.5 ± 2.2 | 8.1 ± 2.4 | 51.8 ± 8.5 | 31.3 ± 12.0 | nil |
| | 30–60 | 10.0 ± 4.5 | 9.4 ± 1.4 | 48.2 ± 10.9 | 32.1 ± 11.8 | 0.9 ± 2.1 |
| | 60–100 | 10.0 ± 5.8 | 7.1 ± 0.7 | 47.4 ± 11.3 | 33.6 ± 11.7 | 1.1 ± 2.0 |
| Malacca Complex (5) | 0–30 | 32.5 ± 9.7 | 14.2 ± 8.8 | 28.6 ± 8.0 | 25.6 ± 20.8 | 13.4 ± 18.3 |
| | 30–60 | 52.5 ± 12.9 | 10.4 ± 6.6 | 18.4 ± 6.3 | 19.9 ± 8.2 | 73.7 ± 6.0 |
| | 60–100 | 56.0 ± 11.5 | 12.1 ± 5.1 | 15.4 ± 2.7 | 16.7 ± 9.0 | 50.0 ± 30.0 |

* Expressed as a percentage of oven-dry mineral weight of the < 2mm fraction ± standard deviation.

† Expressed as a percentage of the total sample weight ‡ standard deviation.

‡ Number of profiles analysed.

from basic rock members have clay contents greater than 60 per cent. The coarsest textured igneous derived soil is the Rengam series. A distinguishing feature of the ingenous derived soils is that the ratio of coarse sand to fine sand is usually greater than 1:1. This contrasts with sedimentary and metamorphosed sedimentary derived soils which seldom have a coarse sand to fine sand ratio as great as 1:1. Soils derived from more acidic igneous rocks have a higher coarse sand to fine sand ratio than those on more basic rocks. In Rengam soils the ratio is usually greater than 2:1, an important distinguishing characteristic of this soil. Silt contents in the igneous derived soils are low compared to sedimentary derived soils.

Particle size distribution in the older alluvial soils of the Harimau series is very similar to that of Rengam soils. These soils are often difficult to distinguish from each other in the field. Particle size analysis reveals only minor textural differences. Average clay contents are lower and coarse sand contents are slightly higher in Harimau compared to Rengam but differences are not significant. Harimau soils in other parts of Malaysia are usually coarser textured than Rengam, with coarse sand to fine sand ratios greater than 3.5:1. Gravels and stones in both Harimau and Rengam soils increase with depth. Although it was expected that coarse sand would also increase with depth, average analyses indicate slight decreases in lower horizons.

Textural variations are greater in sedimentary and metamorphosed sedimentary derived soils than in igneous derived soil deposists. In the sedimentary soils, field identification is sometimes difficult between Serdang—Bungor and Bungor—Durian soils. The particle size analyses indicate that the ranges in textures between Serdang and Bungor can overlap but Serdang is considerably coarser textured, especially in the surface horizons, and will usually contain a much higher content of coarse sand. Durian soils are finer textured than Bungor soils, with clay plus silt contents of approximately 70 per cent in Durian soils. Comparing Jeram and Jempol soils, the Jeram soils are finer textured and contain higher clay plus silt contents. Differences between Serdang and Serdang, sandy clay phase soils are not as great as was expected. Average clay contents are approximately 10 per cent higher in Serdang, sandy clay phase but otherwise distributions with depth are quite similar. The relatively high contents of gravels and stones at depth in the Durian and Kedah soils are due to the lower horizons representing parent material in which laterite and possibly quartz are likely present to some degree.

The metamorphosed sedimentary rock derived soils do not show a wide range in texture in the upper horizons. However, at depth these soils usually have considerable variability, especially in gravels and stones. This variability is to be expected since the soils are usually moderately deep with variable parent material occurring at depth. Pohoi is the finest textured member, having clay plus silt contents of approximately 60 per cent or greater. The high silt content is used as one distinguishing feature in field identification of Pohoi soils.

In the soils developed on subrecent alluvium, Holyrood and Lunas have very low clay contents. Lunas soils tend to have higher silt and fine sand contents while Holyrood soils are higher in coarse sand and occasionally contain gravels. The coarse nature of these soils indicates that they may be somewhat droughty. Rasau soils haye a higher clay content, indicating a slightly better moisture holding capacity. Serok soils are fine textured, containing as much as 80 per cent clay plus silt. Since Serok soils have firm consistency, root penetration and moisture movement can be restricted.

Textural differences in the soils developed on recent alluvium are distinct. Akob soils are fine textured while Telemong and Kampong Kubor soils are coarse textured. Telemong is characterized by a very high fine sand content while Kampong Kubor soils contain a high content of coarse sand and some gravels. Kampong Kubor occurs in poorly drained positions so droughtness should not be a problem but Telemong occurs in well drained positions, therefore it may be susceptible to drought because of its low clay content.

Soils of the Alluvial Complex develop over a range of materials from subrecent to recent deposits, in both moderately well and poorly drained positions. The soils sampled for this complex occured in better drained subrecent alluvial positions, therefore the textural properties are quite similar to those of the Lunas soils.

The Malacca complex of soils has been mapped as soils containing greater than 50 per cent laterite in the form of gravels or stones within 50 cm of the surface, this layer being at least 60 cm in thickness. Analyses indicate that there is a high concentration of gravels and stones within a clay matrix below the 30 cm depth. Such a concentration of gravels, stones together with a high coarse sand content will severely restrict root penetration, water movement and nutrient-holding capacities. The gravels and stones which are present in some of the surface horizons may interfere with cultivation, especially for annual and root crops.

In general, there is a wide range of textural properties in the soils studied. This should allow for a wide range of crops since not all crops require similar physical soil conditions and moisture regimes for growth.

### 4.1.6.2 Comparative soil chemical properties.

*Soil fertility and its determination*

Soil fertility refers to the soil's potential to supply nutrients for crop growth on a sustained yield basis. The luxuriant forest growth in areas of the Pahang Tenggara Region is often interpreted as being sustained by highly fertile soils. In reality the soils are relatively infertile and the dense growth is supported by a delicate balance of nutrient recycling which has been established after centuries of growth. This section presents an evaluation of laboratory data on chemical properties in terms of potential soil fertility.

The term "sustained yield" can not be overemphasised in evaluating soil fertility. Initial high crop yields are generally obtainable in newly cleared and burned areas. This is usually taken as an indication of a high soil potential, however, subsequent croppings usually show a marked decline in yield, sometimes to the point of growth inhibition. This has been the basis for shifting cultivation practiced by the indigenous population in the area. The high initial yields are due to the release, at burning, of large quantities of nutrients which have been stored in the jungle vegetation. In addition, incorporation of ash and organic matter decreases soil acidity and can improve soil structure, making conditions more favourable for plant growth. Under poor management the benefits derived from burning are of short duration.

Soil conditions may even deteriorate to worse than those under natural conditions, with further loss of available nutrients and decrease of soil pH due to leaching and erosion losses. Thus extreme care must be exercised to maintain and improve natural soil fertility. This means strict adherence to soil conservation methods, observance of modern cropping technology, and timely applications of fertilizers and amendments. Recommended agronomic practices and amendment applications for the crops suggested in the region are outlined in the Agronomy Sections of the main report and have taken into account some of the results outlined in this section.

The soil chemical analyses which have been completed for this study give an estimate of soil pH, soil organic matter content and the availability of certain soil nutrients. These analyses are a help in evaluating the capability of a soil to provide good yields. They also aid in predicting the probability of getting a response to the application of fertilizers and other amendments. However, soil analyses alone cannot be used as an exacting science to recommend fertilizer aplication. The analyses give an estimate of "available" plant nutrient reserves but fertilizer requirements also depend on nutrient interactions, crop type and density, residual effects of amendments, past cropping and agronomic practices. Soil physical conditions, water supply, temperature and biological activity also affect fertilizer requirements. Thus, for soil tests to be fully utilized they must be calibrated with soil type, crop type and crop response to fertilizer. Eventually all data should be computerized with results of soilcrop combinations and considerations of soil water supply, biological activity, aeration and temperature being accounted for. Groundwork for this type of refined analysis must be laid down at this stage of regional development. It is with this purpose in mind that detailed soil surveys together with extensive soil tests are recommended immediately for all research sites. This type of work should be extended eventually to cover all areas developed for agriculture.

Even though the results and statistical studies presented here can only be used as general guidelines in evaluating crops and fertilizers, they are important in that they represent virgin conditions and therefore form a baseline for future work. In this way, changes in the natural soil conditions, which are inevitable as land is cultivated, can be more closely monitored.

The results are presented on an equivalent depth basis to facilitate comparison between soils. In Malaysia, chemical soil properties have been used only occasionally as diagnostic soil characteristics. This is partially a result of the reconnaissance nature of the previous surveys and partially because the soil chemical properties are all similar for most soils, reflecting exhaustive leaching of nutrients. The more intensive survey and sampling program in this study has made possible a more precise delineation of ranges in chemical properties for each soil.

*Soil pH*

The majority of the soils in Malaysia are acid to extremely acid. The most important single factor leading to the formation of acidic soils in the Pahang Tenggara Region is the high rainfall resulting in intense weathering and leaching within the soil profile. Basic cations have been leached from the soil complex and subsequently replaced by hydrogen ions with a corresponding decrease in soil pH. Other factors such as acid parent materials (granite), microbiological activity and agronomic practices can also affect the soil acidity.

For this study, soil pH has been determined using both distilled water and dilute KCl solution. In nearly all cases the pH as determined in dilute KCl is approximately half a unit lower than that determined in water (Table 4.4). Determination of pH in a KCl solution is mainly used to overcome discrepancies due to large relative changes in free salt contents within the soil, but such variations rarely occur in the soils sampled. Since pH determination in water probably more closely represents natural conditions, further discussions are based on this determination.

The soil pH values for all the soils sampled in the semi-detailed soil survey area are very uniform. The majority of the soils are very strongly acid throughout the profile (pH 4.5-5.0) with a few of the soils in the extremely acid range, especially in the upper part of the profile (pH $< 4.5$). The soils usually show a slight increase in pH with depth. In general, the soils developed on igneous materials have slightly higher pH values than those developed on other sedentary materials or older alluvium. This indicates that even the sedimentary bedrock materials are acidic in nature. Of the sedentary soils which occupy significant area, soils of the Rengam series have the highest pH values, while soils of the Pohoi series are the most acidic. Soils of the Malacca complex, also developed on sedentary materials, are extremely acid in the surface horizons with the pH rising considerably in the lower horizons. The high surface acidity is likely because Malacca soils usually occur on highs in the landscape. Soils in such positions are subject to greater leaching and therefore are usually more acid in nature than those in lower slope positions. The less acid conditions at depth are probably a result of restricted water movement and leaching due to the indurated lateritic horizon occurring in this soil.

The pH values for the alluvial soils are somewhat more variable than in the sedentary soils, probably due to varying moisture regimes. They are, however, restricted to a very narrow range in soil acidity, mostly very strongly acid.

The most important point to be stressed is that the soils are all fairly uniformly acidic and best growth in many crops cannot be obtained under such conditions. Growth is retarded because of the secondary effects which low pH has on the plant environments, not necessarily because plants are sensitive to hydrogen ion concentrations. Further research is needed on the extent to which the following secondary effects are present in each soil:

(1) shortage of calcium and magnesium;

(2) excess or even toxic amounts of aluminium, manganese and iron;

(3) unavailability of phosphorus and molybdenum, and;

(4) retardation of beneficial soil organisms such as bacteria, actinomycetes and earthworms.

The ranges in soil pH which different crops can tolerate are outlined in Appendix 8.3. Although many crops can tolerate acidic conditions, optimum pH conditions for nearly all crops will be higher than the soil pH found in the Pahang Tenggara Region. Crops may even grow quite well below the range given if other factors such as water supply and soil fertility are optimum, but it is generally felt that most crops will show significant response to liming.

The effects of liming a soil are many fold. In addition to improving the harmful secondary effects caused by low acidity, the efficiency of nutrient uptake is increased, thus increasing the efficiency of fertilizer uptake. Soil physical properties can be improved by long term liming. The increase in organic matter and replacement of aluminium by calcium on the exchange complex improves soil structure, decreases soil bulk density and increases soil permeability. Further research should investigate these aspects of lime application.

Benefits from liming are often a result of correcting aluminum toxicity. Aluminum toxicity is a result of aluminum occupying positions of permanent exchange on the clay complex. However, the clay in the soils in the Pahang Tenggara Region probably consists primarily of amorphous hydrous oxides or kaolinitic clay, both of which have a low permanent charge. Therefore aluminum toxicity should not be a major problem, but more research on the subject is needed.

**Table 4.4—pH[1] of Soils in the Semi-Detailed Soil Survey Area**

| Soil Series | 0–30 cm | 30–60 cm | 60–100 cm |
|---|---|---|---|
| *Soils developed on igneous rocks:* | | | |
| Jerangau (4)[2] | 4.6 ± 0.1 (4.0 ± 0.1) | 4.9 ± 0.3 (4.1 ± 0.2) | 4.9 ± 0.5 (4.2 ± 0.2) |
| Katong (4) | 4.5 ± 0.0 (3.9 ± 0.1) | 4.6 ± 0.1 (4.0 ± 0.0) | 4.6 ± 0.1 (4.0 ± 0.1) |
| Rengam (24) | 4.5 ± 0.2 (3.9 ± 0.1) | 4.7 ± 0.2 (4.0 ± 0.1) | 4.8 ± 0.2 (4.1 ± 0.1) |
| Segamat (6) | 4.5 ± 0.2 (3.9 ± 0.2) | 4.7 ± 0.2 (4.0 ± 0.1) | 4.9 ± 0.3 (4.2 ± 0.2) |
| *Soils developed on sedimentary rocks:* | | | |
| Bungor (34) | 4.4 ± 0.2 (3.8 ± 0.2) | 4.6 ± 0.2 (3.9 ± 0.2) | 4.6 ± 0.3 (3.9 ± 0.2) |
| Durian (12) | 4.5 ± 0.2 (3.8 ± 0.1) | 4.6 ± 0.1 (3.8 ± 0.1) | 4.8 ± 0.1 (3.9 ± 0.1) |
| Jempol (6) | 4.4 ± 0.3 (3.8 ± 0.1) | 4.6 ± 0.2 (3.9 ± 0.1) | 4.8 ± 0.2 (3.9 ± 0.1) |
| Jeram (4) | 4.5 ± 0.2 (3.8 ± 0.0) | 4.5 ± 0.2 (3.8 ± 0.1) | 4.7 ± 0.1 (3.8 ± 0.1) |
| Kedah (5) | 4.4 ± 0.2 (3.8 ± 0.1) | 4.5 ± 0.1 (3.9 ± 0.1) | 4.6 ± 0.1 (3.9 ± 0.1) |
| Serdang (8) | 4.4 ± 0.2 (4.0 ± 0.2) | 4.6 ± 0.3 (4.0 ± 0.3) | 4.7 ± 0.3 (4.0 ± 2.4) |
| Serdang/c (6) | 4.8 ± 0.1 (4.1 ± 0.1) | 4.8 ± 0.1 (4.1 ± 0.1) | 4.9 ± 0.1 (4.1 ± 0.1) |
| *Soils developed on metamorphosed sedimentary rocks:* | | | |
| Kemuning (4) | 4.6 ± 0.0 (3.8 ± 0.0) | 4.7 ± 0.1 (3.9 ± 0.0) | 4.9 ± 0.1 (4.0 ± 0.0) |
| Marang (13) | 4.5 ± 0.2 (3.8 ± 0.1) | 4.6 ± 0.2 (3.9 ± 0.1) | 4.6 ± 0.2 (3.9 ± 0.1) |
| Pohoi (17) | 4.4 ± 0.2 (3.7 ± 0.1) | 4.4 ± 0.2 (3.7 ± 0.1) | 4.5 ± 0.2 (3.8 ± 0.1) |
| *Soils developed on older alluvium:* | | | |
| Harimau (8) | 4.5 ± 0.2 (3.9 ± 0.1) | 4.5 ± 0.2 (3.9 ± 0.1) | 4.5 ± 0.2 (3.8 ± 0.1) |
| *Soils developed on subrecent alluvium:* | | | |
| Holyrood (15) | 4.5 ± 0.3 (4.0 ± 0.3) | 4.8 ± 0.2 (4.3 ± 0.3) | 4.8 ± 0.2 (4.1 ± 0.2) |
| Lunas (3) | 4.1 ± 0.5 (3.8 ± 0.3) | 4.4 ± 0.5 (4.1 ± 0.3) | 4.6 ± 0.5 (4.1 ± 0.4) |
| Rasau (14) | 4.5 ± 0.2 (3.8 ± 0.1) | 4.7 ± 0.2 (4.0 ± 0.1) | 4.7 ± 0.2 (4.0 ± 0.1) |
| Serok (6) | 4.5 ± 0.3 (3.8 ± 0.2) | 4.8 ± 0.2 (3.9 ± 0.1) | 4.9 ± 0.4 (4.0 0.2) |
| *Soils developed on recent alluvium:* | | | |
| Akob (12) | 4.4 ± 0.3 (3.8 ± 0.2) | 4.6 ± 0.2 (3.8 ± 0.2) | 4.5 ± 0.6 (3.7 ± 0.3) |
| Telemong (7) | 4.6 ± 0.3 (4.1 ± 0.2) | 4.6 ± 0.3 (3.9 ± 0.2) | 4.6 ± 0.2 (3.9 ± 0.1) |
| Kampong Kubor (5) | 4.7 ± 0.2 (4.1 ± 0.1) | 5.0 ± 0.2 (4.2 ± 0.2) | 5.0 ± 0.3 (4.2 ± 0.2) |
| *Soils developed on variable parent materials:* | | | |
| Alluvial Complex (5) | 4.6 ± 0.4 (4.0 ± 0.3) | 4.8 ± 0.2 (4.3 ± 0.2) | 4.8 ± 0.2 (4.2 ± 0.2) |
| Malacca Complex (5) | 4.3 ± 0.5 (3.7 ± 0.2) | 4.7 ± 0.5 (3.8 ± 0.2) | 4.7 ± 0.5 (3.9 ± 0.2) |

[1] Expressed as pH in distilled water ± standatd deviation. Brackets indicate pH in 0.01 N KCl ± standard deviation.

[2] Number of profiles analysed.

Besides a possible increase in plant growth due to improving soil conditions, liming may be feasible for other reasons. Plant resistance to disease is low in acid soils and can be increased by raising the soil pH. As well, liming increases the proportion of bacteria microorganisms compared to fungus therefore decreasing the incidence of root rot and other related plant infestations. In pastures where mixed plant species are necessary, the more desirable ones are often less tolerant to soil acidity. Thus more tolerant species thrive, lowering the pasture quality. Even in areas containing similar species it has been found that livestock prefer to graze the less acid areas and sometimes only reluctantly graze where the soil is less than pH 5 (Webster and Wilson, 1966). These situations can be improved by liming but further investigations are required.

Although the benefits from lime application can be considerable, it is not always advisable or economically feasible. In recommending whether or not lime should be applied and in what quantities many soil factors should be taken into account. The amount of lime depends on the cation exchange capacity, and the initial pH and final pH desired. The final pH depends on the crops type, nutrient balance and toxicities or deficiencies of minor elements at that level.

In this area clay content can be used as an indication of lime required, thus sandy soils should require less lime than finer textured soils. For example, sandy loams usually require only one half to two-thirds the amount of lime that sandy clay requires to effect the desired pH change.

Application of fertilizers which decrease soil pH also affect the liming requirements. As well, the purity and reaction rate of the liming material determine the amount of lime to be applied. Under Malaysian conditions, high leaching losses can be expected unless the proper type of lime for specific conditions is used. Timing of applications is also important in minimizing leaching losses.

In the final analysis no one set of detailed recommendations for liming can be made at this time. Requirements will be based on field trial interpretations for specific conditions, taking into account soil conditions, plant type and agronomic practices. In addition, the long term effect on soil fertility must also be observed because improperly used lime may exhaust the soil while properly applied lime can maintain fertility and productivity.

*Soil organic matter carbon and nitrogen*

The importance of soil organic matter in maintenance of soil fertility and crop productivity cannot be over-emphasised. Organic matter reduces surface runoff and erosion by reducing the impact of rain-drops, increasing surface permeability, increasing water holding capacity and binding the soil into stable aggregates. Decaying organic matter provides plant nutrients, especially nitrogen, phosphorus and sulphur, in available forms for plant growth. Humus, the final product of decomposition of organic matter has a high cation exchange capacity and can account for over one half the exchange capacity in the surface horizon of some Malaysian soils.

In general, the organic matter contents of all soils studied are low in the surface horizons, declining to very low levels at depth (Table 4.5). Organic matter contents in the surface 30 cm of the sedentary soils are only occasionally as high as 2 per cent. Soils derived from subrecent alluvium have a relatively higher organic matter content, probably reflecting low erosion losses due to the nearly flat nature of the terrain on which these soils occur.

Even though the subrecent alluviums, except for Serok, are sandy in nature, their relatively high organic matter content in the natural state indicates a good potential for maintaining or improving this level under cultivation. In soils derived from recent alluvial deposits, the organic matter is fairly high in the fine textured Akob soils but very low in the coarser textured members.

High losses or organic matter occur during and shortly after clearing, before establishment of suitable cover crops. Under such conditions intense bombardment of the soil surface by rain can quickly break down soilorgano aggregates thus permitting high erosion losses. In addition, surface temperatures increase on cleared land thus increasing oxidation and losses of organic matter. Since restoration of organic matter is very difficult under Malaysian conditions, conservation measures such as early planting of cover crops, incorporation of plant residues, and erosion control should be strictly adhered to. As well, liming and fertilization can improve the organic matter status of the soil.

Carbon and nitrogen contents and C/N ratios (Table 4.5) reflect the contents of these elements under natural conditions. The values will change considerably when the land is cleared and developed for argiculture, therefore it is sufficient only

**Table 4.5—Soil Organic Matter, Carbon and Nitrogen Contents[1] of Soils in the Semi-Detailed Soil Survey Area**

| Soil Series | Depth (cm) | Organic Matter | Carbon | Nitrogen | C/N[2] |
|---|---|---|---|---|---|
| *Soils developed on igneous rocks:* | | | | | |
| Jerangau (4[3]) .. .. .. | 0–30 | 1.60 ± 1.29 | 0.92 ± 0.76 | 0.10 ± 0.04 | 9 |
| | 30–60 | 0.96 ± 0.31 | 0.56 ± 0.18 | 0.06 ± 0.02 | 9 |
| | 60–100 | 0.78 ± 0.18 | 0.45 ± 0.10 | 0.04 ± 0.01 | 11 |
| Katong (4) .. .. .. .. | 0–30 | 1.71 ± 0.26 | 0.95 ± 0.21 | 0.09 ± 0.04 | 11 |
| | 30–60 | 1.10 ± 0.30 | 0.64 ± 0.17 | 0.06 ± 0.02 | 11 |
| | 60–100 | 0.93 ± 0.22 | 0.54 ± 0.13 | 0.05 ± 0.02 | 11 |
| Rengam (24) .. .. .. .. | 0–30 | 2.31 ± 0.93 | 1.34 ± 0.57 | 0.12 ± 0.05 | 11 |
| | 30–60 | 0.75 ± 0.29 | 0.45 ± 0.22 | 0.05 ± 0.01 | 9 |
| | 60–100 | 0.56 ± 0.23 | 0.34 ± 0.15 | 0.04 ± 0.01 | 8 |
| Segamat (6) .. .. .. .. .. | 0–30 | 2.81 ± 0.96 | 1.63 ± 0.56 | 0.16 ± 0.05 | 10 |
| | 30–60 | 1.25 ± 0.47 | 0.73 ± 0.27 | 0.08 ± 0.02 | 9 |
| | 60–100 | 0.85 ± 0.39 | 0.49 ± 0.23 | 0.06 ± 0.03 | 8 |
| *Soils developed on sedimentary rocks:* | | | | | |
| Bungor (34) .. .. .. .. | 0–30 | 1.89 ± 0.89 | 1.07 ± 0.53 | 0.10 ± 0.04 | 11 |
| | 30–60 | 0.61 ± 0.22 | 0.35 ± 0.13 | 0.04 ± 0.01 | 9 |
| | 60–100 | 0.45 ± 0.16 | 0.26 ± 0.10 | 0.04 ± 0.01 | 6 |
| Durian (12) .. .. .. .. .. | 0–30 | 2.06 ± 1.53 | 1.17 ± 0.90 | 0.10 ± 0.06 | 12 |
| | 30–60 | 0.55 ± 0.25 | 0.31 ± 0.14 | 0.05 ± 0.02 | 6 |
| | 60–100 | 0.41 ± 0.17 | 0.22 ± 0.10 | 0.14 ± 0.02 | 6 |
| Jempol (6) .. .. .. .. .. .. | 0–30 | 2.07 ± 1.34 | 1.20 ± 0.78 | 0.12 ± 0.06 | 10 |
| | 30–60 | 0.66 ± 0.39 | 0.38 ± 0.23 | 0.06 ± 0.04 | 6 |
| | 60–100 | 0.33 ± 0.12 | 0.19 ± 0.07 | 0.04 ± 0.02 | 5 |
| Jeram (4) .. .. .. .. .. .. | 0–30 | 1.60 ± 0.68 | 0.93 ± 0.40 | 0.10 ± 0.04 | 9 |
| | 30–60 | 0.84 ± 0.14 | 0.49 ± 0.08 | 0.06 ± 0.01 | 8 |
| | 60–100 | 0.56 ± 0.09 | 0.33 ± 0.05 | 0.04 ± 0.00 | 8 |
| Kedah (5) .. .. .. .. .. | 0–30 | 1.58 ± 0.89 | 0.92 ± 0.52 | 0.08 ± 0.03 | 12 |
| | 30–60 | 0.55 ± 0.10 | 0.32 ± 0.06 | 0.04 ± 0.00 | 8 |
| | 60–100 | 0.44 ± 0.11 | 0.26 ± 0.06 | 0.04 ± 0.01 | 6 |
| Serdang (8) .. .. .. .. .. .. | 0–30 | 2.18 ± 0.08 | 1.26 ± 0.47 | 0.11 ± 0.04 | 11 |
| | 30–60 | 0.53 ± 0.17 | 0.31 ± 0.10 | 0.05 ± 0.03 | 6 |
| | 60–100 | 0.40 ± 0.06 | 0.23 ± 0.04 | 0.03 ± 0.01 | 8 |
| Serdang (sandy clay phase) .. .. | 0–30 | 1.03 ± 0.37 | 0.60 ± 0.21 | 0.05 ± 0.02 | 12 |
| | 30–60 | 0.78 ± 0.41 | 0.45 ± 0.24 | 0.04 ± 0.02 | 11 |
| | 60–100 | 0.43 ± 0.21 | 0.25 ± 0.13 | 0.03 ± 0.01 | 8 |
| *Soils developed on metamorphosed sedimentary rocks:* | | | | | |
| Kemuning (4) .. .. .. .. .. | 0–30 | 1.31 ± 0.48 | 0.80 ± 0.25 | 0.09 ± 0.04 | 9 |
| | 30–60 | 0.53 ± 0.24 | 0.31 ± 0.14 | 0.05 ± 0.02 | 6 |
| | 60–100 | 0.25 ± 0.07 | 0.14 ± 0.04 | 0.06 ± 0.02 | 2 |
| Marang (13) .. .. .. .. .. | 0–30 | 1.70 ± 1.14 | 0.92 ± 0.56 | 0.10 ± 0.04 | 9 |
| | 30–60 | 0.57 ± 0.21 | 0.32 ± 0.13 | 0.06 ± 0.02 | 5 |
| | 60–100 | 0.36 ± 0.16 | 0.21 ± 0.10 | 0.05 ± 0.02 | 4 |
| Pohoi (17) .. .. .. .. .. | 0–30 | 1.39 ± 0.94 | 0.81 ± 0.54 | 0.10 ± 0.04 | 8 |
| | 30–60 | 0.41 ± 0.16 | 0.24 ± 0.09 | 0.06 ± 0.02 | 4 |
| | 60–100 | 0.25 ± 0.10 | 0.14 ± 0.06 | 0.06 ± 0.02 | 2 |
| *Soils developed on older alluvium:* | | | | | |
| Harimau (8) .. .. .. .. .. | 0–30 | 1.73 ± 1.16 | 1.01 ± 0.08 | 0.08 ± 0.05 | 13 |
| | 30–60 | 0.65 ± 0.38 | 0.34 ± 0.14 | 0.04 ± 0.01 | 8 |
| | 60–100 | 0.44 ± 0.14 | 0.25 ± 0.09 | 0.03 ± 0.00 | 8 |

**Table 4.5—Soil Organic Matter, Carbon and Nitrogen Contents[1] of Soils in the Semi-Detailed Soil Survey Area—(*cont.*)**

| Soil Series | Depth (cm) | Organic Matter | Carbon | Nitrogen | C/N[2] |
|---|---|---|---|---|---|
| *Soils developed on subrecent alluvium:* | | | | | |
| Holyrood (15)[3] | 0–30 | 2.61 ± 0.89 | 1.51 ± 0.52 | 0.12 ± 0.03 | 13 |
| | 30–60 | 0.62 ± 0.30 | 0.36 ± 0.17 | 0.03 ± 0.01 | 12 |
| | 60–100 | 0.32 ± 0.21 | 0.18 ± 0.12 | 0.02 ± 0.01 | 9 |
| Lunas (3) | 0–30 | 2.04 ± 0.60 | 1.18 ± 0.35 | 0.09 ± 0.01 | 13 |
| | 30–60 | 0.68 ± 0.19 | 0.39 ± 0.11 | 0.04 ± 0.01 | 10 |
| | 60–100 | 0.45 ± 0.35 | 0.26 ± 0.20 | 0.20 ± 0.01 | 14 |
| Rasau (14) | 0–30 | 2.58 ± 1.58 | 1.49 ± 0.92 | 0.12 ± 0.06 | 12 |
| | 30–60 | 0.59 ± 0.36 | 0.34 ± 0.21 | 0.04 ± 0.01 | 8 |
| | 60–100 | 0.32 ± 0.15 | 0.19 ± 0.09 | 0.02 ± 0.01 | 9 |
| Serok (6) | 0–30 | 2.40 ± 0.78 | 1.39 ± 0.45 | 0.12 ± 0.02 | 12 |
| | 30–60 | 0.53 ± 0.23 | 0.31 ± 0.13 | 0.04 ± 0.01 | 8 |
| | 60–100 | 0.40 ± 0.26 | 0.23 ± 0.15 | 0.02 ± 0.01 | 12 |
| *Soils developed on recent alluvium:* | | | | | |
| Akob (12) | 0–30 | 3.28 ± 2.86 | 1.91 ± 1.66 | 0.17 ± 0.13 | 11 |
| | 30–60 | 0.57 ± 0.24 | 0.33 ± 0.14 | 0.05 ± 0.03 | 7 |
| | 60–100 | 0.37 ± 0.14 | 0.22 ± 0.08 | 0.04 ± 0.02 | 6 |
| Telemong (7) | 0–30 | 0.99 ± 0.47 | 0.56 ± 0.27 | 0.06 ± 0.02 | 9 |
| | 30–60 | 0.35 ± 0.08 | 0.20 ± 0.05 | 0.03 ± 0.01 | 7 |
| | 60–100 | 0.22 ± 0.12 | 0.13 ± 0.07 | 0.02 ± 0.01 | 6 |
| Kampong Kubor (5) | 0–30 | 1.35 ± 0.46 | 0.79 ± 0.27 | 0.07 ± 0.02 | 11 |
| | 30–60 | 0.35 ± 0.23 | 0.20 ± 0.13 | 0.03 ± 0.01 | 7 |
| | 60–100 | 0.24 ± 0.11 | 0.19 ± 0.15 | 0.02 ± 0.01 | 9 |
| *Soils developed on variable parent materials:* | | | | | |
| Alluvial Complex (5) | 0–30 | 3.16 ± 1.74 | 1.83 ± 1.01 | 0.12 ± 0.06 | 15 |
| | 30–60 | 1.58 ± 1.17 | 0.92 ± 0.68 | 0.05 ± 0.03 | 18 |
| | 60–100 | 0.68 ± 0.33 | 0.42 ± 0.20 | 0.03 ± 0.02 | 14 |
| Malacca Complex (5) | 0–30 | 2.79 ± 1.75 | 1.62 ± 1.01 | 0.14 ± 0.09 | 12 |
| | 30–60 | 0.80 ± 0.25 | 0.46 ± 0.14 | 0.05 ± 0.01 | 9 |
| | 60–100 | 0.65 ± 0.22 | 0.38 ± 0.13 | 0.05 ± 0.02 | 8 |

[1] Expressed as a percentage of the oven-dry < 2mm soil ± standard deviation.
[2] Ratio of carbon to nitrogen.
[3] Number of profiles analyzed.

to note the values before opening the land. An attempt should be made to maintain or improve the levels which are established under natural conditions.

*Cation exchange capacity and exchangeable cations*

Cation exchange capacity (CEC) and percentage base saturation are the most important analyses used to determine the fertility potential of the soil. Cation exchange capacity is a measure of the soil's potential to hold cations in a form which is easily exchangeable with other cations in soil solution and consequently easily absorbed by plant roots. Absorption of positively charged cations in an exchangeable form occurs mostly on the negatively charged surfaces of clay and humus. This mechanism provides a reservoir of plant nutrients which can be readily utilized. Base saturation refers to the proportion of the cation exchange complex occupied by bases, usually nutrient cations.

The CEC of most of the soils in the region is in the moderately low range of 5-10 meq/100g soil (Table 4.6). This low CEC together with the factor that there is little or no relationship between CEC and clay content, indicates that the clays are probably either amorphorus or kaolinitic, or a mixture of the two. It is likely that they are dominantly amorphous hydrous oxides of iron and aluminum which have even a lower CEC than kaolinitic clay, however more research is needed on the nature of the clay minerals.

In igneous derived soils and alluvial soils, the CEC is highest in the surface horizons, reflecting the importance of organic matter in contributing to CEC. The sandier alluvial soils of Holyrood, Lunas, Rasau, Telemong and Kampong Kubor show very low CEC values at depth. The trend of lower exchange capacities at depth is not shown to the same extent in the sedimentary or metamorphosed sedimentary derived soils as it is in the igneous and alluvial derived soils. This may be due to a dominating influence of a higher kaolinite or muscovite mica content inherent in shale-sandstone parent materials compared to igneous or alluvial materials.

Cation exchange capacity not only indicates the soil's natural fertility but also reflects the potential for absorbing fertilizer nutrients thus minimizing leaching losses. The CEC in most soils is not so low as to seriously retard fertilizer efficiency, however investigations should be conducted to evaluate the extent to which aluminum blocks the exchange complex.

The exchangeable cations and consequently the base saturations are all very low and quite variable. Thus the soils are all of very low fertility. There do not appear to be significant differences between soils, with perhaps the metamorphosed sedimentary rock derived soils being slightly lower in base saturation. It should be noted that the base saturation determined for this study does not include possible exchangeable aluminum which may even occur in toxic quantities. However, absence of bases or the presence of undesirable bases can be changed by addition of fertilizers and lime. Changes should be monitored carefully for effective use of these amendments.

*Easily soluble potassium and phosphorus*

Total potassium and phosphorus contents are usually fairly high in soils, however the amount which is available to plants is low. The analysis for easily soluble potassium determines the exchangeable potassium plus some of the slowly available forms which are dissolved by weak acids. The slowly available form represents a reserve for replenishing available potassium. Easily soluble potassium in the soils studied is low, indicating low potassium reserves (Table 4.7). This is an end result of the high degree of weathering of the primary minerals. Easily soluble potassium contents are higher in shale derived soils, however variation is greater among such soils.

The amount of phosphorus extracted by chemical means from a soil depends to a large extent on the method used and soil type. The easily soluble contents of phosphorus in the soils studied are highly variable and there is little significant difference between soils (Table 4.7). Soils derived from basic rocks tend to have higher phosphorus contents but the values are all low and this is likely one of the first nutrients to become deficient when soils are brought into intensive cultivation. Phosphates applied to acid soils can be quickly fixed by iron and aluminium oxides, therefore water soluble forms which are more available to plants should be used. Fixation of phosphorus can be lessened by liming. In very sandy soils it might be necessary to use slowly soluble forms to prevent leaching losses.

*Micronutrients*

Micronutrient determinations were not undertaken by this study but it is recognized that soil trace element imbalances may occur in the region.

## Table 4.6—Exchangeable Cation Contents* of Soils in the Semi-Detailed Soil Survey Area

| Soil Series | Depth (cm) | C.E.C. | Ca++ | Mg++ | Na+ | K+ | Base Saturation† |
|---|---|---|---|---|---|---|---|
| *Soils developed on igneous rocks:* | | | | | | | |
| Jerangau ‡ .. .. | 0–30 | 9.16 ± 1.89 | 0.13 ± 0.07 | 0.28 ± 0.19 | 0.02 ± 0.03 | 0.07 ± 0.03 | 6 ± 3 |
| | 30–60 | 7.65 ± 0.78 | 0.10 ± 0.06 | 0.20 ± 0.06 | 0.02 ± 0.02 | 0.04 ± 0.03 | 4 ± 1 |
| | 60–100 | 6.58 ± 0.70 | 0.10 ± 0.04 | 0.15 ± 0.05 | 0.02 ± 0.03 | 0.04 ± 0.03 | 5 ± 1 |
| Katong (4) .. .. | 0–30 | 8.19 ± 0.36 | 0.11 ± 0.02 | 0.16 ± 0.08 | 0.03 ± 0.03 | 0.06 ± 0.01 | 4 ± 1 |
| | 30–60 | 7.16 ± 1.27 | 0.10 ± 0.02 | 0.16 ± 0.06 | 0.01 ± 0.02 | 0.03 ± 0.04 | 4 ± 2 |
| | 6–100 | 7.66 ± 1.30 | 0.11 ± 0.04 | 0.19 ± 0.12 | 0.01 ± 0.02 | 0.03 ± 0.04 | 5 ± 3 |
| Rengam (24) .. .. | 0–30 | 9.22 ± 2.21 | 0.19 ± 0.17 | 0.29 ± 0.22 | 0.04 ± 0.04 | 0.11 ± 0.05 | 7 ± 5 |
| | 30–60 | 6.47 ± 1.44 | 0.11 ± 0.09 | 0.15 ± 0.12 | 0.03 ± 0.03 | 0.04 ± 0.03 | 5 ± 3 |
| | 60–100 | 6.09 ± 1.39 | 0.10 ± 0.08 | 0.13 ± 0.12 | 0.04 ± 0.03 | 0.04 ± 0.03 | 5 ± 3 |
| Segamat (6) .. .. | 0–30 | 10.26 ± 2.62 | 0.38 ± 0.34 | 0.51 ± 0.25 | 0.05 ± 0.04 | 0.10 ± 0.04 | 10 ± 5 |
| | 30–60 | 7.85 ± 1.59 | 0.17 ± 0.18 | 0.27 ± 0.06 | 0.06 ± 0.05 | 0.05 ± 0.02 | 7 ± 2 |
| | 60–100 | 6.75 ± 1.31 | 0.41 ± 0.11 | 0.23 ± 0.08 | 0.06 ± 0.04 | 0.03 ± 0.02 | 7 ± 2 |
| *Soils developed on sedimentary rocks:* | | | | | | | |
| Bungor (34) .. .. | 0–30 | 9.87 ± 2.53 | 0.19 ± 0.13 | 0.30 ± 0.21 | 0.05 ± 0.05 | 0.11 ± 0.06 | 6 ± 2 |
| | 30–60 | 7.62 ± 1.90 | 0.11 ± 0.06 | 0.12 ± 0.07 | 0.04 ± 0.05 | 0.05 ± 0.02 | 4 ± 2 |
| | 60–100 | 8.17 ± 2.64 | 0.11 ± 0.06 | 0.14 ± 0.12 | 0.03 ± 0.04 | 0.05 0.02 | 4 ± 2 |
| Durian (12) .. .. | 0–30 | 9.96 ± 3.29 | 0.20 ± 0.20 | 0.36 ± 0.30 | 0.04 ± 0.05 | 0.11 ± 0.07 | 6 ± 4 |
| | 30–60 | 9.31 ± 2.68 | 0.14 ± 0.14 | 0.17 ± 0.09 | 0.03 ± 0.06 | 0.06 ± 0.05 | 4 ± 2 |
| | 60–100 | 9.99 ± 3.46 | 0.08 ± 0.06 | 0.16 ± 0.11 | 0.06 ± 0.13 | 0.05 ± 0.06 | 4 ± 2 |
| Jempol (6) .. .. | 0–30 | 10.17 ± 4.77 | 0.28 ± 0.13 | 0.25 ± 0.11 | 0.08 ± 0.06 | 0.15 ± 0.12 | 10 ± 5 |
| | 30–60 | 10.27 ± 4.54 | 0.15 ± 0.03 | 0.19 ± 0.12 | 0.07 ± 0.05 | 0.13 ± 0.15 | 7 ± 6 |
| | 60–100 | 10.51 ± 2.80 | 0.20 ± 0.05 | 0.22 ± 0.13 | 0.07 ± 0.06 | 0.14 ± 0.17 | 6 ± 4 |
| Jeram (4) .. .. | 0–30 | 9.83 ± 6.70 | 0.24 ± 0.07 | 0.86 ± 0.60 | 0.09 ± 0.06 | 0.13 ± 0.05 | 9 ± 1 |
| | 30–60 | 15.47 ±14.67 | 0.19 ± 0.05 | 0.51 ± 0.27 | 0.09 ± 0.05 | 0.07 ± 0.04 | 6 ± 3 |
| | 60–100 | 16.38 ± 4.77 | 0.13 ± 0.02 | 0.38 ± 0.24 | 0.08 ± 0.06 | 0.06 ± 0.03 | 3 ± 0 |
| *Soils developed on sedimentary rocks:* | | | | | | | |
| Kedah (5) .. .. | 0–30 | 7.77 ± 1.64 | 0.20 ± 0.09 | 0.26 ± 0.14 | 0.08 ± 0.08 | 0.07 ± 0.05 | 8 ± 2 |
| | 30–60 | 6.59 ± 0.58 | 0.18 ± 0.14 | 0.11 ± 0.07 | 0.07 ± 0.07 | 0.04 ± 0.02 | 6 ± 1 |
| | 60–100 | 6.71 ± 1.31 | 0.15 ± 0.12 | 0.09 ± 0.08 | 0.05 ± 0.04 | 0.03 ± 0.02 | 5 ± 2 |
| Serdang (8) .. .. | 0–30 | 7.81 ± 1.21 | 0.33 ± 0.14 | 0.36 ± 0.24 | 0.06 ± 0.01 | 0.08 ± 0.07 | 10 ± 4 |
| | 30–60 | 6.21 ± 1.67 | 0.15 ± 0.03 | 0.13 ± 0.09 | 0.04 ± 0.02 | 0.04 ± 0.01 | 6 ± 2 |
| | 60–100 | 6.25 ± 1.84 | 0.21 ± 0.23 | 0.18 ± 0.28 | 0.04 ± 0.02 | 0.04 ± 0.01 | 8 ± 8 |
| Serdang (Sandy clay phase) (6) .. | 0–30 | 6.58 ± 1.11 | 0.10 ± 0.05 | 0.10 ± 0.05 | 0.02 ± 0.02 | 0.04 ± 0.01 | 4 ± 2 |
| | 30–60 | 6.20 ± 2.15 | 0.09 ± 0.02 | 0.08 ± 0.04 | 0.03 ± 0.03 | 0.03 ± 0.02 | 4 ± 2 |
| | 60–100 | 5.04 ± 1.50 | 0.07 ± 0.03 | 0.08 ± 0.05 | 0.04 ± 0.04 | 0.04 ± 0.00 | 5 ± 2 |
| *Soils developed on metamorphosed sedimentary rocks:* | | | | | | | |
| Kemuning (4) .. .. | 0–30 | 8.23 ± 2.07 | 0.06 ± 0.04 | 0.14 ± 0.05 | 0.03 ± 0.03 | 0.08 ± 0.02 | 4 ± 1 |
| | 30–60 | 6.63 ± 1.67 | 0.06 ± 0.01 | 0.06 ± 0.04 | 0.04 ± 0.02 | 0.04 ± 0.00 | 3 ± 1 |
| | 60–100 | 7.70 ± 1.96 | 0.07 ± 0.03 | 0.06 ± 0.04 | 0.04 ± 0.02 | 0.04 ± 0.00 | 3 ± 1 |
| Marang (13) .. .. | 0–30 | 9.01 ± 2.29 | 0.18 ± 0.11 | 0.19 ± 0.10 | 0.03 ± 0.02 | 0.08 ± 0.04 | 5 ± 2 |
| | 30–60 | 7.30 ± 2.00 | 0.11 ± 0.05 | 0.10 ± 0.08 | 0.03 ± 0.03 | 0.06 ± 0.03 | 4 ± 1 |
| | 60–100 | 7.05 ± 2.36 | 0.11 ± 0.05 | 0.09 ± 0.11 | 0.02 ± 0.02 | 0.05 ± 0.02 | 4 ± 1 |
| Pohoi (17) .. .. | 0–30 | 9.35 ± 1.68 | 0.13 ± 0.05 | 0.15 ± 0.08 | 0.03 ± 0.02 | 0.10 ± 0.07 | 4 ± 1 |
| | 30–60 | 7.60 ± 1.83 | 0.10 ± 0.04 | 0.09 ± 0.06 | 0.02 ± 0.04 | 0.06 ± 0.03 | 4 ± 2 |
| | 60–100 | 7.10 ± 1.52 | 0.10 ± 0.04 | 0.09 ± 0.05 | 0.02 ± 0.03 | 0.05 ± 0.03 | 4 ± 1 |

* Expressed as meq/100g soil ± standard deviation.
† Expressed as percentage ± standard deviation.
‡ Number of profiles analyzed.

**Table 4.6—Exchangeable Cation Contents* of Soils in the Semi-Detailed Soil Survey Area—(*cont.*)**

| Soil Series | Depth (cm) | C.E.C. | Ca++ | Mg++ | Na+ | K+ | Base Saturation† |
|---|---|---|---|---|---|---|---|
| *Soils developed on older alluvium:* | | | | | | | |
| Harimau (8) .. .. | 0–30 | 7.13 ± 1.82 | 0.25 ± 0.09 | 0.34 ± 0.08 | 0.07 ± 0.03 | 0.07 ± 0.03 | 10 ± 2 |
| | 30–60 | 6.84 ± 0.91 | 0.24 ± 0.12 | 0.33 ± 0.34 | 0.06 ± 0.03 | 0.05 ± 0.03 | 11 ± 7 |
| | 60–100 | 7.22 ± 0.70 | 0.22 ± 0.10 | 0.35 ± 0.41 | 0.07 ± 0.04 | 0.06 ± 0.05 | 9 ± 6 |
| *Soils developed on subrecent alluvium:* | | | | | | | |
| Holyrood (15) .. .. | 0–30 | 10.10 ± 1.68 | 0.22 ± 0.08 | 0.19 ± 0.14 | 0.05 ± 0.02 | 0.08 ± 0.04 | 6 ± 2 |
| | 30–60 | 5.86 ± 1.26 | 0.14 ± 0.02 | 0.06 ± 0.04 | 0.03 ± 0.02 | 0.04 ± 0.02 | 5 ± 2 |
| | 60–100 | 4.65 ± 1.09 | 0.15 ± 0.05 | 0.07 ± 0.06 | 0.04 ± 0.01 | 0.03 ± 0.01 | 7 ± 3 |
| *Soils developed on sub-recent alluvium:* | | | | | | | |
| Lunas (3) .. .. | 0–30 | 10.87 ± 2.77 | 0.20 ± 0.04 | 0.40 ± 0.16 | 0.07 ± 0.04 | 0.05 ± 0.03 | 6 ± 1 |
| | 30–60 | 7.57 ± 4.43 | 0.14 ± 0.04 | 0.22 ± 0.23 | 0.05 ± 0.01 | 0.05 ± 0.03 | 6 ± 1 |
| | 60–100 | 5.36 ± 2.31 | 0.12 ± 0.02 | 0.19 ± 0.20 | 0.07 ± 0.04 | 0.04 ± 0.01 | 8 ± 2 |
| Rasau (14) .. .. | 0–30 | 8.71 ± 3.05 | 0.16 ± 0.11 | 0.22 ± 0.12 | 0.06 ± 0.06 | 0.09 ± 0.05 | 6 ± 2 |
| | 30–60 | 5.85 ± 1.20 | 0.10 ± 0.05 | 0.11 ± 0.06 | 0.05 ± 0.06 | 0.04 ± 0.02 | 5 ± 2 |
| | 60–100 | 5.43 ± 1.50 | 0.10 ± 0.05 | 0.14 ± 0.09 | 0.04 ± 0.03 | 0.03 ± 0.02 | 6 ± 2 |
| Serok (6) .. .. | 0–30 | 10.04 ± 3.14 | 0.33 ± 0.26 | 0.47 ± 0.31 | 0.08 ± 0.06 | 0.13 ± 0.05 | 10 ± 4 |
| | 30–60 | 7.65 ± 1.97 | 0.13 ± 0.07 | 0.19 ± 0.08 | 0.06 ± 0.07 | 0.05 ± 0.02 | 6 ± 3 |
| | 60–100 | 7.57 ± 0.43 | 0.13 ± 0.05 | 0.18 ± 0.12 | 0.06 ± 0.06 | 0.04 ± 0.01 | 6 ± 5 |
| *Soils developed on recent alluvium:* | | | | | | | |
| Akob (12) .. .. | 0–30 | 11.04 ± 4.76 | 0.26 ± 0.25 | 0.33 ± 0.27 | 0.05 ± 0.05 | 0.12 ± 0.09 | 5 ± 3 |
| | 30–60 | 7.82 ± 1.76 | 0.13 ± 0.08 | 0.16 ± 0.11 | 0.03 ± 0.03 | 0.05 ± 0.05 | 4 ± 2 |
| | 60–100 | 7.87 ± 2.52 | 0.12 ± 0.05 | 0.17 ± 0.08 | 0.03 ± 0.04 | 0.04 ± 0.03 | 4 ± 1 |
| Telemong (7) .. .. | 0–30 | 5.76 ± 1.49 | 0.15 ± 0.10 | 0.19 ± 0.03 | 0.02 ± 0.02 | 0.06 ± 0.03 | 7 ± 3 |
| | 30–60 | 3.79 ± 1.12 | 0.08 ± 0.06 | 0.10 ± 0.04 | 0.03 ± 0.04 | 0.03 ± 0.02 | 5 ± 2 |
| | 60–100 | 3.49 ± 1.06 | 0.08 ± 0.06 | 0.10 ± 0.04 | 0.04 ± 0.04 | 0.02 ± 0.02 | 6 ± 2 |
| Kampong Kubor (5) .. | 0–30 | 5.90 ± 2.68 | 0.09 ± 0.05 | 0.25 ± 0.18 | 0.03 ± 0.05 | 0.07 ± 0.03 | 9 ± 5 |
| | 30–60 | 3.66 ± 1.89 | 0.09 ± 0.12 | 0.19 ± 0.11 | 0.03 ± 0.04 | 0.04 ± 0.00 | 12 ± 8 |
| | 60–100 | 3.89 ± 1.55 | 0.26 ± 0.45 | 0.23 ± 0.20 | 0.03 ± 0.05 | 0.03 ± 0.02 | 15 ± 18 |
| *Soils developed on variable parent materials:* | | | | | | | |
| Alluvial Complex (5) .. | 0–30 | 10.27 ± 4.60 | 0.13 ± 0.07 | 0.19 ± 0.12 | 0.04 ± 0.05 | 0.10 ± 0.04 | 4 ± 1 |
| | 30–60 | 9.02 ± 6.06 | 0.08 ± 0.04 | 0.11 ± 0.04 | 0.02 ± 0.03 | 0.04 ± 0.02 | 4 ± 2 |
| | 60–100 | 5.78 ± 2.56 | 0.07 ± 0.04 | 0.11 ± 0.05 | 0.03 ± 0.03 | 0.04 ± 0.00 | 5 ± 2 |
| Malacca Complex (5) .. | 0–30 | 10.46 ± 4.02 | 0.25 ± 0.20 | 0.35 ± 0.37 | 0.05 ± 0.03 | 0.14 ± 0.09 | 7 ± 3 |
| | 30–60 | 10.47 ± 2.91 | 0.18 ± 0.13 | 0.28 ± 0.18 | 0.04 ± 0.02 | 0.07 ± 0.03 | 5 ± 2 |
| | 60–100 | 10.53 ± 3.19 | 0.19 ± 0.13 | 0.24 ± 0.20 | 0.04 ± 0.02 | 0.07 ± 0.03 | 5 ± 2 |

* Expressed as meq/100g soil ± standard deviation.
† Expressed as percentage ± standard deviation.
‡ Number of profiles analyzed.

Small variations in micronutrient contents can result in severe deficiencies or toxicities, both of which are very difficult to rectify. Deficiencies are more probable in the region because the soils are formed on highly weathered and leached acid parent materials, probably originally low in micronutrients. In addition, under the intense management systems envisaged for parts of the region, the availability of micronutrients will be further affected by agronomic practices such as liming which can cause decreased availability.

Analyses for copper, manganese, zinc and cobalt have been determined recently on some soils in Malaysia (Johore Tengah and Tenjong Penggerang Region Masterplan, 1971). With the exception of zinc contents, which are likely adequate, the levels of the other micronutrients appear low to very low. Plant response could possibly be obtained for manganese and maybe for copper on the soils studied in Johore.

More research on micronutrients should be definitely incorporated into future research programs. In addition to crop growth-micronutrient relationships, investigations into livestock enterprises should also include micronutrient studies. For example, cobalt, although not important for plant growth, and copper deficiencies in the soil can result in livestock malnutrition.

## Table 4.7—Easily Soluble Potassium and Phosphorus Contents[1] of Soils in the Semi-Detailed Soil Survey Area

| Soil Series | Depth (cm) | Sol. K (ppm) | Sol. P (ppm) |
|---|---|---|---|
| *Soils developed on igneous rocks:* | | | |
| Jerangau (4)[2] | 0–30 | 26 ± 18 | 44 ± 38 |
| | 30–60 | 15 ± 15 | 36 ± 35 |
| | 60–100 | 5 ± 6 | 33 ± 32 |
| Katong (4) | 0–30 | 17 ± 9 | 34 ± 4 |
| | 30–60 | 9 ± 7 | 24 ± 5 |
| | 60–100 | 9 ± 7 | 22 ± 7 |
| Rengam (24) | 0–30 | 38 ± 26 | 23 ± 9 |
| | 30–60 | 14 ± 12 | 18 ± 11 |
| | 60–100 | 12 ± 12 | 17 ± 11 |
| Segamat (6) | 0–30 | 43 ± 18 | 72 ± 46 |
| | 30–60 | 12 ± 5 | 54 ± 35 |
| | 60–100 | 13 ± 8 | 55 ± 31 |
| *Soils developed on sedimentary rocks:* | | | |
| Bungor (34) | 0–30 | 36 ± 18 | 23 ± 10 |
| | 30–60 | 16 ± 14 | 19 ± 18 |
| | 60–100 | 12 ± 7 | 19 ± 10 |
| Durian (12) | 0–30 | 42 ± 29 | 22 ± 9 |
| | 30–60 | 15 ± 12 | 17 ± 7 |
| | 60–100 | 13 ± 12 | 15 ± 8 |
| Jempol (6) | 0–30 | 55 ± 33 | 38 ± 23 |
| | 30–60 | 40 ± 35 | 35 ± 23 |
| | 60–100 | 37 ± 41 | 35 ± 27 |
| Jeram (4) | 0–30 | 41 ± 19 | 21 ± 16 |
| | 30–60 | 21 ± 12 | 19 ± 21 |
| | 60–100 | 18 ± 8 | 20 ± 26 |
| Kedah (5) | 0–30 | 29 ± 23 | 26 ± 12 |
| | 30–60 | 10 ± 10 | 31 ± 20 |
| | 60–100 | 10 ± 9 | 34 ± 24 |
| Serdang (8) | 0–30 | 38 ± 25 | 26 ± 13 |
| | 30–60 | 20 ± 5 | 25 ± 15 |
| | 60–100 | 22 ± 10 | 26 ± 16 |
| Serdang (sandy clay phase) (6) | 0–30 | 11 ± 4 | 14 ± 5 |
| | 30–60 | 8 ± 4 | 14 ± 5 |
| | 60–100 | 6 ± 5 | 13 ± 6 |
| *Soils developed on metamorphosed sedimentary rocks:* | | | |
| Kemuning (4) | 0–30 | 30 ± 7 | 29 ± 6 |
| | 30–60 | 10 ± 1 | 29 ± 4 |
| | 60–100 | 10 ± 1 | 30 ± 5 |
| Marang (13) | 0–30 | 34 ± 19 | 18 ± 9 |
| | 30–60 | 16 ± 11 | 15 ± 10 |
| | 60–100 | 21 ± 20 | 15 ± 11 |
| Pohoi (17) | 0–30 | 26 ± 11 | 19 ± 10 |
| | 30–60 | 13 ± 6 | 19 ± 12 |
| | 60–100 | 9 ± 7 | 21 ± 14 |

**Table 4.7—Easily Soluble Potassium and Phosphorus Contents[1] of Soils in the Semi-Detailed Soil Survey Area—(*cont.*)**

| Soil Series | Depth (cm) | Sol. K (ppm) | Sol. P (ppm) |
|---|---|---|---|
| ***Soils developed on older alluvium:*** | | | |
| Harimau (8) | 0–30 | 29 ± 11 | 13 ± 5 |
| | 30–60 | 20 ± 9 | 11 ± 4 |
| | 60–100 | 19 ± 18 | 10 ± 5 |
| ***Soils developed on subrecent alluvium:*** | | | |
| Holyrood (15) | 0–30 | 37 ± 18 | 18 ± 4 |
| | 30–60 | 12 ± 9 | 14 ± 3 |
| | 60–100 | 10 ± 9 | 12 ± 4 |
| Lunas (3) | 0–30 | 33 ± 21 | 14 ± 1 |
| | 30–60 | 15 ± 4 | 10 ± 1 |
| | 60–100 | 12 ± 2 | 9 ± 1 |
| Rasau (14) | 0–30 | 35 ± 17 | 16 ± 6 |
| | 30–60 | 10 ± 7 | 12 ± 5 |
| | 60–100 | 11 ± 9 | 10 ± 4 |
| Serok (6) | 0–30 | 49 ± 22 | 32 ± 10 |
| | 30–60 | 16 ± 7 | 16 ± 6 |
| | 60–100 | 11 ± 9 | 14 ± 4 |
| ***Soils developed on recent alluvium:*** | | | |
| Akob (12) | 0–30 | 29 ± 24 | 30 ± 21 |
| | 30–60 | 10 ± 7 | 13 ± 5 |
| | 60–100 | 9 ± 7 | 13 ± 10 |
| Telemong (7) | 0–30 | 18 ± 8 | 15 ± 4 |
| | 30–60 | 11 ± 2 | 15 ± 8 |
| | 60–100 | 7 ± 5 | 18 ± 7 |
| Kampong Kubor (5) | 0–30 | 22 ± 14 | 13 ± 4 |
| | 30–60 | 9 ± 5 | 8 ± 4 |
| | 60–100 | 9 ± 5 | 7 ± 4 |
| ***Soils developed on variable parent materials:*** | | | |
| Alluvial Complex (5) | 0–30 | 28 ± 20 | 13 ± 4 |
| | 30–60 | 8 ± 4 | 12 ± 4 |
| | 60–100 | 6 ± 5 | 12 ± 1 |
| Malacca Complex (5) | 0–30 | 47 ± 30 | 36 ± 12 |
| | 30–60 | 17 ± 7 | 35 ± 22 |
| | 60–100 | 18 ± 5 | 35 ± 23 |

[1] Expressed as parts per million ± standard deviation.
[2] Number of profiles analysed.

## 4.2 GENERALIZED SOIL INFORMATION FOR THE ENTIRE PAHANG TENGGARA REGION

### 4.2.1 The Generalized Soil Map

The Generalized Soil Map (Map 5) of the Pahang Tenggara Region represents the extent and distribution of the soils in the overall region. This map does not have a uniform amount of detail nor does it possess equal accuracy for each part of the study area. The semi-detailed soil survey results, previous soil survey reports, and limited field surveys of existing timber tracks were used to prepare this map. It is presented on a soil series and soil association basis, much the same as the soil map for the semi-detailed soil survey area, except no terrain or soil phase information is given.

The map was drawn basically from the two previous reconnaissance soil surveys of the region (Ives, 1967; Dumanski and Ooi, 1966) and from the semi-detailed map. Amendments from more detailed soil surveys of the region as well as information from timber track soil surveys, in specific areas, were incorporated into the final map. Information from within the semi-detailed soil survey area was generalized mainly by grouping small parcels of land into larger land units and identifying them by the soil association. It is apparent that while an area may be indicated on the soil map as a soil series or soil association, related soils may occur to a limited extent within that area. Generally soils which constitute less than 25 percent of an area are not indicated on the map.

It should be emphasized that the generalized soil map for the Pahang Tenggara Region is not solely suitable for specific detailed planning. The soils indicated on the map should be regarded as an average for the area rather than specific for individual land parcels. More detailed surveys of specific areas should be undertaken before any large scale development is initiated. However, the soil map does, as the name implies, give the general distribution and kind of soils found in the Pahang Tenggara Region.

### 4.2.2 Soil Series

The following are brief descriptions of soils that are found in the Pahang Tenggara which were not mapped in the semi-detailed area and therefore not described previously in this report. Only a brief description of these soils is given, and if more detailed information is required it can be obtained from the reconnaissance soil survey reports for the west and east portions of the region (Dumanski and Ooi, 1966 and Ives, 1967).

*Baging Series (BGN)*

Baging soils consist of somewhat excessively drained, loose, olive brown to very pale brown, coarse textured soils developed on sandy marine deposits. These soils are found on the most recent beach ridges, on level terrain, in the northern and southern parts of the region adjacent to the coast. Horizonation is very weakly expressed and small flakes of muscovite may be found throughout the profile.

A thin, loose, structureless, brown or grayish brown, humus enriched, loamy sand or sand, usually overlies a deep eluvial horizon of yellowish brown to olive yellow, sand or loamy sand, with loose consistency and very weak subangular blocky aggregation. Below, a transitional BC horizon consisting of a loose to very friable sand, with very weak subangular blocky aggregation and olive brown to very pale brown colors overlies the parent material of olive brown to brown sand. White, pale yellow and, rarely, strong brown mottles, are often found throughout the subsoil. Roots are particularly numerous, especially in the surface horizons and the soil is highly porous.

*Batu Anam Series (BTM)*

Batu Anam soils are moderately well to imperfectly drained, very pale brown to yellow, firm to very firm, fine textured soils developed on an iron-poor siliceous shale. These soils are commonly associated with Durian, Tavy and Malacca soils on undulating to hilly topography. These associations occupy vast tracts of land in the inland plain area on the west side of the region.

The surface soil is a moderately firm, light yellowish brown to pale yellow, clay loam to clay, which possesses well developed, medium to coarse subangular blocky structures and weakly to moderately developed clayskins. This passes abruptly into a firm to very firm, very pale brown to yellow, clay subsoil, which is highly mottled, and possesses a well developed, coarse, jagged prismatic breaking to coarse, subangular blocky structure. Clayskins are extremely well developed. This is underlain by a highly mottled zone of non-hardened plinthite. The soil is usually rather shallow, exhibits a well defined Ae/Bt horizon sequence, and is commonly lateritic. The laterite appears as a continuous band of closely packed, nodular and fragmental concretions at depths of 45-90 cm and up to 60 cm thick. Fragments of partially weathered shale are often found at depths greater than 100 cm.

*Briah Series (BRH)*

The Briah series consists of poorly drained, strongly mottled, light yellowish brown to olive yellow, plastic and sticky, fine textured soils developed on recent alluvium. They are found on level to depressional sites, occurring generally as a narrow strip between the peat soils and the better drained alluvial soils bordering the rivers. They are sometimes associated with Akob soils.

A thin accumulation of decomposed and semi-decomposed plant remains overlies a gray or light gray clay loam or silty clay loam, with friable or firm consistence, moderately developed sub-angular blocky structures and faint, pale yellow mottling. A narrow transitional layer separates this horizon from the underlying B horizon. This latter horizon is usually, a plastic and sticky, massive, weakly structured, light yellowish brown, olive yellow or pale olive, clay or silty clay, which shows weak clayskin development and is strongly mottled in red, reddish yellow and light gray. Below this horizon, a sandy or clayey parent material occurs which may be olive or olive yellow in color exhibiting weak subangular blocky structure and common gray and dark brown mottles. Roots normally penetrate to below 90 cm and small flakes of muscovite are found throughout the profile. The level of the water table varies from the surface to about 90 cm, depending upon the season.

*Kawang Series (KWG)*

Kawang soils are moderately well drained, brownish yellow to brown, friable to slightly firm, fine to moderately fine textured soils developed on older alluvium deposits. These soils occur on a highly dissected upper terrace along the S. Pahang in the northwestern portion of the region. They occur on undulating to hilly terrain, and in most cases are associated with intensely lateritic Malacca soils. They have a distribution pattern that indicates extensive erosion in the past.

The surface soil is a friable, yellowish brown sandy loam to sandy clay loam, possessing poorly to moderately well developed, fine, subangular blocky structures and weakly developed clayskins. Beneath this is a friable, brownish yellow to brown subsoil, which is sandy clay loam to gravelly clay in texture, and exhibits fine to medium, moderately well developed clayskins. The soil is distinctly gritty throughout with the grit sometimes concentrated in a thin band occurring within 90 cm of the surface. Below this is a thick layer of well rounded quartz pebbles lying in an argillaceous matrix of quartz grit and clay. This commonly overlies a thin, discontinous, iron-rich hard pan which in turn overlies a firm, variegated clay.

*Kranji Series (KNJ)*

Kranji soils are poorly drained, dark gray to gray, friable to firm, moderately fine textured, saline gley soils developed on marine deposits. They occur on level terrain adjacent to the estuaries of the larger streams and rivers, on the eastern margin of the region. Their parent material is estuarine alluvial silts and clays with occasional sandy lenses and they are inundated by saline water during tides. Some Kranji soils may have potential to develop acid sulphate conditions, especially on drying in depressional areas.

A thin dark brown, plastic and sticky, humic, very fine sandy clay loam, with moderately developed fine blocky structures, normally occurs at the surface. Dark red and reddish brown mottles in this layer indicate a reduction of iron rich compounds. Below, a dark gray, friable to firm, very fine sandy clay loam to fine sandy clay occurs. Structures are weakly developed and living and decaying roots are abundant. Iron oxide stained clayskins line pores and channels, and dark red mottles are common. This horizon gives way to dark grayish brown to dark olive gray, plastic and sticky, fine sandy clay loam, with very weak blocky structures. Dark yellowish brown, dark red and olive colored mottles are prevalent, as are dead and decaying roots. Small flakes of muscovite are found in all horizons and a noticeable smell of hydrogen sulphide can be detected in all horizons.

*Kuala Brang Series (KLG)*

These soils are well drained, friable, yellowish brown to brownish yellow, moderately fine textured soils developed on sandstones, quartzites and sandy shales. They occur over a variety of terrain classes ranging from undulating to steep, but are generally found on moderately steep slopes. The parent material is encountered at less than 100 cm and there is only a weakly expressed Ae/Bt horizon sequence.

A friable, yellowish brown, humus enriched, sandy loam topsoil with weakly developed subangular blocky and crumb structures usually overlies a transitional horizon to the illuvial B horizon. The B horizon is invariably a brownish yellow sandy loam to sandy clay loam with friable consistency and weakly to moderately developed subangular blocky and crumb structures. Clayskins are patchy and only occur towards the base of this horizon and continue in the underlying stony, yellow to reddish yellow sandy clay loam which contains fragments of weathering parent rock. The depth to this horizon depends very much on topography. Roots seldom penetrate to the stony horizon, but the soil is very porous throughout.

*Linau Series* (*LNU*)

Soils of the Linau series are poorly drained, dark grayish brown to olive, friable to firm, moderately fine textured soils developed on marine deposits. These soils can develop from soils of the Kranji series in areas where estauarine alluviums are no longer subject to tidal inundation. These soils have a distinct sulphurous odour in the subsoil below about 60 cm.

Under primary forest, much generally forms the surface layer. This horizon has a black to reddish gray color, loose consistency and weakly developed granular and crumb structure. This is underlain by a very dark grayish brown to olive, sandy clay loam to silty clay loam which has a friable consistency and weakly to moderately developed subangular blocky and crumb structures. Dead and decaying roots and large quantities of incorporated humus are a distinct feature. Below, a firm, almost structureless, dark grayish brown to bluish gray, sandy loam to silty clay occurs. This horizon gives off a strong sulphurous odour and large amounts of incorporated humus are invariably present. The water table varies seasonally between the surface and about 60 cm. Mica flakes are normally found at all levels below the surface horizon. Controlled drainage, not allowing pronounced drying, is recommended otherwise acid sulphate conditions may worsen.

*Penyabong Series* (*PYG*)

Penyabong soils are well drained, friable to firm, brown, moderately fine textured soils developed on lithic tuffs of rhyolitic composition. These soils are found over hilly and steep terrain in minor valleys of the eastern and southern parts of the Lesong Forest Highlands. They generally occur above the steepland boundary.

Penyabong soils are juvenile soils and display an A/C profile, with a weakly developed eluvial horizon. The topsoil is a friable, brown clay loam with moderate to strongly developed very fine subangular blocky, fine crumb and fine granular structures. Occasional angular gravel and stones are usually present towards the base of this horizon, and may be coated with thin clayskins. This horizon is underlain by a stony, friable to firm, brown clay loam with moderate, fine subangular blocky and granular structures. Stoniness increases rapidly with depth, and the depth to solid rock is between 30 to 45 cm.

*Rompin Series* (*RPN*)

Rompin soils are well drained, friable, yellowish brown or brownish yellow, coarse textured soils developed on marine deposits. These soils occur on almost level terrain, along the eastern margin of the region, mainly south of Kuala Rompin. They may be differentiated from Baging soils by their darker colors, obvious red and yellow mottles, and absence of mica flakes.

A brown, humic, loamy fine sand with a loose or very friable consistence and very weak fine granular and crumb structure overlies an eluvial horizon which also displays humic enrichment. This horizon is a yellowish brown to brown, loose or very friable, fine sand, with very weak crumb and granular structure. A transitional layer separates the top soil from a weakly formed B horizon which is generally a loose or very friable, yellowish brown or brownish yellow, fine sand, displaying very weak subangular blocky aggregation and red and gray colored mottles. This merges into a very pale brown or pale yellow, structureless, friable, fine sand parent material which exhibits yellowish brown mottles.

*Rudua Series* (*RDU*)

Rudua soils consist of well to somewhat excessively drained, coarse textured, loose and friable, soils developed on raised sand ridges of marine origin. The soils are characterized by a black, dark or dusky red illuvial horizon of organic and iron accumulation. These soils are found in a narrow strip parallel to the coast between Pekan and Kuala Rompin on level to undulating terrain.

A relatively thick surface horizon of organic matter accumulation is generally present. This is a black or dark brown loose sand which exhibits some crumb-like aggregation. This horizon passes gradually into a strongly leached horizon. The latter horizon is invariably light grey or white in color, and is predominantly a loose and structureless sand. A thin transitional horizon occurs between this horizon and the underlying spodic horizon. The latter variably indurated horizon is predominantly sand, cemented with collodial humic material and a little iron oxide, giving it a characteristic, black, dark or dusky red color. This horizon is rarely more than 30 cm thick. Underneath, the brown to light yellowish brown, loose, structureless sand may have some mottles near the upper boundary but is generally fairly uniform in appearance. The soil is extremely porous throughout. Roots are particularly abundant, but this demonstrates a search for water and nutrients rather than high fertility. The water table is generally at the level of the humic pan, which may occur anywhere between 35 cm and 120 cm.

*Rusila Series (RSL)*

Soils of the Rusila series are loose and very friable, gray or light gray, coarse to moderately fine textured soils developed on marine sands. They are found in low lying, poorly drained locations in the coastal sand ridge region. The swales between strand lines, which are the sites of these soils, vary considerably in width from a few chains to quarter of a mile, but are invariably of greater longitudinal extent.

A surface humic accumulation, containing enough mineral matter to be called a muck, usually overlies a gray or light gray, often humic, loamy sand or clayey sand. This eluvial horizon is usually waterlogged for the greater part of the year, has some very weak subangular blocky aggregation and passes into a gray or light gray, mottled, structureless sandy clay loam. Occasionally, sulphurous odour may be detected below 60 cm, especially in those locations immediately adjacent to the coast or estuaries.

*Tampin Series (TPN)*

Tampin soils are moderately well drained, friable, pale brown to olive yellow, fine textured to moderately fine textured soils developed on acid granites. These soils are associated with Rengam soils on undulating to rolling terrain and tend to occupy lower slope positions. A small area of these soils occurs on the extreme western side on the region.

The surface soil is a friable, very pale brown to yellow sandy to gravelly clay loam, with poorly developed, fine to medium subangular blocky structures and weakly expressed clayskins. This is underlain by a pale brown to olive yellow subsoil, which is sandy clay to gravelly clay in texture, friable in consistence and possesses weakly to moderately developed, medium subangular blocky structures and moderately developed clayskins. These soils are commonly weakly mottled at depths greater than 100 cm, and exhibit an increase in clay with depth. They have many roots, sometimes contain mica, and are distinctly gritty throughout.

*Tavy Series (TVY)*

Tavy soils are well drained, reddish yellow to brownish yellow, firm, fine textured soils developed on argillaceous parent materials interbedded with ferruginous sandstones and conglomerates. These soils are characterized by the common presence of an illuvial horizon above a horizon of nodular and fragmental laterite. This horizon is normally less than 60 cm thick and occurs within 50 cm of the surface. These soils occur on rolling to hilly terrain associated with Batu Anam, Malacca, Marang and Durian soils mainly in the western portion of the region.

The surface soil consists of a yellowish brown to reddish yellow sandy clay loam, with weakly to moderately well developed subangular blocky structures and friable consistency. This is underlain by a moderately firm, reddish yellow to brownish yellow illuvial horizon that is fine textured, and exhibits medium, well developed subangular blocky structures with moderately developed clayskins. Beneath this is a moderately thick band of closely packed, nodular, lateritic concretion in which the matrix is a yellowish red gritty clay. This in turn is underlain by a firm, highly mottled and iron stained clay. In general, the soil becomes redder and firmer with depth. The soil is somewhat gritty and porous throughout.

*Yong Peng Series (YPG)*

Yong Peng soils in tnis area consist of well drained yellowish brown to olive yellow, friable, fine textured soils developed on dacite. They are found on rolling terrain in a small area near the Lesong Forest Highlands in the southeastern portion of the region. Flakes of muscovite commonly occur throughout the soils and structures are only moderately well developed.

### 4.2.3 Description of each updated Segment

Since the reconnaissance soil surveys (Dumanski and Ooi, 1966; Ives, 1967), there have been a number of recent surveys within the Pahang Tenggara Region, outside the semi-detailed area. The information from these surveys and from timber track checks carried out by this study have been used to draw up the generalized soil map for the region.

The results of the reconnaissance type field checks carried out by this study along existing timber tracks can be summarized as follows:

(1) Rompin Plateau Area

The majority of this area has been upgraded considerably as a result of timber track checks. Large areas of Kuala Brang and Bungor soils with Serdang soils adjacent to the steepland were indicated on the reconnaissance survey map. However, much of this area has been remapped to Rengam and Jerangau soils. The terrain in the area is undulating to rolling except adjacent to the steepland areas where Serdang soils on hilly terrain occur.

(2) Jeram Valley Area

Although the main portion of the Jeram Valley is inaccessible by vehicle, checks of the soils in the periphery area indicate that a high proportion of good soils on favourable terrain do exist. Although significant areas of Munchong soils are found in the area, their occurence seems to be more sporadic than was indicated in the reconnaissance soil survey. They occur in small specific areas rather than over large areas. Many of the soils in the area were observed to be lateritic but the scale of mapping does not warrant their separation. Since the centre of the Jeram Valley could not be checked because of inaccessability, the majority of this area was not changed significantly from the original reconnaissance soil survey.

(3) Temerloh-Bahau Area

Basically, field checks of the soils to the west of the Tasek Bera betwen Temerloh and Bahau indicate that the soils are similar to those mapped in the reconnaissance soil survey except for an area south of Ft. Iskander near the Johore border. In this area a significant amount of igneous derived Rengam soils on undulating to rolling terrain occur. This area was originally indicated to contain Serdang and Bungor soils.

The updated results from the surveys completed by the Department of Agriculture can be summarized as follows:

(1) Pekan D.I.D. Scheme (101,500 acres)

The most pertinent finding of this detailed reconnaissance survey was the remapping of a small area of organic clay and muck as deep peat. Other minor changes in soil distribution and soil types were made.

(2) Endau-Rompin D.I.D. Scheme (aproximately 121,000 acres)

In this detailed reconnaissance survey large acreages of soils mapped as organic clay and muck have been remapped, mostly as deep peat. Other minor changes in soil distribution and soil types have been initiated.

(3) Bukit Ibam Area (approximately 32,000 acres)

The information in this semi-detailed soil survey is basically similar to the reconnaissance findings with more accurate delineation of soil patterns.

In addition to the surveys by this study and by the Department of Agriculture, the Ladang Pegawai area has been resurveyed by the company concerned and some of this information has been used in the updated map. The information is generally similar to the reconnaissance surveys with more accurate delineation of soil patterns.

## 5.0 SOIL SURVEY INTERPRETATIONS

In the course of a soil survey, pedologists make innumerable soil observations and descriptions in preparation for the compilation of the final soil map and report. The soil map is compiled by mapping soil series, phases and variants of series, and soil complexes in combination with various classes of terrain. The map is intended primarily for other pedologists, and therefore appears complex and difficult to read to people who are uninitiated in the science. A procedure is therefore necessary which summarizes and compiles this information in such a way that other people can make use of it. This has been attempted for agricultural soil interpretations in the Pahang Tenggara study area by development of a soil capability classification. Interpretation of soil survey information for engineering uses has also been made, but at a very broad level.

Through the application of the concept of soil series pedologists classify, map, describe and study soils as natural bodies. Since each soil series is unique from all other series, each soil in its particular environment has an expected response to crop suitability, soil management, engineering uses or any other manipulation.

Soil survey interpretations for agriculture should be treated as evaluations of soil performance under specified management, *not* as recommendations for the use of soil. Optimal use of a soil depends on many factors other than soil characteristics and performance. Size of tracts or potential tracts, and their relation to water, transport facilities and markets, and preference of the owner and his resources and skills, all play a big part in the selection of land uses and cropping systems. Soil maps and technical groupings of soils are important in classifying land, selecting type of land use, and prescribing management practices.

Good soil survey interpretations help the soil user to apply the most profitable crop and management to each soil. Although management alone can invariably increase crop yield, optimization of yield depends on manipulating management practices to fit the various kinds of soils. In some instances a cultivator can change certain soil characteristics, but in the majority of cases he must fit his practices to the needs of the soil. Permanent soil characteristics, such as soil texture, kinds of clay, depth of soil, permeability, water holding or release capacity and presence of strongly compacted or laterized layer, largely determine the response of soil to a particular crop or to a particular kind and level of management.

Performance and response of a soil to management or use depend on its characteristics and quality. Deep, friable, well-drained soils that respond well to management are ideal soils for agricultural use, but many soils fall far short of this ideal. Soil survey interpretations deal with the entire range of soil characteristics, and evaluate all soils and their phases and variants that are encountered in a soil survey.

The detail and accuracy of the soil survey interpretations for agriculture in the Pahang Tenggara Region vary according to the detail of survey. In areas covered only by reconnaissance surveys, the information is very general and therefore the interpretations can only be of a general nature. However, in areas covered by the semi-detailed soil surveys the information is detailed enough to provide a sound basis for interpretations which can be used for planning and direct implementation.

## 5.1 SOIL CAPABILITY CLASSIFICATION FOR AGRICULTURE IN THE SEMI-DETAILED SOIL SURVEY AREA

A system of soil capability tailored to the needs of agriculture in the Pahang Tenggara semi-detailed survey area is outlined. The capability classification described herein is based on the approach outlined by Wong (1970). Wong's approach was chosen because it is widely used in Malaysia and has received general acceptance. However, his classification is designed mainly for reconnaissance soil surveys, and therefore is inadequate for the soil map that was produced in the area covered by the semi-detailed soil survey.

Whenever possible Wong's original definitions and criteria were employed. In many instances, however, they were modified and revised to comply with current information and opinions, and some new criteria were added. Also, a new category, the *soil capability performance group*, was defined.

The system is described in this report in considerable detail for two reasons. Firstly, it is highly possible that it may be used in the Pahang Tenggara area for perhaps the next 20 years. Secondly, if found suitable, the concepts and criteria used in the system may be expanded into a national system of soil capability classification for Malaysia.[1]

The system is based on capability classes, capability subclasses and capability performance groups. When combined, these units reflect relative soil agricultural potential, limiting soil properties for agricultural use, and soil groups which have equal potential productivity and performance.

In practice, the basic building blocks of the system are the soil mapping units. A soil mapping unit is a portion of a landscape that has similar characteristics and qualities, and whose range is fixed within cartographic limitations and the purpose for which the map is made. It is the unit which provides the most detailed soils information and is the one about which the best possible evaluation can be made. In the Pahang Tenggara area, however, a total of 241 soil mapping units are employed in the semi-detailed survey map, and this is considered to be an unwieldy number. Soil mapping units are combined into soil capability performance groups for interpretation purposes.

A soil capability performance group is a grouping of one or more soil mapping units that have comparable potential productivity and need similar management to maintain or improve their level of productivity. Capability performance groups condense and simplify soil information for planning purposes. Soils within capability performance groups are sufficiently uniform that they can be used for evaluation of crop suitability and detailed management practices.

Capability subclasses are clusters of capability performance groups that have the same kind and severity of limitations of hazards to agricultural use. As such they serve as general guides to management and conservation practices that are necessary to sustain long term cultivation of land, but are generally too broad for specific recommendations.

Capability classes are groups of subclasses that have the same relative degree and number of limitations.

[1] Personal communication, Enche' Law Wei Min, Senior Agricultural Officer, Soil and Analytical Services Branch, Dept. of Agriculture, Kuala Lumpur.

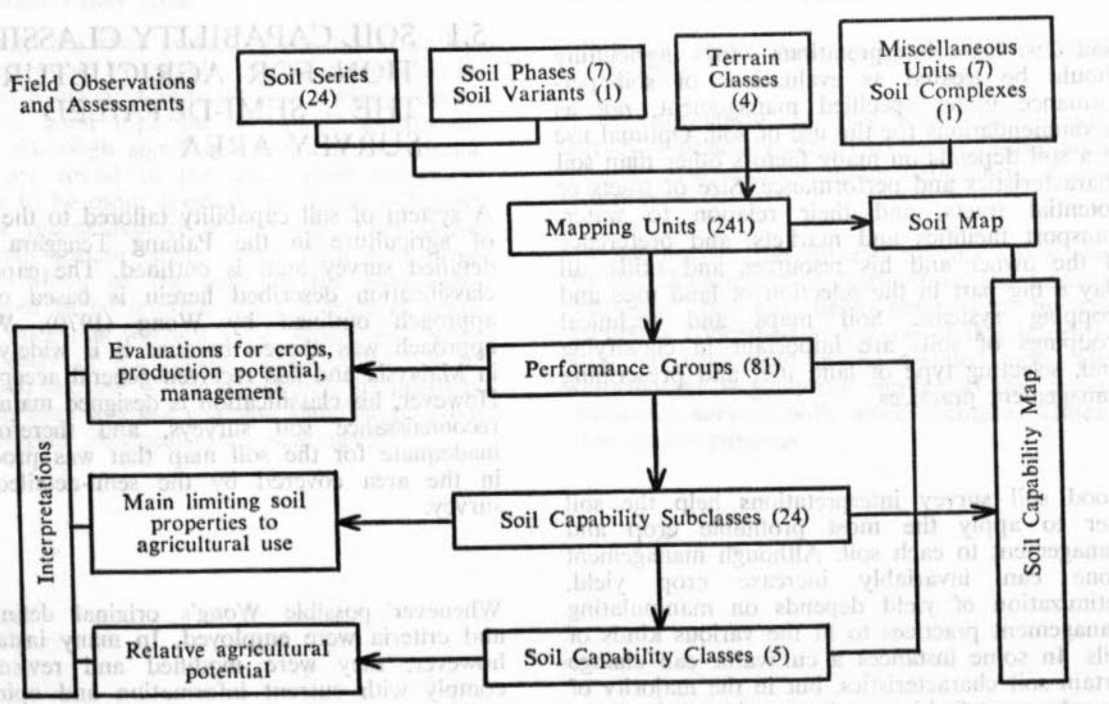



**Fig. 5.1. Diagram showing relationship between soil survey information and soil capability. (Numbers in brackets indicate the number of individual categories used in the semi-detailed area).**

The classes indicate the relative potential of soil-land areas for crop diversification, and the suitability of land for agricultural use and development, but they have a very low soil evaluation capacity. An indication of the flow of information among soil observations, soil mapping units and the various levels of the soil capability classification scheme is shown in Fig. 5.1.

The basic assumptions for the system are as follows:

1. The capability classification outlined herein is a special purpose classification in that it is intended to be used solely as a guide to the capability of land for agricultural uses and crop suitability.

2. The capability classification is tailored to the requirements of the Pahang Tenggara Project and to the detail of soil information which was obtained in the area covered by the semi-detailed soil survey. Soil interpretation made from more general soil maps would not use the entire system, but only the broader categories.

3. The capability classification is an interpretative grouping of kinds of soils integrated with the nature of the terrain on which the soils are found. It is a three-component classification which describes land as capability classes, capability subclasses and capability performance groups. Subdivisions between the categories are based on the effects of permanent soil and land characteristics in relation to use, management or productive capacity of soil, or the risks of soil erosion, degradation, etc. under use.

4. A relatively uniform climate over the central portion of the Pahang Tenggara area is assumed. If this scheme is expanded into a national system, then climatic subdivisions should be incorporated at the appropriate level.

5. Soils and land are classified in their natural state, and only those crop growth limiting factors which are currently known are considered. The implementation of amelioration techniques (drainage, irrigation, etc.) which permanently alter the limitations to crop growth would require adjustments. The classification would then be based on the remaining crop growth limitations.

6. Accessibility and proximity to markets do not influence the classification.

7. Soil limitations to crop growth are based mainly on physical limitations since these tend to be permanent and are difficult to rectify. If known, limiting chemical properties, e.g. micronutrient deficiencies or toxicities, are also taken into account.

8. The system is based on current knowledge of the effect of soil properties on crop behaviour; where there is a lack of data, criteria for the system are based on subjective information on use and management for similar soils elsewhere. Groupings are subject to change as new information becomes available.

9. The capability classification is not intended to suggest the most profitable agricultural use of soils. It is an inventory to soil resources, and a guide to better land use.

10. The capability classification can be affected by poor soil or land management practices or both. In such instances the classification for those areas become invalid since the performance evaluations are based on a certain level of management.

### 5.1.1 Soil Capability Classes

Soil capability classes are the broadest category in the soil classification. They are based on the *severity and number of permanent limitations to agricultural use* and as such they indicate the general suitability of soil or soil-land areas for agricultural use. Soils within a capability class are similar with respect to degree but not to kind of limitations or hazards to agricultural use.

Soil capability classes are made up of wide collections of soils. In a general sense such soils have comparatively equal productive capacities for similar crops, and have approximately equivalent potential for crop diversification. They may, however, require different management although usually at similar levels of input.

Five soil capability classes are employed in the system. Class I soils have no limitations to productivity, or limitations which are of only minor significance. The limitations or hazards become progressively greater from Class I to Class V, generally narrowing down the range of suitable crops.

*Capability Class Definitions*

*Class I*—Soils with no limitations, or one or more minor limitations.[1]

Soils in Class I are suitable for the widest range of crops. They can be profitably cropped under a moderate level of management.

Class I soils generally occur on flat to undulating terrain and possess the fewest number and the least serious soil limitations for crop growth. They are deep, well-structured soils with good water and nutrient-holding capacities.

*Class II*—Soils with one moderate limitation, or one moderate plus one or more minor limitations.

These soils are suitable for a narrower range of crops than Class I soils. A moderate level of management is necessary to obtain satisfactory yields. Management practices may include minor erosion control measures, minor drainage and irrigation works, or improvements in air and water relationships.

Class II soils generally occur on undulating to rolling terrain and possess moderate soil limitations for crop growth.

*Class III*—Soils with one serious limitation or one serious and one or more moderate limitations, or two or more moderate limitations with or without other minor limitations.

These soils are restricted to a narrow range of crops. A high standard of management is often required to develop or conserve them for long term crop production, and, even so, yields may be depressed. Necessary management practices may include erosion control measures, an intensive fertilizer or amendment application and/or drainage or irrigation works involving moderate expense.

[1] *See* Section 5.1.2 for definitions of severity of limitations.

Class III soils are generally on rolling to hilly terrain and possess combinations of serious and moderate soil limitations for crop growth.

*Class IV*—Soils with two or more serious limitations with or without other moderate or minor limitations.

These soils are limited to a very narrow range of crops and often only specific crops. A very high level of management is required to maintain a moderate level of continuing productivity. Major conservation or amelioration measures are necessary if these soils are to be cultivated on a long term basis.

Class IV soils are generally on hilly terrain and may possess a number of serious soil limitations for crop growth.

*Class V*—Soils with at least one very serious limitation with or without other serious, moderate or minor limitations.

Soils in this class are least suitable for crop growth. Where they are not built over for urban development or excavated for mining or quarrying purposes they are best allowed to continue under primary or regenerating forest. Areas designated as steepland and those mapped as having high concentrations of thick massive or fragmental laterite on hilly terrain have Class V soils.

To avoid necessary confusion, the above soil capability classes were designated to closely approximate Wong's (1970) soil suitability classes. However, it was necessary to alter slightly several of Wong's initial definitions in order to reconcile differences in scale of observation between reconnaissance surveys and semi-detailed soil surveys. A schematic comparison between the two approaches is shown in Table 5.1.

Soils within the capability classes are similar only with respect to degree and number of soil and terrain limitations to agricultural use. Such classes are useful only in terms of a general appraisal of the agricultural potential of an area. Since the limitations within each class may be any of several kinds or combinations, soil capability classes have little or no evaluation capacity for choice of crops, arrangement of cropping systems, choice of management practices or estimation of yield.

**Table 5.1—Comparison Between the Proposed Soil Capability System and the Soil Suitability System (Wong, 1970)**

| Capability or Suitability Class | Pahang Tenggara System | Wong's System |
|---|---|---|
| Class I | None or one or more minor | None or one or more minor |
| Class II | One moderate, or one moderate plus one or more minor | One or more moderate |
| Class III | One serious, or one serious plus one or more moderate, or two or more moderate | One serious |
| Class IV | Two or more serious | Two or more serious |
| Class V | At least one very serious | At least one very serious |

## 5.1.2 Soil Capability Subclasses

Soil capability subclasses are subdivisions of soil capability classes. They are groupings of soil and/or soil mapping units on the basis of *similarities of kinds and severity of limitations* to crop production. In focusing on particular kinds of limitations as well as the severity of these limitations, capability subclasses serve as guides to management or conservation practices which may be needed to sustain long term cultivation of land. When soil capability subclasses are combined with capability classes the map user is provided with information on the degree, the number and the kind of limitations to agricultural production.

Wong (1970) proposed the use of nine soil capability subclasses. These subclasses formed the basis on which soil capability subclasses were defined for the study area. Where possible Wong's definitions were left intact. However, the greater number of soil observations that were available for the semi-detailed area necessitated that several subclasses be redefined. Also, two new subclasses were added. The final subclass definitions are described below; they are also summarized in Table 5.2.

*Erodibility* (*E*)

Erosion by water is severe and often difficult to control in tropical countries where heavy rainstorms are common. To assess soil erodibility, soil texture and structure have been considered, as well as surface topography.

In this classification coarse textured soils or soils with poor surface structures are grouped into one class. Coarse textured soils are referred to as any soils with subsoil textures coarser than a sandy clay. These are the sandy clays, silts, sandy clay loams, silt loams, loams, sandy loams, loamy sands and sands. Such materials are very susceptible to erosion, and this severely affects crop growth by removing fertile topsoil and reducing soil depth.

Fine textured soils with well structured surface horizons are grouped together because of their capability for resisting erosion. These are the clays, silty clays, clay loams and silty clay loams.

Slope and texture have been grouped together because of their influence on erodibility. However, slope can be interpreted directly for use as a criteria for crop growth and management.

The division between coarser and finer textured soils is a very useful one from an engineering standpoint. The classification of soils according to bearing strength and workability for construction of roads, cities, airports, etc. may be divided into coarse and fine soils. Coarse textured soils have a high bearing strength and are easily workable. Fine textured soils have a low bearing strength and are more difficult to manage.

*Depth to strongly compacted layer* (*C*)

Soil depth and gradient are considered together because the severity of soil depth limitations is dependant on slope. Shallower soils are a more serious limitation on steeper slopes because effective depth changes by contouring. Crop growth is limited by shallow soils because of the restricted rooting depth, and reduced water and nutrient holding capacities.

A compacted layer is defined as a layer which impedes root penetration because of the presence of hardpans, weathered or partially weathered rocks, or concentration of massive or fragmental laterite. Lateritic soil series (greater than 60cm of laterite beginning within 50cm of the surface) and lateritic soil phases (greater than 25cm but less than 60cm of laterite within 100cm of the surface) are included in this subclass. Layers of fragmental laterite that are less than 25cm thick as well as soils that contain considerable quantities of laterite dispersed throughout the solum are considered within the subclass "rockiness". Similarly, B and BC horizons of firm consistence are considered under "physical soil characteristics" rather than "depth to compacted layer".

In rating certain soil mapping units both depth and physical soil properties may be limiting factors. In such cases including both factors places undue emphasis on depth limitations; therefore the least serious limitation should be omitted.

Depth limitations are important for engineering soil uses, and may be interpreted for this purpose from the soil capability subclass.

*Physical soil characteristics (P)*

In Malaysia many criteria for the classification of soils into series and phases are based on soil structure, texture and consistency. These physical soil characteristics are important to plant growth because they affect permeability, porosity, root penetration, soil stability, water and nutrient-holding capacity and workability. Therefore, it is considered necessary to add physical soil properties to the suitability classification.

Included in this limitation are massive BC horizons, firm to extremely firm B horizons with coarse blocky or prismatic structures, and compact parent material horizons. Also included in this limitation are highly stratified soils or soils with sharp textural unconformities which restrict water movement. A limitation for loamy sands and structureless sandy loams has been included because these properties are important for specific crops.

As with depth phases, the physical soil characteristics are more serious on steeper slopes and therefore gradient and physical properties have been considered together.

*Drainage (D)*

The drainage status of a soil does not affect all plants the same way. While wetland crops such as padi and sago palms thrive under very wet conditions all dryland crops may not survive these conditions. As most crops are inhibited in growth with increasing wetness or dryness the drainage classes of the U.S.D.A. Soil Survey Manual (Soil Survey Staff, 1951) have been adopted in this classification.

Since this classification is to be used to predict the growth of specific crops, it was necessary to distinguish between poorly drained conditions and excessively drained conditions. Soils with low moisture releasing properties have been grouped as having the same degree of seriousness as somewhat excessively drained soils. More research is required to establish what effect low moisture release has on specific crops. Very poorly drained conditions are serious limitations for most crops while poorly and imperfectly drained conditions are only moderate and minor limitations respectively.

At the other end of the drainage spectrum, excessively drained conditions are only a moderate limitation since in the humid climate of this country dry spells are seldom of long duration. Accordingly, somewhat excessive drainage would be a minor limitation.

*Salinity (S) (no changes from Wong, 1970)*

Salinity is associated with fine textured marine deposits inundated by sea water. A salinity classification which has been found to be satisfactory by the U.S. Salinity Laboratory (salinity Laboratory Staff, 1954) for appraising soil salinity in relation to plan growth has been adopted for Malaysian conditions and is indicated below.

## SALINITY SCALE

**Conductivity of Saturation Extract of Soil (Millimhos/cm at 250C)**

| 0 | 2 | 4 | 8 | 16 |
|---|---|---|---|---|
| **Non Saline** | **Very Slightly Saline** | **Moderately Saline** | **Strongly Saline** | **Very Strongly Saline** |
| Salinity effects mostly negligible | Yields of very sensitive crops may be restricted | Yields of many crops restricted | Only tolerant crops yield satisfactorily | Only a few very tolerant crops yield satisfactorily |

## Table 5.2—Soil Limitations to Crop Growth Rated According to Severity

| Symbol | Type | Very Serious ($v$) | Serious ($s$) | Moderate ($m$) | Minor ($n$) |
|---|---|---|---|---|---|
| E | Erodibility | Very high<br>>20° slopes with soils of light textures or poor surface structures<br>*Or*<br>>25° slopes with heavy textured, well structured soils | High<br>12°-20° slopes with soils of light textures or poor surface structures<br>*Or*<br>20°-25° slopes with heavy textured, well structured soils | Moderate<br>6°-12° slopes with soils of light textures or poor surface structures<br>*Or*<br>12°-20° slopes with heavy textured, well structured soils | Slight<br>2°-6° slopes with soils of light textures or poor surface structures<br>*Or*<br>2°-12° slopes with heavy textured, well structured soils |
| C | Depth to strongly compacted layer | Very shallow<br>0-25 cm on 0°-20° slopes<br>*Or*<br>Shallow<br>25-50cm on 12-20° slopes | Shallow<br>25-50cm on 0-12° slopes<br>*Or*<br>Moderately deep<br>50-100cm on 12-20° slopes | Moderately deep<br>50-100cm on 0-12° slopes<br>*Or*<br>Deep<br>100-125cm on 12-20° slopes | Deep<br>100-125cm on 0-12° slopes<br>— |
| P | Physical soil characteristics (structure, texture consistency and horizonation) | Vfi to efi, csbk to pr and massive structures less than 25cm from surface<br>*Or*<br>Fi within 0-25cm and vfi-efi csbk-pr or massive structures within 25-50cm of surface on 12-20° slopes | Fi within 0-25cm and vfi to efi, csbk to pr or massive structures within 25-50cm of surface on 0-12° slopes<br>*Or*<br>Fi within 25-50cm and vfi-efi, csbk-pr or massive within 50-100cm of surface on 12-20° slopes | Fi within 25-50cm and vfi to efi, csbk to pr or massive structures within 50-100cm of surface on 0-12° slopes<br>*Or*<br>Loamy sand textures or lighter to depths of 100cm | Highly stratified or sharp lithic discontinuities within 100cm of the surface<br>*Or*<br>Sand loam testures with little soil profile development to depts of 100cm |
| D | Drainage | — | Very poorly drained<br>— | Poorly drained<br>*Or*<br>Excessively drained | Imperfectly drained<br>*Or*<br>Somewhat excessively drained or low moisture release |
| S | Salinity | Very strongly saline<br>>16 mmhos within 50cm of the surface | Strongly saline<br>8-16 mmhos within 50cm of the surface | Moderately saline<br>4-8 mmhos within 50cm of the surface | Weakly saline<br>2-4 mmhos within 50cm of the surface |
| R | Soil Reaction | pH 3.5 | pH 3.5-4.0 | pH 4.0-4.5 | — |
| A | Acid Sulphate Layer | Very shallow<br>0-25cm from the surface | Shallow<br>25-50cm from the surface | Moderately deep<br>50-100cm from the surface | Deep<br>100-125cm from the surface |
| O | Organic Horizon | Water logged—more than 100cm deep | Water logged—less than 100cm deep | — | — |
| V | Rockiness | Extremely stony<br>75% of soil volume | Very stony<br>50-75% of soil volume | Moderately stony<br>25-50% of soil volume | Slightly stony<br>10-25% of soil volume |
| N | Nutrient Imbalance | Toxicity caused by extremely high contents of certain elements | Acute nutrient deficiencies difficult to rectify by management | Acute nutrient deficiencies moderately difficult to rectify by management | Acute nutrient deficiencies easily rectified by management |
| H | Human | Disturbed land | — | — | — |

(Fi = firm; vfi = very firm; efi = extremely firm: pr = prismatic; csbk = coarse subangular blocky)

Salinity usually is not uniform throughout any one area. In general, however, the type of natural vegetation can be taken as an indication of the frequency of tidal flooding of a soil; mangrove, characterized by Rhizophora species occupy sites daily subjected to two tidal floods. The soils in such sites would be strongly to very strongly saline. Where the mangrove vegetation consists of species of Avicennia and Sonneratia, flooding by saline water is less frequent; soils in such sites can be expected to have conductivity readings of up to 8 millimhos/cm at 25°C, which would be within the moderately saline range. Often moderately saline sites can be identified by the presence of a mixture of mangrove and nipah palm (*Nipa fruticans*). On sites where the nipah palm is predominant, flooding by saline water is even less frequent so that the soils are very slightly saline. Where the nibong palm (*Oncosperma filamentosa*) is predominant, flooding by saline water is of very occasional occurrence, so that the soils are usually non-saline, under high rainfall conditions.

*Soil Reaction (R)*

Soil reaction (pH) is a critical factor in terms of crop growth and yield. Low soil pH causes reduced availability of major nutrients, deficiencies in minor nutrients, possible toxic effects from highly soluble elements, and lowering of the plants resistance to disease. Also, at pH values below 5.5 (water) considerable amounts of aluminium become strongly absorbed onto cation exchange sites thereby drastically reducing the value of the already low cation exchange capacity. This is further complicated by the remarkably low soil base saturation. Since there is such an abundance of acid soils in Malaysia and because soil acidity has a limiting effect on crop growth, this soil property has been added to the classification system.

Divisions of severity are based on the pH of the B horizon or in the case that no B horizon is present they are based on the pH of the subsurface. Most of the soils fall in the pH range of 4.5 to 5.0 and therefore no subclass value has been placed on them. It should be understood, however that soils in this range possess at least a minor limitation to some crops.

*Acid Sulphate Layer (A)—(no changes from Wong, 1970)*

A considerable acreage of marine alluvial soils in Malaysia are highly acid due to the presence of excessive amounts of oxidisable sulphur compounds. These sulphur compounds are produced by the microbiological reduction of sulphur derived from sea water. When the soil is drained oxidation of the sulphur compounds to sulphate takes place. Hydrolysis of the sulphate in water produces an acid condition in the soil. Drainage of a sulphide-containing soil usually results in severe deterioration of the condition of the soil so that very many years of continued aeration and leaching must elapse before the soil can become suitable for cultivation.

The acid sulphate condition of a soil can be determined in the laboratory. Two measurements are made, the pH of the air dried soil in a water culture and the water soluble sulphur content as sulphate. Soils with pH readings of 3.5 or lower and sulphate concentrations of more than 0.1% inhibit the growth of cultivated crops. As the acid sulphate condition of a soil is influenced by the permanent ground water table, this condition occurs in affected soils as a definite layer within the soil. Depth to the highly acid and strongly sulphurous layer is considered in the limitations to be similar to those for strongly compacted layers

*Organic Horizon (O)—(no changes from Wong, 1970)*

Organic or bog soils in Malaysia are associated with low areas which are usually waterlogged. They vary in organic matter content from true peats to organic clays and mucks. A true peat consists of incompletely decomposed organic debris and when ignited at 800°C to a constant weight, the loss in weight is more than 65%. Muck is organic material which has decayed to such an extent that plant remains are well broken down; on ignition its loss in weight is between 35% and 65%. Organic clay is predominantly clay in which there is a substantial proportion of decayed organic matter; its loss in weight on ignition is between 20% and 35%. High acidity is frequently associated with such soils.

Peats are poor anchoring mediums for trees. Because of their high porosity the permeability of peats is very rapid. Very frequently, in deep peats, large logs occur which impede tillage operations.

The maintenance of a correct water table level is critical in the proper utilization of peats. Over-draining produces very rapid initial shrinkage followed by irreversible drying and oxidation of the organic matter at the surface. Lack of draining results in waterlogging and inhibition of root development which in trees can result in poor anchorage and consequent leaning. With proper drainage, however, the cultivation of shallow-rooting crops is a feasible proposition and it has been shown that pineapple cultivation is very successful under such conditions. Mucks and organic clays, because they have higher mineral matter content, more thoroughly decomposed organic matter and are shallower, do not limit the cultivation of tree crops except where the drainage is poor or where the underlying clay is strongly sulphurous. In their natural condition even shallow peats possess a serious limitation to crop growth, namely, very poor drainage. When drained, however, progressive shrinkage of the peat occurs so that cultivation of permanent tree crops is limited.

*Rockiness (V)—(no changes from Wong, 1970)*

This limitation includes rocks, stones and concretions of varying sizes which occur as loosely dispersed particles within the soil and/or on its surface. Thus bands of stones, gravels and iron concretions occurring as non-indurated bands, or spread throughout the profile, are included under this heading.

Instead of considering only the surface area of land occupied by rocks, stones or concretions, the whole volume of a soil down to 100cm depth is taken into account so that soils which do not have rocky surfaces but are internally filled with stones and concretions can also be considered. While rocks on the surface can reduce the effective area for crop cultivation, those within the soil not only have the same effect but also impede proper root ramification besides reducing the effective soil volume for moisture and nutrient retention.

*Nutrient Imbalance (N)—(no changes from Wong, 1970)*

The soils of Malaysia are highly leached and low in fertility. In most cases nutrient deficiencies can be corrected by correct fertilizer application, but in other cases this is very difficult. Also, a soil with acute nutrient deficiencies needs a higher level of management or higher resource inputs. Acute nutrient deficiencies which are easily rectified by management are included as a minor limitation. Acute nutrient deficiencies which are difficult to rectify have been accorded moderate and serious limitations. The presence of excessive quantities of some elements such as boron, nickel and sulphur can be toxic to plants. Fertilizer application alone will not correct such excesses easily. Continuous applications of chemicals and years of continuous leaching may be necessary before the toxicity can be brought under control. Therefore, toxicity is considered a very serious limitation.

Nutrient imbalance limitations are presently defined on a subjective bases. This category will become more meaningful when more crop response information and soil analysis data becomes available.

*Human (H)*

Land that has been disturbed by human activity, particularly mining or urbanization, is non-agricultural land. This limitation is rated as very serious. If such land is reclaimed its capability classification will depend on the properties it has acquired as a result of the change in land use.

Thus, soil capability subclasses define the kinds of limitations to agricultural use that can be expected in an area. These are indicated on a map by the use of upper case letters (Table 5.2). No more than three limitations are shown, with these coming from the two most serious categories.

As is shown in Table 5.2, each limitation is subdivided into minor (n), moderate (m), serious (s) and very serious (v) according to the degree to which they affect crop growth. The severity of limitations are shown on a map by the use of lower case letters which are always placed to the right of the limitations which they modify. In cases where two limitations of equal severity are used, the severity symbol is used only once. In such instances the single severity notation should be taken as modifying the two limitations directly to its left.

Although soil capability subclasses are more narrowly defined than the capability classes, they are usually too broad to be of much use in terms of specific interpretations for crop suitability, cropping systems, management practices or levels of management. This is due to their inherent definition that they be used solely to indicate limitations and the severity of limitations to general agricultural use. Specific interpretations and recommendations require further subdivision of the system.

## 5.1.3 Soil Capability Performance Groups

Soil capability performance groups are subdivisions of capability subclasses, and are defined as collections of soils or soil mapping units, or single soils, that have comparable potential productivity and need similar management to maintain or improve their level of productivity. Performance groups are the finest subdivision of the system. Soils within each group are sufficiently similar that they can be expected to require similar conservation and management under the same kind and condition of vegetative cover, and have approximately the same potential productivity under comparable management. The uniformity of soils or soil mapping units within each performance group allows these groups to be used for making specific interpretations on crop suitability, required management practices, and the response of soil to various management practices.

Soil capability performance groups are derived by grouping soil and/or soil mapping units primarily on *similarities of soil physical and morphological characteristics and topographic similarities*. Decisions in this regard are influenced by considering the nature of the relationships between *soil parent materials* and *soil internal drainage* on the character of soil physical and morphological properties Significant *soil chemical differences* are considered also, but the general exhaustive state of these soils dictated that this property can be considered only rarely.

Soil capability performance groups condense and simplify soils information for planning purposes. When such units are combined with capability classes and subclasses, the map user is provided with information as to the kind, severity and number of limitations to agricultural use, as well as evaluations as to crop suitability and general management requirements.

Soil capability performance groups are shown on a map by the use of common Arabic numerals. They are listed from one to as many as are needed. They are summarized below in relation to their position to capability classes and subclasses.

CLASS I Soils with no limitations, or one or more minor limitations to agricultural use.

*Subclass I* Soils with no limitations.

*Group I—1* Friable, deep, moderately fine textured, brownish yellow to yellowish brown soils on level or nearly level terrain; developed on recent alluvium.

*Mapping Unit*—$\frac{\text{TMG/f}}{1}$

*Group I—2* Friable, deep, fine textured, brownish yellow to reddish yellow soils on level or nearly level terrain; developed on granite.

*Mapping Unit*—$\frac{\text{RGM}}{1}$

*Group I—3* Friable, deep, moderately fine textured, brownish yellow soils on level or nearly level terrain; developed on arenaceous shale.

*Mapping Unit*—$\frac{\text{BGR}}{1}$

*Group I—4* Friable, deep, moderately fine textured, brownish yellow to yellowish brown soils; developed on subrecent and older alluvium.

*Mapping Units*—$\frac{\text{HMU}}{1}$, $\frac{\text{RSU}}{1}$

*Subclass IEn* Soils subject to minor erosion if not protected.

*Group IEn—1* Friable, deep, fine textured, brownish yellow soils on undulating terrain; developed on granite.

*Mapping Unit*—$\frac{\text{RGM}}{2}$

*Group IEn—2* Friable, deep, fine textured, strong brown to yellowish red soils on undulating terrain; developed on andesite, quartz andesite or granodiorite.

*Mapping Units*—$\frac{\text{JRA}}{2}$, $\frac{\text{SGT-KTG}}{2}$, $\frac{\text{KTG}}{2}$

*Group IEn—3* Friable, deep, fine textured, strong brown to yellowish red soils on undulating terrain; developed on tuffaceous shale and sandstone.

*Mapping Units*—$\frac{\text{MUN}}{2}$, $\frac{\text{JML}}{2}$, $\frac{\text{SDG/c}}{2}$,

$\frac{\text{JML/f}}{2}$

*Group IEn—4* Friable, deep, moderately coarse to moderately fine textured, brownish yellow to reddish yellow soils on undulating terrain; developed on arenaceous shale and sandstone.

*Mapping Units*—$\frac{\text{BGR}}{2}$, $\frac{\text{BGR-KTG}}{2}$,[1] $\frac{\text{BGR-JML}}{2}$, $\frac{\text{BGR-SDG}}{2}$, $\frac{\text{SDG-BGR}}{2}$, $\frac{\text{SDG}}{2}$

*Group IEn—5* Deep, friable, moderately fine textured yellowish brown soils on undulating terrain; developed on older alluvium.

*Mapping Unit*—$\frac{\text{HMU}}{2}$

*Group IEn—6* Deep, friable fine textured, yellowish red to strong brown soils on rolling terrain; developed on andesite and quartz andesite.

*Mapping-Units*—$\frac{\text{SGT}}{3}$, $\frac{\text{KTG}}{3}$

*Group IEn—7* Deep, friable, fine textured, yellowish red to strong brown soils on rolling terrain; developed on tuffaceous shale and sandstone.

*Mapping Units*—$\frac{\text{JML}}{3}$, $\frac{\text{MUN-BGR}}{3}$, $\frac{\text{JML-BGR}}{3}$

*Subclass IDPn* Soils with minor limitations due to excessive drainage and sandy texture.

*Group IDPn—1* Deep, friable, moderately coarse textured, slightly stratified, pale brown to brownish yellow soils on level or nearly level terrain; developed on recent alluvium.

*Mapping Unit*—$\frac{\text{TMG}}{1}$

*Group IDPn—2* Deep, friable, moderately fine to moderately coarse textured, yellowish brown to pale brown soils on level or nearly level terrain; developed on subrecent alluvium.

*Mapping Units*—$\frac{\text{RSU-LNS}}{1}$, $\frac{\text{RSU-HYD}}{1}$

*Group IDPn—3* Deep, friable, moderately coarse textured, brownish yellow to pale brown soils on level or nearly level terrain; developed on subrecent alluvium.

*Mapping Units*—$\frac{\text{HYD}}{1}$, $\frac{\text{HYD-RSU}}{1}$, $\frac{\text{HYD-LNS}}{1}$

*Group IDPn—4* Deep, friable, moderately fine textured, yellowish brown soils on undulating terrain; developed on subrecent alluvium.

*Mapping Units*—$\frac{\text{RSU-LNS}}{2}$, $\frac{\text{RSU}}{2}$

*Group IDPn—5* Deep, friable, moderately coarse textured, pale brown to brownish yellow soils on undulating terrain; developed on subrecent alluvium.

*Mapping Units*—$\frac{\text{LNS}}{1}$, $\frac{\text{LNS-RSU}}{1}$, $\frac{\text{LNS-HYD}}{1}$

CLASS II Soils with one moderate limitation, or one moderate plus one or more minor limitations to agricultural use.

*Subclass IIEm* Soils moderately susceptible to erosion if not protected.

*Group IIEm—1* Deep, friable, moderately fine textured, brownish yellow soils on rolling terrain; developed on granite.

*Mapping Unit*—$\frac{\text{RGM}}{3}$

*Group IIEm—2* Deep, friable, moderately coarse to moderately fine textured, brownish yellow soils on rolling terrain; developed on sandstone and shale.

*Mapping Units*—$\frac{\text{BGR}}{3}$, $\frac{\text{BGR-BGR/r}}{3}$, $\frac{\text{BGR-JEM}}{3}$, $\frac{\text{BGR-SDG}}{3}$, $\frac{\text{SDG-BGR}}{3}$, $\frac{\text{SDG}}{3}$

*Group IIEm—3* Deep, friable, moderately fine textured, yellowish brown soils on rolling terrain; developed on older alluvium.

*Mapping Unit*—$\frac{\text{HMU}}{3}$

[1] Units of insignificant acreages are positioned into performance groups of similar properties as a matter of convenience rather than by definition.

*Group IIEm—4* Deep, friable, fine textured, yellowish red to strong brown soils on hilly terrain; developed on andesite, quartz andesite and granodiorite.

*Mapping Units*—$\frac{\text{SGT}}{4}$, $\frac{\text{KTG}}{4}$, $\frac{\text{JRA}}{4}$, $\frac{\text{JML-MUN}^1}{4}$

*Subclass IIDm EPn* Sandy, somewhat excessively drained soils, slightly susceptible to erosion.

*Group IIDm Epn—1* Deep, friable, moderately coarse textured, pale yellowed to strong brown soils on undulating terrain; developed on subrecent and older alluvium.

*Mapping Units*—$\frac{\text{HYD}}{2}$, $\frac{\text{HYD-LNS}}{2}$, $\frac{\text{TPI}^1}{2}$, $\frac{\text{LNS}^1}{2}$

*Subclass IIDm* Imperfectly to poorly drained soils with high water tables; textures are generally fine but may be variable.

*Group IIDm—1* Moderately deep, firm, fine textured, light gray soils on level or nearly level terrain; developed on recent alluvium.

*Mapping Unit*—$\frac{\text{AKB}}{1}$

*Group IIDm—2* Moderately deep, slightly firm to friable, variable textured, variable colored soils on level or nearly level terrain; developed on subrecent and recent alluvium.

*Mapping Units*—$\frac{\text{AKB-RVA}}{1}$, $\frac{\text{RVA-AKB}}{1}$, $\frac{\text{RVA}}{1}$, $\frac{\text{RSU-RVA}}{1}$

*Subclass IIPm En* Soils with firm to slightly firm subsoils and minor susceptibility to erosion if not protected.

*Group IIPm En—1* Deep to moderately deep, friable to firm, fine textured, brownish yellow soils on undulating terrain; developed on arenaceous shale.

*Mapping Units*—$\frac{\text{BGR-DRN}}{2}$, $\frac{\text{BGR-PHI}}{1}$

*Group IIPm En—2* Moderately deep, firm, fine textured, brownish yellow soils on undulating terrain; developed on shale and arenaceous shale.

*Mapping Units*—$\frac{\text{DRN}}{2}$, $\frac{\text{DRN-BGR}}{2}$, $\frac{\text{DRN-PHI}}{2}$

*Group IIPm En—3* Moderately deep, firm to slightly firm; moderately fine textured, very pale brown to olive soils on undulating terrain; developed on carbonaceous shale, shale and arenaceous shale.

*Mapping Units*—$\frac{\text{PHI}}{2}$, $\frac{\text{PHI-BGR}}{2}$, $\frac{\text{PHI-DRN}}{2}$, $\frac{\text{PHI-MRG}}{2}$, $\frac{\text{KMG}}{2}$

*Subclass IICm En* Soils having a compact layer at moderate depth, and minor susceptibility to erosion if left unprotected.

*Group IICm En—1* Deep to moderately deep, friable, fine textured, brownish yellow soils on undulating terrain; sporadic lateritic or compact layers within 100cm; developed on granite.

*Mapping Units*—$\frac{\text{RGM-RGM/co.}}{2}$, $\frac{\text{RGM-RGM/1}}{2}$

*Group IICm En—2* Deep to moderately deep, friable, fine textured, brownish yellow soils on undulating terrain; sporadic lateritic layers within 100cm; developed on sandstone.

*Mapping Unit*—$\frac{\text{SDG/c-SDG/cl}}{2}$

[1] Units of insignificant acreage are positioned into performance groups of similar properties as a matter of convenience rather than by definition.

*Group IICm En—3* Deep to moderately deep, friable, moderately fine to moderately coarse textured, brownish yellow soils on undulating terrain; sporadic lateritic layers within 100cm; developed on arenaceous shale and sandstone.

*Mapping Units*—BGR-BGR/1 / 2, BGR-JEM/1 / 2, BGR-SDG/1 / 2, BGR-MRG / 2, SDG-BGR/1 / 2, SDG-SDG/1 / 2.

*Group IICm En—4* Deep to moderately deep, friable, moderately fine textured, brownish yellow soils on undulating terrain; sporadic lateritic layers within 100cm; developed on subrecent alluvium.

*Mapping Unit*—RSU-BGR/1 / 2

*Group IICmEn—5* Moderately deep, friable, fine textured, brownish yellow soils on undulating terrain; lateritic and/or compact layers within 100cm; developed on granite.

*Mapping Units*—RGM/1-RGM / 2, RGM/co / 2, RGM/1 / 2, SGT/1-KTG[1] / 2, KTG/1[1] / 2

*Group IICmEn—6* Moderately deep, friable, moderately fine textured, brownish yellow soils on undulating terrain; lateritic layer layers within 100cm; developed on arenaceous shale or sandstone.

*Mapping Units*—BGR/1-BGR / 2, BGR/1-SDG / 2, BGR/1-DRN / 2, BGR/1-PHI / 2, BGR/1 / 2, BGR/1-MRG / 2, SDG/1-BGR/1 / 2

*Group IICmEn—7* Moderately deep, firm to slightly friable, fine textured, brownish yellow soils on undulating terrain; lateritic layer within 100cm; development on shale.

*Mapping Units*—DRN/1-BGR / 2, DRN/1-PHI/1 / 2

*Group IICmEn—8* Moderately deep, firm to slightly friable, moderately fine textured, pale yellowish brown to olive yellow soils on undulating terrain; sporadic lateritic layers within 100cm; developed on carbonaceous shale.

*Mapping Units*—PHI-PHI/1 / 2, PHI-DRN/1 / 2, DRN-DRN/1[1] / 2

*Group IICmEn—9* Moderately deep, friable, moderately fine textured, very pale brown to grayish soils on undulating terrain; compact layer within 100cm; developed on arenaceous shale and vein quartz.

*Mapping Units*—MRG-PHI / 2, MRG / 2

*Group IICmEn—10* Moderately deep, friable, fine textured, strong brown soils on rolling terrain; lateritic layer within 100cm; developed on granodiorite and arenaceous shale.

*Mapping Units*—JRA/1-BGR / 3, JML/1 / 3

[1] Units of insignificant acreages are positioned into performance groups of similar properties as a matter of convenience rather than by definition.

[1] Units of insignificant acreages are positioned into performance groups of similar properties as a matter of convenience rather than by definition.

CLASS III Soils with one serious limitation, or one serious and one or more moderate limitations, or two or more moderate limitations with or without other minor limitations to agricultural use.

*Subclass IIIEs* Soils subject to serious erosion if not protected.

*Group IIIEs—1* Deep, friable, fine textured, brownish yellow soils on hilly terrain; developed on granite.

*Mapping Unit*—$\frac{\text{RGM}}{4}$

*Group IIIEs—2* Deep, friable, moderately fine to moderately coarse textured, brownish yellow soils on hilly terrain; developed on arenaceous shale and sandstone.

*Mapping Units*—$\frac{\text{BGR}}{4}$, $\frac{\text{BGR-BGR/r}}{4}$, $\frac{\text{BGR-SDG}}{4}$, $\frac{\text{SDG}}{4}$, $\frac{\text{SDG-BGR}}{4}$, $\frac{\text{SDG-SDG/r}}{4}$

*Subclass IIIEPm* Soils with firm subsoil horizons that are subject to moderate erosion if not protected.

*Group IIIEPm—1* Moderately deep to deep, friable to firm, moderately fine to fine textured, brownish yellow soils on rolling terrain; developed on arenaceous shale.

*Mapping Units*—$\frac{\text{BGR-DRN}}{3}$, $\frac{\text{BGR-PHI}}{3}$, $\frac{\text{BGR-DRN-BGR/1}}{3}$

*Group IIIEPm—2* Moderately deep, firm to slightly firm, fine textured, brownish yellow soils on rolling terrain, developed on shale and arenaceous shale.

*Mapping Units*—$\frac{\text{DRN}}{3}$, $\frac{\text{DRN-BGR}}{3}$, $\frac{\text{DRN-PHI}}{3}$, $\frac{\text{DRN/r}}{3}$

*Group IIIEPm—3* Moderately deep, firm to slightly firm, moderately fine textured, pale yellowish brown soils on rolling terrain; developed on carbonaceous shale.

*Mapping Units*—$\frac{\text{PHI}}{3}$, $\frac{\text{PHI-BGR}}{3}$, $\frac{\text{PHI-MRG}}{3}$

*Subclass IIIPs* Shallow, very firm to extremely firm soils.

*Group IIIPs—1* Shallow to moderately deep, very firm, fine textured, brownish yellow soils on level to gently undulating terrain; developed on subrecent alluvium.

*Mapping Units*—$\frac{\text{SRK}}{1}$, $\frac{\text{SRK}}{2}$

*Subclass IIICEm* Soils with a compact layer at moderate depth, and moderate susceptibility to erosion if left unprotected.

*Group IIICEm—1* Moderately deep, friable, fine textured, brownish yellow soils on rolling errain; sporadic compact and/or lateritic layers within 100cm; developed on granite.

*Mapping Units*—$\frac{\text{RGM-RGM/1}}{3}$, $\frac{\text{RGM-RGM/co}}{3}$

*Group IIICEm—2* Moderately deep to deep, friable fine textured, brownish yellow soils on rolling terrain; lateritic or compact layer within 100cm; developed on granite.

*Mapping Units*—$\frac{\text{RGM/1-RGM}}{3}$, $\frac{\text{RGM/co-RGM}}{3}$, $\frac{\text{RGM/co}}{3}$, $\frac{\text{RGM/1}}{3}$

*Group IIICEm—3* Moderately deep to deep, friable, moderately fine to moderately coarse textured, brownish yellow soils on rolling terrain; sporadic lateritic layer within 100cm;

developed on arenaceous shale and sandstone.

*Mapping Units*—$\frac{\text{BGR-BGR/1,}}{3}$

$\frac{\text{BGR-BGR/1-SDG,}}{3}$

$\frac{\text{SDG-BGR/1,}}{3}$

$\frac{\text{SDG-SDG/1}}{3}$

*Group IIICEm—4* Moderately deep, firm to slightly firm, fine textured, brownish yellow soils on rolling terrain; sporadic lateritic layer within 100cm; developed on shale.

*Mapping Units*—$\frac{\text{DRN-BGR/1,}}{3}$

$\frac{\text{DRN-DRN/1}}{3}$

*Group IIICEm—5* Moderately deep, friable to slightly firm, moderately fine textured, brownish yellow soils on rolling terrain; lateritic layer within 100cm; developed on arenaceous shale and sandstone.

*Mapping Units*—$\frac{\text{BGR/1,}}{3}$ $\frac{\text{BGR/1-BGR,}}{3}$

$\frac{\text{BGR/1-SDG,}}{3}$

$\frac{\text{BGR/1-DRN,}}{3}$

$\frac{\text{BGR/1-PHI,}}{3}$

$\frac{\text{SDG/1-SDG}}{3}$

*Group IIICEm—6* Moderately deep, firm to slightly firm, fine textured, brownish yellow soils on rolling terrain; lateritic layer within 100cm; developed on shale and sandstone.

*Mapping Units*—$\frac{\text{DRN/1-BGR,}}{3}$

$\frac{\text{DRN/1-PHI,}}{3}$

$\frac{\text{DRN/1-BGR/1,}}{3}$

$\frac{\text{DRN/1-DRN}}{3}$

*Group IIICEm—7* Moderately deep, firm moderately fine textured, light yellowish brown soils on rolling terrain; sporadic lateritic layer within 100cm; developed on carbonaceous shale and shale.

*Mapping Units*—$\frac{\text{PHI-PHI/1,}}{3}$

$\frac{\text{PHI-BGR/1,}}{3}$

$\frac{\text{PHI-DRN/1}}{3}$

*Group IIICEm—8* Moderately deep, firm to slightly firm, moderately fine textured, light yellowish brown soils on rolling terrain, lateritic layer within 100cm; developed on carbonaceous shale.

*Mapping Units*—$\frac{\text{PHI/1-PHI,}}{3}$

$\frac{\text{PHI/1-BGR/1}}{3}$

*Group IIICEm—9* Moderately deep, friable, moderately fine textured, very pale brown to grayish soils on rolling terrain; compact layer within 100cm; developed on arenaceous shale and vein quartz.

*Mapping Units*—$\frac{\text{MRG,}}{3}$ $\frac{\text{MRG-PHI}}{3}$

*Group IIICEm—10* Moderately deep, friable, fine textured, strong brown to yellowish red soils on hilly terrain; lateritic layer within 100cm; developed on quartz andesite.

*Mapping Units*—$\frac{\text{KTG/1,}}{4}$ $\frac{\text{JML/1[1]}}{4}$

*Subclass IIICs* Soils with a compact layer at shallow depth.

*Group IIICm—1* Moderately deep to shallow, friable, fine textured, brownish yellow soils on undulating terrain; sporadic, thick lateritic layer within 50cm; developed on granite.

*Mapping Units*—$\frac{\text{RGM-MCA,}}{2}$

$\frac{\text{KTG-MCA[1]}}{2}$

[1] Units of insignificant acreages are positioned into performance groups of similar properties as a matter of convenience rather than by definition.

*Group IIICs—2* Moderately deep to shallow, friable, moderately fine textured, brownish yellow soils on undulating terrain; sporadic, thick lateritic layer wihin 50 cm; developed on arenaceous shale.

*Mapping Unit*—$\frac{\text{BGR-MCA}}{2}$

*Group IIICs—3* Moderately deep to shallow, firm, moderately fine textured, brownish yellow to very pale brown soils on undulating terrain; sporadic thick lateritic layer within 50 cm; developed on arenaceous shale and vein quartz.

*Mapping Units*—$\frac{\text{MRG-MCA,}}{2}$ $\frac{\text{PHI-MCA[1],}}{2}$

$\frac{\text{DRN-MCA[1]}}{2}$

*Subclass IIICsEm* Soils with a compact layer at shallow depth and moderate erosion hazards if unprotected.

*Group IIICsEm—1* Moderately deep to shallow, friable, fine textured, brownish yellow soils on rolling terrain; sporadic, thick lateritic layer within 50 cm; developed on granite.

*Mapping Unit*—$\frac{\text{RGM-MCA}}{3}$

*Group IIICsEm—2* Moderately deep to shallow, friable to firm, moderately fine textured, brownish yellow soils on rolling terrain; sporadic, thick lateritic layer within 50 cm; developed on shale, arenaceous shale, and sandstone.

*Mapping Units*—$\frac{\text{BGR-MCA,}}{3}$ $\frac{\text{SDG-MCA,}}{3}$

$\frac{\text{DRN-MCA,}}{3}$ $\frac{\text{PHI-MCA}}{3}$

*Subclass IIICsVm* Soils with a compact layer at shallow depth and moderate stone contents.

*Group IIICsVm—1* Shallow to moderately deep, friable, moderately fine to fine textured, brownish yellow soils on undulating terrain; lateritic layer of variable thickness within 50 cm; developed on arenaceous shale.

*Mapping Units*—$\frac{\text{BGR/1-MCA,}}{2}$

$\frac{\text{SDG/c1-MCA}}{2}$

*Group IIICsVm—2* Shallow, friable, moderately fine textured, reddish yellow to yellowish brown soils on undulating terrain; thick lateritic layer within 50 cm that occurs in more than 50% but less than 75% of the area; variable parent materials.

*Mapping Units*—$\frac{\text{MCA-RGM,}}{2}$

$\frac{\text{MCA-RGM-RGM/1,}}{2}$

$\frac{\text{MCA-BGR,}}{2}$ $\frac{\text{MCA-SDG,}}{2}$

$\frac{\text{MCA-RSU,}}{2}$

$\frac{\text{MCA-RGM/1,}}{2}$

$\frac{\text{MCA-BGR/1,}}{2}$

$\frac{\text{MCA-MRG.}}{2}$

*Group IIICsVm—3* Shallow to very shallow, friable to firm, moderately fine textured, brownish yellow soils on undulating terrain; thick layer of fragmental and massive laterite within 50 cm that covers more than 75% of the area; variable parent material.

*Mapping Unit*—$\frac{\text{MCA}}{2}$

*Subclass IIIDs* Soils with severely restricted internal drainage, and water tables at or near the surface.

*Group IIIDs—1* Shallow to moderately deep, firm to friable, fine to moderately fine textured, gray to pale brown soils on level or nearly level terrain; developed on recent alluvium.

*Mapping Units*—$\frac{\text{AKB-LAA,}}{1}$

$\frac{\text{LAA-AKB,}}{1}$ $\frac{\text{LAA}}{1}$

[1] Units of insignificant acreages are positioned into performance groups of similar properties as a matter of convenience rather than by definition.

*Group IIIDs—2* Shallow to moderately deep, friable, moderately coarse textured, yellowish brown to pale brown soils on level or nearly level terrain; developed on recent and sub-recent alluvium.

*Mapping Units*—KKR/1, RSU-LAA/1, LNS-LAA/1, ALC/1, LAA-LNS/1

CLASS IV Soils with two or more serious limitations with or without other moderate or minor limitations. These soils are restricted to a narrow range of crops.

*Subclass IVEPs* Soils with firm subsoil horizon and serious susceptibility to erosion if not protected.

*Group IVEPs—1* Deep to moderately deep, friable to firm, moderately fine textured, brownish yellow soils on hilly terrain; developed on shale and arenaceous shale.

*Mapping Unit*—BGR-DRN/4

*Group IVEPs—2* Moderately deep, firm, fine textured, brownish yellow soils on hilly terrain; developed on shale.

*Mapping Units*—DRN/4, DRN-BGR/4

*Group IVEPs—3* Moderately deep, firm to slightly firm, moderately fine textured, light yellowish brown soils on hilly terrain; developed on carbonaceous shale.

*Mapping Units*—PHI/4, PHI-MRG/4

*Subclass IVCEs* Soils with a compact layer at shallow depth and serious susceptibility to erosion if not protected.

*Group IVCEs—1* Moderately deep, friable, fine textured, brownish yellow soils on hilly terrain; sporadic compact and/or lateritic layer within 100 cm; developed on granite.

*Mapping Units*—RGM-RGM/1/4, RGM/co/4, RGM-RGM/co/4

*Group IVCEs—2* Moderately deep, friable, moderately fine to moderately coarse textured, brownish yellow soils on hilly terrain; sporadic compact and/or lateritic layer within 50-100 cm; developed on shale, arenaceous shale and sandstone.

*Mapping Units*—BGR-BGR/1/4, BGR-BGR/1-DRN/4, SDG-BGR/1/4, BGR/1-BGR/4, SDG/1-SDG/4, BGR/1/4, BGR/1-DRN/1/4, SDG/1/4, KDH-BGR/4, KDH-SDG/4, KDH/4, BGR/1-KDH/4, SDG-BGR/1/4, SDG-SDG/1/4, SDG-BGR/1-SDG/1/4

*Group IVCEs—3* Moderately deep, firm, fine textured, brownish yellow soils on hilly terrain; sporadic to continuous lateritic layers within 100 cm; developed on shale.

*Mapping Units*—$\frac{\text{DRN-DRN/1,}}{4}$

$\frac{\text{DRN/1-BGR/1,}}{4}$

$\frac{\text{DRN/1}}{4}$

*Group IVCEs—4* Moderately deep, firm to slightly firm, moderately fine to fine textured, light yellowish brown soils on hilly terrain; sporadic to continuous compact and/or lateritic layers within 100 cm; developed on carbonaceous shale and arenaceous shale.

*Mapping Units*—$\frac{\text{PHI-PHI/1,}}{4}$

$\frac{\text{PHI-BGR/1,}}{4}$

$\frac{\text{PHI-DRN/1}}{4}$

$\frac{\text{PHI/1-PHI,}}{4}$

$\frac{\text{PHI/1-BGR,}}{4}$

$\frac{\text{MRG-PHI}}{4}$

$\frac{\text{MRG,}}{4}$ $\frac{\text{KMG}}{4}$

*Subclass IVCV Em*—Very stony soils with a compact layer at shallow depth and moderate susceptibility to erosion if left unprotected.

*Group IVCVsEm—1* Moderately deep to shallow, friable to firm, moderately fine to fine textured, brownish yellow soils on rolling terrain; lateritic and/or compact layer of variable thickness within 50 cm; developed on arenaceous shales.

*Mapping Units*—$\frac{\text{BGR/1-MCA,}}{3}$

$\frac{\text{DRN/1-MCA,}}{3}$ $\frac{\text{UTM}^{1}}{3}$

*Group IVCVsEm—2* Shallow, firm to slightly firm, moderately fine textured, brownish yellow soils on rolling terrain; thick lateritic layer within 50 cm that occurs in more than 50% but less than 75% of the area; variable parent material.

[1] Units of insignificant acreage are positioned into performance groups of similar properties as a matter of convenience rather than by definition.

*Mapping Units*—$\frac{\text{MCA-RGM,}}{3}$

$\frac{\text{MCA-BGR,}}{3}$

$\frac{\text{MCA-DRN,}}{3}$

$\frac{\text{MCA/BGR/1,}}{3}$

$\frac{\text{MCA-DRN/1,}}{3}$

$\frac{\text{MCA-PHI}}{3}$

*Group IVCVsEm—3* Shallow to very shallow, friable to firm, moderately fine textured, brownish yellow soils on rolling terrain; thick layer of fragmental and massive laterite within 50 cm that occurs in more than 75% of the area; variable parent material.

*Mapping Unit*—$\frac{\text{MCA}}{3}$

*Subclass IVDOs* Very poorly drained organic soils with a high water table and less than 100 cm of surface peat.

*Group IVDs—1* Highly variable, gray to dark gray organo-mineral soils on level to nearly level terrain; developed on alluvium.

*Mapping Unit*—OCM

*Group IVDOs—2* Relatively undecomposed organic soils overlying coarse textured mineral materials.

*Mapping Unit*—PET/m

CLASS V Soils with at least one very serious limitation with or without other serious, moderate or minor limitations. Soils in this category are least suitable for crop growth and should be allowed to continue under primary or regenerating forest.

*Subclass VCvEVs* very stony soils with a compact layer at shallow depth and serious susceptiability to eroion if left unprotected.

*Group VCvEVs—1* Moderately deep to shallow, friable to firm, moderately fine textured, yellowish brown soils on hilly terrain; sporadic, thick lateritic layer within 50 cm; developed on carbonaceous shale and arenaceous shale.

*Mapping Units*—$\frac{\text{BGR-MCA}}{4}$, $\frac{\text{PHI-MCA}}{4}$

*Group VCvEVs—2* Shallow, friable to firm, moderately fine textured, brownish yellow soils on hilly terrain; lateritic and/or compact layer of variable thickness within 50 cm; developed on arenaceous shale, shale and carbonaceous shale.

*Mapping Units*—$\frac{\text{BGR/1-MCA}}{4}$, $\frac{\text{SDG/1-MCA-BGR/1}}{4}$, $\frac{\text{DRN/1-MCA}}{4}$, $\frac{\text{PHI/1-MCA}}{4}$, $\frac{\text{MRG-MCA}}{4}$, $\frac{\text{KMG-MCA}}{4}$

*Group VCvEVs—3* Shallow to very shallow, friable to firm, moderately fine to fine textured, brownish yellow soils on hilly terrain; thick lateritic layer within 50 cm that occurs in more than 50% but less than 75% of the area; variable parent material.

*Mapping Units*—$\frac{\text{MCA-BGR}}{4}$, $\frac{\text{MCA-DRN}}{4}$, $\frac{\text{MCA-PHI}}{4}$, $\frac{\text{MCA-BGR/1}}{4}$, $\frac{\text{MCA-PHI/1}}{4}$, $\frac{\text{MCA-MRG}}{4}$

*Group VCvEVs—4* Shallow to very shallow, friable to firm, moderately fine textured, brownish yellow soils on hilly terrain; thick layer of fragmental and massive laterite within 50 cm that covers more than 75% of the area; variable parent material.

*Mapping Unit*—$\frac{\text{MCA}}{4}$

*Subclass VOv* Very poorly drained organic soils with a high water table and more than 100 cm of surface peat.

*Group VOv—1* Relatively undecomposed organic soils overlying coarse textured mineral materials.

*Mapping Unit*—PET/d

*Subclass VEs* Soils with very serious susceptibility to erosion if left unprotected.

*Group VEv—1* Highly variable soils found on terrain in which slopes commonly exceed 20 degrees.

*Mapping Unit*—STP

*Subclass VHvEs* Soils disturbed by human activity and therefore seriously susceptible to erosion.

*Group VHvEs—1* Soils disturbed by open cast mining.

*Mapping Unit*—$\frac{\text{DLD}}{4}$

### 5.1.4 Assessment for Agriculture

#### 5.1.4.1 Soil suitability interpretations for selected crops

Rating the various soil capability performance groups for selected crops (Table 5.3) is one of many applications that can be made from the soil capability classification system. Each capability performance group is ranked according to the soil and terrain conditions in the group being well suited (W), suited (S), marginally suited (M) or unsuited (U) to the production of selected crops or groups of crops. These ratings are meant to indicate the suitability of individual crop groups on certain soil-land areas, disregarding climatic factors. They should *not* be taken as recommendations for the use of land. The latter decision can be based on these ratings, but must also take into consideration more implications than are intended here.

## Table 5.3—Crop Suitability According to Soil Performance Groups

| Soil Performance Group | Acreage | Crop Groups A Rubber | B Oil Palm | C Sago | D Tapioca | E Tea | F Grass | G Citrus | H Papaya | I Banana | J Cashew | K Cocoa | L Coconut | M Maize | N Rice |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Soil Capability Class I** | | | | | | | | | | | | | | | |
| I–1 .. .. | 790 | W | W | U | W | S | W | W | W | W | S | S | W | W | U |
| I–2 .. .. | 570 | W | W | U | W | W | W | W | W | W | S | W | W | W | U |
| I–3 .. .. | 390 | W | W | U | W | W | W | W | W | W | S | W | W | W | U |
| I–4 .. .. | 7,920 | W | W | U | W | W | W | W | W | W | W | S | W | W | U |
| IEn–1 .. .. | 43,410 | W | W | U | W | W | W | W | W | W | S | W | S | W | U |
| IEn–2 .. .. | 1,740 | W | W | U | S | W | W | W | W | W | S | W | S | S | U |
| IEn–3 .. .. | 1,230 | W | W | U | S | W | W | W | W | W | S | W | M | S | U |
| IEn–4 .. .. | 22,560 | W | W | U | W | W | W | W | W | W | S | S | M | W | U |
| IEn–5 .. .. | 12,210 | W | W | U | W | W | W | W | W | W | W | S | S | W | U |
| IEn–6 .. .. | 1,060 | W | S | U | U | W | M | W | S | W | S | W | U | U | U |
| IEn–7 .. .. | 740 | W | S | U | U | W | M | W | S | W | S | W | U | U | U |
| IDPn–1 .. .. | 3,260 | W | W | U | W | W | W | W | W | W | W | W | W | W | U |
| IDPn–2 .. .. | 9,170 | W | W | U | W | W | W | S | W | W | W | S | W | W | U |
| IDPn–3 .. .. | 6,540 | S | S | U | W | S | S | S | S | S | W | M | S | W | U |
| IDPn–4 .. .. | 1,570 | W | W | U | W | W | W | S | W | W | W | S | S | W | U |
| IDPn–5 .. .. | 8,330 | S | S | U | W | S | W | S | W | W | W | M | W | W | U |
| **Soil Capability Class II** | | | | | | | | | | | | | | | |
| IIEm–1 .. .. | 47,750 | W | S | U | U | W | M | W | M | W | S | W | U | U | U |
| IIEm–2 .. | 27,020 | W | S | U | U | W | M | W | M | W | S | W | U | U | U |
| IIEm–3 .. .. | 1,640 | W | S | U | U | W | M | S | M | W | W | S | U | U | U |
| IIEm–4 .. .. | 770 | S | M | U | U | S | U | S | U | U | S | M | U | U | U |
| IIDmEPn–1 .. | 2,440 | S | S | U | S | S | S | S | M | S | W | U | M | S | U |
| IIDm–1 .. | 26,950 | M | M | W | U | U | S | U | S | U | U | U | M | S | W |
| IIDm–2 .. | 15,130 | M | M | W | U | U | S | U | S | U | U | U | S | S | S |
| IIPmEn–1 .. | 4,110 | W | W | U | S | W | W | S | W | S | S | M | M | W | U |
| IIPmEn–2 .. | 2,600 | W | S | U | M | S | W | M | S | M | U | U | U | S | U |
| IIPmEn–3 .. | 2,800 | W | S | U | M | S | W | M | S | M | U | U | U | S | U |
| IICmEn–1 .. | 5,490 | W | W | U | W | W | W | W | W | S | S | S | M | W | U |
| IICmEn–2 .. | 1,820 | W | W | U | S | W | W | W | W | W | M | S | M | W | U |
| IICmEn–3 .. | 10,000 | W | W | U | S | W | W | W | W | S | S | S | M | W | U |
| IICmEn–4 .. | 870 | W | S | U | W | W | W | W | W | S | W | S | S | W | U |
| IICmEn–5 .. | 1,110 | W | S | U | S | W | W | S | W | M | S | M | U | W | U |
| IICmEn–6 .. | 3,870 | W | S | U | S | W | W | S | S | S | S | M | U | W | U |
| IICmEn–7 .. | 690 | S | M | U | U | S | W | M | S | U | U | U | U | S | U |
| IICmEn–8 .. | 660 | S | M | U | U | S | W | M | S | U | U | U | U | S | U |
| IICmEn–9 .. | 4,670 | S | M | U | M | S | W | M | M | U | S | U | U | S | U |
| IICmEn–10 .. | 1,990 | W | M | U | U | W | M | S | M | M | S | M | U | U | U |
| **Soil Capability Class III** | | | | | | | | | | | | | | | |
| IIIEs–1 .. | 6,410 | S | M | U | U | S | U | M | U | U | M | M | U | U | U |
| IIIEs–2 .. | 5,190 | S | M | U | U | S | U | M | U | U | M | U | U | U | U |
| IIIEPm–1 .. | 3,330 | S | M | U | U | M | M | M | M | M | U | U | U | U | U |
| IIIEPm–2 .. | 790 | S | M | U | U | U | M | U | M | U | U | U | U | U | U |
| IIIEPm–3 .. | 2,960 | S | M | U | U | U | M | U | U | U | U | U | U | U | U |

**Table 5.3—Crop Suitability According to Soil Performance Groups—(*cont.*)**

| Soil Performance Group | Acreage | A Rubber | B Oil Palm | C Sago | D Tapioca | E Tea | F Grass | G Citrus | H Papaya | I Banana | J Cashew | K Cocoa | L Coconut | M Maize | N Rice |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |
| **SOIL CAPABILITY CLASS III—(*cont.*)** | | | | | | | | | | | | | | | |
| IIIPs-1 .. .. | 9,690 | M | U | U | U | U | S | U | M | U | U | U | M | M | M |
| IIICEm-1 .. | 4,760 | W | S | U | U | W | M | S | M | S | S | S | U | U | U |
| IIICEm-2 .. | 1,630 | S | M | U | U | S | M | M | M | U | M | M | U | U | U |
| IIICEm-3 .. | 8,610 | W | S | U | U | W | M | S | M | S | S | M | U | U | U |
| IIICEm-4 .. | 500 | S | M | U | U | M | M | U | M | U | U | U | U | U | U |
| IIICEm-5 .. | 7,140 | S | M | U | U | S | M | M | M | U | M | U | U | U | U |
| IIICEm-6 .. | 1,470 | S | M | U | U | U | M | U | M | U | U | U | U | U | U |
| IIICEm-7 .. | 1,630 | S | M | U | U | U | M | U | M | U | U | U | U | U | U |
| IIICEm-8 .. | 1,910 | S | U | U | U | U | M | U | M | U | U | U | U | U | U |
| IIICEm-9 .. | 2,900 | S | M | U | U | M | M | U | M | U | M | U | U | U | U |
| IIICEm-10 .. | 350 | S | U | U | U | M | U | U | U | U | U | U | U | U | U |
| IIICs-1 .. | 980 | S | M | U | U | S | W | M | S | M | M | M | U | M | U |
| IIICs-2 .. | 4,250 | S | M | U | U | S | W | M | S | M | M | M | U | M | U |
| IIICs-3 .. | 1,290 | S | M | U | U | M | W | U | M | U | M | U | U | M | U |
| IIICsEm-1 .. | 1,280 | S | M | U | U | S | M | M | M | M | M | M | U | U | U |
| IIICsEm-2 .. | 1,800 | S | M | U | U | S | M | M | M | U | M | U | U | U | U |
| IIICsVm-1 .. | 2,390 | S | M | U | U | M | W | U | M | U | M | U | U | M | U |
| IIICsVm-2 .. | 7,480 | M | U | U | U | M | S | U | M | U | M | U | U | M | U |
| IIICsVm-3 .. | 6,960 | M | U | U | U | U | M | U | U | U | U | U | U | U | U |
| IIIDs-1 .. .. | 20,440 | M | M | S | U | U | S | U | M | U | U | U | S | U | S |
| IIIDs-2 .. .. | 12,520 | M | M | U | M | U | S | U | M | M | M | U | M | M | M |
| **SOIL CAPABILITY CLASS IV** | | | | | | | | | | | | | | | |
| IVEPs-1 .. | 870 | S | M | U | U | M | U | M | U | U | U | U | U | U | U |
| IVEPs-2 .. | 760 | S | U | U | U | U | U | U | U | U | U | U | U | U | U |
| IVEPs-3 .. | 1,570 | S | U | U | U | U | U | U | U | U | U | U | U | U | U |
| IVCEs-1 .. | 1,520 | S | M | U | U | S | U | M | U | U | S | U | U | U | U |
| IVCEs-2 .. | 9,890 | S | U | U | U | S | U | U | U | U | S | U | U | U | U |
| IVCEs-3 .. | 630 | M | U | U | U | U | U | U | U | U | U | U | U | U | U |
| IVCEs-4 .. | 6,480 | M | U | U | U | U | U | U | U | U | U | U | U | U | U |
| IVCVsEm-1 .. | 1,120 | S | U | U | U | U | M | U | U | U | M | U | U | U | U |
| IVCVsEm-2 .. | 8,320 | M | U | U | U | U | M | U | U | U | U | U | U | U | U |
| IVCVsEm-3 .. | 6,370 | M | U | U | U | U | M | U | U | U | U | U | U | U | U |
| IVDOs-1 .. | 360 | U | U | W | U | U | U | U | M | U | U | U | M | U | S |
| IVDOs-2 .. | 3,320 | U | U | U | U | U | U | U | U | U | U | U | U | U | U |
| **SOIL CAPABILITY CLASS V** | | | | | | | | | | | | | | | |
| VCvEVs-1 .. | 3,160 | M | U | U | U | U | U | U | U | U | U | U | U | U | U |
| VCvEVs-2 .. | 2,800 | U | U | U | U | U | U | U | U | U | U | U | U | U | U |
| VCvEVs-3 .. | 1,320 | U | U | U | U | U | U | U | U | U | U | U | U | U | U |
| VCvEVs-4 .. | 3,880 | U | U | U | U | U | U | U | U | U | U | U | U | U | U |
| VOv-1 .. .. | 61,350 | U | U | U | U | U | U | U | U | U | U | U | U | U | U |
| VEv-1 .. .. | 46,970 | U | U | U | U | U | U | U | U | U | U | U | U | U | U |
| VHvEs-1 .. | 60 | U | U | U | U | U | U | U | U | U | U | U | U | U | U |
| | 561,145 | | | | | | | | | | | | | | |

Assumption used in rating soil capability performance groups:

1. It is assumed that crops will be grown with at least a moderate level of management as determined by up to date research in equivalent environments. This means that fertilizers, lime and green manures will be used in accordance with the needs of the crop, and that erosion and competition from weeds will be controlled.

2. The ratings are based on current levels of agricultural technology. Advances in technology may require a reevaluation of the rating.

3. The ratings are compiled by the joint consent of the pedologists and agrologists employed in the Pahang Tenggara Masterplanning study. The evaluations of crop performance are based on past experience and on the knowledge gained from consultation with Malaysian officials. The guidelines used in evaluating crop performance according to limiting soil properties are provided in Appendix 8.3. Ratings may change as more research data on the relationships of crop growth to soil type becomes available.

4. The list of crops considered in this section are those which are widely grown or have been considered for commercial production. Absence of a crop from the list should not be interpreted as indicating that the crop cannot be grown.

5. The skill and resources of individual operators who can put in a higher level of management are not taken into account in the rating. Under extreme levels of management, applied with unusual skill, satisfactory yields of crops can sometimes be obtained on highly unfavourable soils. The ratings do not reflect such extreme levels of management.

6. The ratings are based on subjective rather than actual yield information, and should be interpreted in relation to this.

*Crop Groups*

For purposes of the rating, crops are clustered into groups of crops with similar growing habits, soil requirements and management requirements.

| | |
|---|---|
| A. Rubber Group ... | Rubber |
| B. Oil Palm Group | Oil Palm |
| C. Sago Group ... | Sago Palm |
| D. Tapioca Group ... | Tapioca, Sweet Potatoes, Soyabeans, Chillies, Vegetables |
| E. Tea Group ... | Lowland Tea |
| F. Grass Group ... | Stylo, Grasses (cut) |
| G. Citrus Group ... | Citrus, Mangosteen, Chiku |
| H. Papaya Group ... | Papaya, Pineapple, Passion Fruit, Guava, Salak |
| I. Banana Group ... | Bananas, Durian, Rambutan, Langsat, Duku, Soursop, Jackfruit, Chempedak, Avocado, Kundangan |
| J. Cashew Group ... | Cashew |
| K. Cocoa Group ... | Cocoa, Coffee |
| L. Coconut Group ... | Coconut |
| M. Maize Group ... | Maize, Sorghum, Groundnuts |
| N. Rice Group ... | Lowland Rice |

*Suitability Ratings*:

Definitions of the individual suitability ratings are as follows:

Well Suited (W)

Soil capability performance groups having few or no limitations for the production of the named crop. Such areas have soils that have favourable physical conditions or ones which respond well to management, and they have terrain which is favourable for the cultivation of the named crop. Moderate to high yields can be expected provided there are no climatic restrictions.

Suited (S)

Soil capability performance groups having few limitations of moderate severity to the production of the named crop. Physical soil conditions and/or terrain are only moderately favourable, but these can be overcome by moderate levels of management. Yields in relation to well suited soil-land areas are somewhat reduced for similar levels of management.

Marginal Suited (M)

Soil capability performance groups having several limitations of moderate severity, or few limitations of significant severity to production of the named crop. Physical soil conditions and/or terrain are only moderately favourable, and these are difficult to overcome with moderate levels of management. High management inputs are necessary to obtain satisfactory yields.

Unsuited (U)

Soil capability performance groups having severe limitations to production of the named crop. Satisfactory production is not feasible without the implementation of severely high levels of management.

A summary of the crop suitability information is shown in Table 5.4. This table shows acreages within each soil capability class which are either well suited (W) or suited (S) for the production of various crops or crop groups. It indicates that soil capability Classes I and II, which total about 280,700 acres, include soils which have the capacity to grow a wide range of crops. Only sago, rice and to a lesser degree coconut have limited acreages in these classes. Class III soils have some potential for the production of rubber, tea and/or grasses, and limited potential for sago, rice, coconut or other crops. A portion of the Class IV soils could be used for rubber, cashew or tea and to a much lesser extent for sago or rice. Class V soils are unsuitable for agriculture.

Table 5.4 shows considerable acreages of Class III and IV soils unaccounted for. These remaining soils are either highly lateritic or peaty, and these are only marginally suited for agriculture (See Table 5.3). Considering the total acreage of Class I and II soils, as well as the acreage suitable for rubber in Class III and IV, the total acreage suitable for development in the area covered by the semi-detailed soil survey is approximately 358,000 acres. This figure is based exclusively on soil suitability and does not necessarily represent the total acreage which would be desirable to develop.

### 5.1.4.2 Soil erodibility

Evaluation of soil erodibility is one of the many interpretive uses of the Soil Capability Classification. Evaluation of soil erodibility allows for better erosion management. The consequences of poor soil erosion control, especially in developing regions, can have serious long term effects. Decline in fertility with the loss in top soil usually results in lower crop yields. Silting of rivers can cause an appreciable change in stream flows with subsequent flooding and damage to water supplies, communications and property.

Soil erosion and conservation measures have been mentioned in several sections throughout the overall study report as well as various places throughout the soil survey report. This section attempts to tie together the various comments and recommendations and relate these to the soil conditions found in the region.

The Soil Capability Classification assesses soil erodibility according to soil texture, soil structure and surface topography. The relative erodibility of the soils in the semi-detailed soil survey area is indicated in Table 5.5. Over 10 per cent of the area is occupied by soils which should be left in protective forest because of very serious erosion hazards.

These areas include mostly land with average slopes of over 20°. A further 6 per cent of the area is occupied by soils with poor surface aggregation on slopes of 12 to 20°, which, if left unprotected, are susceptible to serious erosion. These areas have been recommended for development only where they contain deep soils or where they occur in smaller isolated tracts within larger areas of better soil. Conservation measures such as terracing and benching must be practiced in such areas. Nearly a quarter of the area surveyed is susceptible to moderate erosion if left unprotected. Such areas predominantly represent soils developed on 6 to 12° slopes and in most cases recommendations have included tree crops which provide a closed canopy or, tree crops grown in

**Table 5.5—Soil Erodibility According to Soil Capability Subclass Groupings**

| Symbol | Description | Acreage | Percentage |
|---|---|---|---|
| None | Little or no erosion hazard ... ... ... ... ... | 209,510 | 37.4 |
| En | Susceptible to minor erosion if left unprotected ... ... | 123,630 | 22.0 |
| Em | Susceptible to moderate erosion if left unprotected ... | 136,490 | 24.3 |
| Es | Susceptible to serious erosion if left unprotected ... | 33,380 | 6.0 |
| Ev | Susceptible to very serious erosion if left unprotected ... | 58,130 | 10.3 |

## Table 5.4—Summation of Crop Suitability Acreages According to Soil Capability Classes and Crop Groups

### Soil Capability Class I—119,380 acres

| | Rubber | Oil Palm | Sago | Tapioca | Tea | Grass | Citrus |
|---|---|---|---|---|---|---|---|
| W .. .. | 104,510 | 102,720 | — | 114,620 | 103,720 | 110,050 | 102,510 |
| S .. .. | 14,870 | 16,660 | — | 2,970 | 15,660 | 6,540 | 23,400 |
| | **Papaya** | **Banana** | **Cashew** | **Cocoa** | **Coconut** | **Maize** | **Rice** |
| W .. .. | 111,050 | 112,840 | 46,790 | 52,390 | 28,230 | 114,620 | — |
| S .. .. | 8,330 | 6,540 | 72,580 | 52,120 | 65,460 | 2,970 | |

### Soil Capability Class II—161,360 acres

| | Rubber | Oil Palm | Sago | Tapioca | Tea | Grass | Citrus |
|---|---|---|---|---|---|---|---|
| W .. .. | 111,050 | 21,420 | 42,080 | 6,350 | 105,650 | 38,670 | 92,940 |
| S .. .. | 9,230 | 90,080 | — | 23,350 | 14,620 | 44, 530 | 15,930 |
| | **Papaya** | **Banana** | **Cashew** | **Cocoa** | **Coconut** | **Maize** | **Rice** |
| W .. .. | 23,390 | 78,216 | 4,940 | 74,760 | | 27,260 | 26,950 |
| S .. .. | 52,690 | 26,780 | 106,780 | 19,810 | 16,000 | 55,940 | 15,130 |

### Soil Capability Class III—118.660 acres

| | Rubber | Oil Palm | Sago | Tapioca | Tea | Grass | Citrus |
|---|---|---|---|---|---|---|---|
| W .. .. | 13,370 | — | — | — | 13,370 | 8,900 | — |
| S .. .. | 48,200 | 13,370 | 20,440 | — | 28,680 | 50,130 | 13,370 |
| | **Papaya** | **Banana** | **Cashew** | **Cocoa** | **Coconut** | **Maize** | **Rice** |
| W .. .. | — | — | — | — | — | — | — |
| S .. .. | 5,230 | 13,370 | 13,370 | 4,763 | 20,438 | — | 20,440 |

### Soil Capability Class IV—41,200 acres

| | Rubber | Oil Palm | Sago | Tapioca | Tea | Grass | Citrus |
|---|---|---|---|---|---|---|---|
| W .. .. | — | — | 360 | — | — | — | — |
| S .. .. | 15,730 | — | — | — | 11,411 | — | — |
| | **Papaya** | **Banana** | **Cashew** | **Cocoa** | **Coconut** | **Maize** | **Rice** |
| W .. .. | — | — | — | — | — | — | — |
| S .. .. | — | — | 11,411 | — | — | — | 360 |

### Soil Capability Class V—119,550 acres

| | Rubber | Oil Palm | Sago | Tapioca | Tea | Grass | Citrus |
|---|---|---|---|---|---|---|---|
| W .. .. | — | — | — | — | — | — | — |
| S .. .. | — | — | — | — | — | — | — |
| | **Papaya** | **Banana** | **Cashew** | **Cocoa** | **Coconut** | **Maize** | **Rice** |
| W .. .. | — | — | — | — | — | — | — |
| S .. .. | — | — | — | — | — | — | — |

conjunction with suitable cover crops. The areas which are susceptible to minor erosion occur on 2 to 6° slopes and represent over 20 per cent of the land area. From an erosion standpoint, these areas are suitable for permanent cultivation of annual crops provided some soil conservation methods are followed. Conservation methods for such areas include mulching, contour plowing, or zero cultivation, or a combination of these. Mulching reduces the raindrop impact and reduces also the rate of decomposition of organic matter. Mulching is particularly effective with crops such as cocoa, coffee, bananas, and fruit trees where it often leads to higher yields. Zero cultivation resulting in minimal disturbance of the land surface is also a possibility in such areas but, so far, this technique has not been sufficiently tested.

Although over 37 per cent of the area is only slightly susceptible to erosion, these land areas represent lows which are affected by deposition of materials eroded from the upper slopes. In this regard, although these areas do not require such strict conservation measures, they are seriously affected if erosion is present in adjoining areas.

There are certain general recommendations which can be applied to all areas regardless of susceptibility to erosion, especially when new areas are opened. Other conservation measures need only be established according to erosion hazard. The following is a summary of conservation practices recommended for the Pahang Tenggara Region:

(1) Land should be cleared when the probability of rain is low, leaving a trash cover on the surface whenever possible.

(2) Clearing should be limited to acreages in which early establishment of fast growing crops for cover can be undertaken.

(3) Terracing, benching or contour plowing should be employed as necessary.

(4) Larger streams and their tributaries should be cleared of fallen trees and other debris.

(5) Natural vegetation should be preserved in a band about 5 chains wide along the banks of rivers.

(6) Construction of dropstructures in drains, to prevent erosion of drainage channels by reducing the velocity of water, should be undertaken.

(7) Proper agronomic practices such as fertilization and crop rotation should be followed to maintain adequate crop growth and possibly upgrade the soil base.

(8) Land with average slopes over 20° should not be opened for agriculture and should be left in protective forest.

(9) The more dissected areas with slopes of 12-20° should be left in protective forest wherever possible, especially in areas of coarse textured or shallow soils.

(10) Permanent annual crops should be restricted to slopes of less than 6°, preferably less than 4° on sandy soils.

(11) If logging is found necessary in steepland areas it should be planned carefully to minimize erosion. This can be done by careful design of timber tracks along slopes.

## 5.2 SOIL CAPABILITY CLASSIFICATION FOR ENTIRE PAHANG TENGGARA REGION

### 5.2.1 Soil Capability Classification

It is imperative to remember that the Soil Capability Classification scheme outlined in Section 5.1 was developed primarily to satisfy the detail of soil information obtained in the area covered by the semi-detailed soil survey. In the semi-detailed area all three levels of the capability classification can be employed, however, in the remainder of the region, where available soils information is more general, interpretations involve only the top category of the scheme, i.e. Capability Class. Consequently, the classifications for the overall region are similar to the system presently employed over Malaysia (Wong, 1970). Since the information used in assessing these classes is considerably more general than that in the semi-detailed area, it is correspondingly less useful for planning and implementation purposes. Even where information from the semi-detailed area was used, it was generalized to an extent which limits its usefulness for detailed planning.

### 5.2.2 Assessment for Agriculture

The evaluation of the soil and terrain conditions for agriculture throughout the entire Pahang Tenggara Region has been based on the Soil Capability Classification. Class definitions are the same as those outlined in Section 5.1.1. Table 5.6 indicates the relative proportions of the different soil capability classes in the overall region. There is a fairly high potential for the area outside the central semi-detailed survey

**Table 5.6—Soil Capability Acreages for the Entire Pahang Tenggara Region**

| Soil Capability Class | Acreage | Percentage |
|---|---|---|
| Class I | 377,000 | 15.2 |
| Class II | 359,000 | 14.4 |
| Class III | 595,000 | 24.0 |
| Class IV | 280,000 | 11.13 |
| Class V | 874,000 | 35.1 |
| TOTAL | 2,485,000 | 100.0 |

corridor, since more than half of the Class I and II soils (over 400,000[1] acres total) are not within the corridor. Future soil surveys will indicate more accurately the extent and usefulness of the better quality soils outside the semi-detailed area. In addition, over 400,000[1] acres of Class III soils suitable at least for rubber production are located outside the semi-detailed soil survey area. Areas of Class IV soils mostly represent the coastal sands and the firm, lateritic soils immediately west of the Tasek Bera. These soils are presently of low agricultural potential. The large acreages of Class V soils represent almost exclusively steepland areas and deep peat areas of the east coast peat swamp. These areas are presently designated as having little or no agricultural potential.

## 5.3 INTERPRETATIONS FOR ENGINEERING APPLICATIONS

In providing an overall masterplan for the region this project has made certain recommendations for town sites and road networks. These planning decisions have been partly influenced by the nature of the soil properties throughout the region. A broad assessment of the soil conditions as they are related to infrastructure planning has been made. Although the soil survey of the region was basically conducted to assess the soil suitability for agriculture, many of the soil properties determined have application for engineering uses. Soil properties of interest to engineers include those properties which affect the design, construction and maintenance of roads, airports, building foundations, sewage-disposal systems, drainage systems and pipelines.

[1] Acreages estimated by subtracting the acreage in each respective Soil Capability Class in the semi-detailed survey area from the total acreage in each Class in the overall region.

The reliability of the interpretations is controlled by the detail of the information which was available. Delineations are considerably more accurate in areas covered by the semi-detailed soil survey. In addition, the interpretations made from the soil survey information in this study are based only on a broad soil classification. The classifications infer certain pertinent soil properties and as such suggest the kinds of problems which may be encountered, but, since the interpretation of soil classifications and soil maps for engineering purposes is a more specialized field, more detailed interpretations and ratings have not been undertaken. The actual planning of buildings and roads will require detailed soil tests at the proposed sites of construction.

Table 5.7 indicates the groupings which have been designated on the Soil Interpretation Map For Engineering Purposes (Map 7). Areas of steepland and organic soils are designated as separate units and have not been included in the interpretive groupings. Steepland includes all areas with averages slopes greater than 20°, while the organic unit includes areas of peat, organic clay and muck, open water and marshes.

Classification of the soils outside the steepland and organic areas has been made according to the parent material and textural properties of the soil units which are designated on the Generalized Soil Map (Map 5). Each land area so grouped has been further rated on the probability of finding areas of laterite suitable for road building.

Textural groupings can be used as a guide in assessing soil bearing strength and soil workability. The coarse textured division refers to soils with sandy clay textures or coarser, while the fine textured soils consist of clays and silty clays.

## Table 5.7—Classification of Soils for Engineering Purposes

| Origin of Meterial | Texture | Map Symbol | Soil Units Included |
|---|---|---|---|
| Igneous .. | Coarse .. | Ic .. | Rengam, Harimau, Tampin, Tampoi, Yong Peng, Malacca[1] |
| | Fine .. | If .. .. | Katong, Segamat, Jerangau |
| Metamorphosed Sedimentary | Coarse .. | Mc .. | Marang, Malacca |
| | Fine .. | Mf .. | Pohoi, Kemuning |
| Sedimentary .. | Coarse .. | Sc.. .. | Bungor, Serdang, Jempol, Kedah, Kuala Barang, Tavy, Penyabong, Malacca |
| | Fine .. | Sf .. | Batu Anam, Durian, Munchong, Jeram |
| Alluvial .. | Coarse .. | Ac .. | Holyrood, Lunas, Rasau, Alluvial Complex, Local Alluvium, Telemong, Kawang, Riverine Alluvium, Baging, Linau, Rompin, Rudua, Rusila |
| | Fine .. | Af .. | Akob, Briah, Serok, Kranji |

[1] Malacca complex occurs on a range of geologic deposits but predominantly in sedimentary and metamorphosed sedimentary areas.

Coarse textured materials usually have a higher bearing strength and better workability than fine textured materials.

The parent material groups reflect the soils developed on the four major types of geological deposits in the region. These groups are important for engineering interpretations because soils developed on similar geological deposits acquire similar ranges in soil properties.

Igneous derived soils in both the coarse and fine textured divisions tend to be deep and friable, occurring uniformly over large areas. Igneous bedrock materials are usually void of stratifications and should provide good foundation footing. The coarse textured igneous soils have a high bearing strength while the good aggregate development in the fine textured group should give at least a moderately high bearing strength. Workability is good in all igneous derived soils. Lateritic horizons are not of common occurrence in igneous areas.

Soils developed on sedimentary rocks and metamorphosed sedimentary rocks are more variable than soils developed on igneous rocks. Depth to the underlying bedrock is commonly shallow, especially in the fine textured soils on hilly terrain. Fine textured soils in this group tend to have a firm to very firm consistency while the coarse textured members are generally more friable. The fine textured members occur predominantly in the western part of the region. They are considered to have a low bearing strength and tend to be very difficult to work. Laterite deposits are common in all areas where the soils are derived from sedimentary and metamorphosed sedimentary rocks.

The alluvial unit has been used to designate only extensive areas of soils developed on alluvium. The unit does not include the alluvial deposits which are scattered throughout the region along minor streams. These minor alluvial areas are significant factors in planning road construction but they occur in a fairly predictable and regular manner and, therefore, they are assumed as part of the natural catena. The designated alluvial areas occur on level to nearly level terrain and are commonly poorly drained or susceptible to flooding, or both. Complex minor drainage channels are common in this type of alluvial area. They are delineated as being relevant to infrastructure planning because of development costs associated with the large amounts of fill and extensive drainage works necessary.

Since laterite is an important component in road construction, it is significant that some indication of possible sources be given. The probability ratings, indicating the occurrence of laterite suitable for road construction, are based on the occurrence of lateritic soils in each area. The map delineations are not intended to be used to pinpoint suitable deposits but rather to give an indication of the vicinity in which laterite is more common. In the semi-detailed soil survey area more precise locations can be obtained from the soil map.

A high probability rating has been assigned to the areas where the intensely lateritic soils of the Malacca complex are dominant. Soils of this type contain a layer of laterite greater than 60 cm thick, the top of which is within 50 cm of the surface, (usually between 25-50 cm from the surface). This type of laterite should be quite suitable for road construction. The moderate probability rating has been used to delineate areas where soils with thin lateritic layers (usually 25-60 cm) are dominant, or in areas where soils of the Malacca Complex occur to a small but significant extent. Most areas with soils developed from sedimentary type deposits, which are not included in the high probability class, are included as having a moderate probability for laterite occurrence. Low probability areas include sedimentary areas where no laterite has been detected but some laterite is expected. This rating also includes most of the igneous rock areas because laterite occurs in such areas but it is not common. The designation which indicates that there is no potential for finding suitable laterite includes mostly alluvial areas.

# 6.0 FUTURE RESEARCH AND SOIL SURVEY REQUIREMENTS

Throughout the report comments have been made about a lack of data, the need for more data and the need for different data. In this section a summary of what is needed in the soil characterization is presented.

## 6.1 SOIL-CROP STUDIES

In order to practically apply the research results and yield records all studies should be done on a soil-crop basis. Research should be done on specific soils for specific purposes to ensure useful results which can be employed to improve current agricultural practices.

It would be impossible to test every soil type for all crops and purposes, therefore research should be done on soils which also occupy significant areas and extrapolations made to other soils. Selection of such soils in the Pahang Tenggara Region is simple because the soils of the Rengam and Bungor series occupy the most extensive areas in the semi-detailed area (20.4% and 15.6% respectively) and also represent some of the better soil areas of the region. The proposed MARDI research site is on the soils of the Rengam and Bungor series.

Once reliable yield data and management practices are established for the major soils, extrapolations can be made to other areas based on the Soil Capability Classification particularly at the Performance Group level. Further development of the Soil Capability Classification will be necessary depending on new research results.

More basic research is recommended on soils in the Pahang Tenggara Region. The clay mineralogy should be characterized. The relationships among clay mineralogy, pH, Al, Fe, Mn, micronutrients and microorganisms should be defined.

The need for lime and fertilizer as well as their long term effects on specific soils should be investigated.

The additions of organic material to increase the cation exchange capacity should be investigated. Crop yields on various soils do suffer during times of drought. The extent of drought periods and their relationship to soil type should be characterized. In this regard, available moisture, moisture retention and water-holding capacities should be investigated for different soils.

In doing research, applications to specific crops should be kept in mind. There will be a new nutrient cycling system set up for each crop. The optimum amendment applications will have to be defined in this new system. In certain areas the system will have to include livestock in addition to soils and crops.

The ultimate goal in understanding any soil-crop system is a mathematical model from which yields could be predicted at critical times of the growing season so that marketing arrangements could be made for disposing of excess production at a profit. In this regard, attempts should be made to computerize soil and crop data.

## 6.2 FUTURE SOIL SURVEY REQUIREMENTS

All the soil survey information necessary to implement development within the region is not presently available. Future information required can be broadly divided into two categories:

(1) semi-detailed surveys required to make final decisions on development strategies in some areas and,

(2) detailed surveys required to maximize land use and facilitate implementation of efficient management practices.

### 6.2.1 Semi-detailed Soil Surveys

It has not been possible to assess the entire region at a semi-detailed level of soil survey. Although all of the agricultural areas to be phased in during the Second Malaysia Plan period and almost all of the areas for the Third period have been surveyed in semi-detail, further surveys of this nature should be attempted for this latter period and for the second decade of

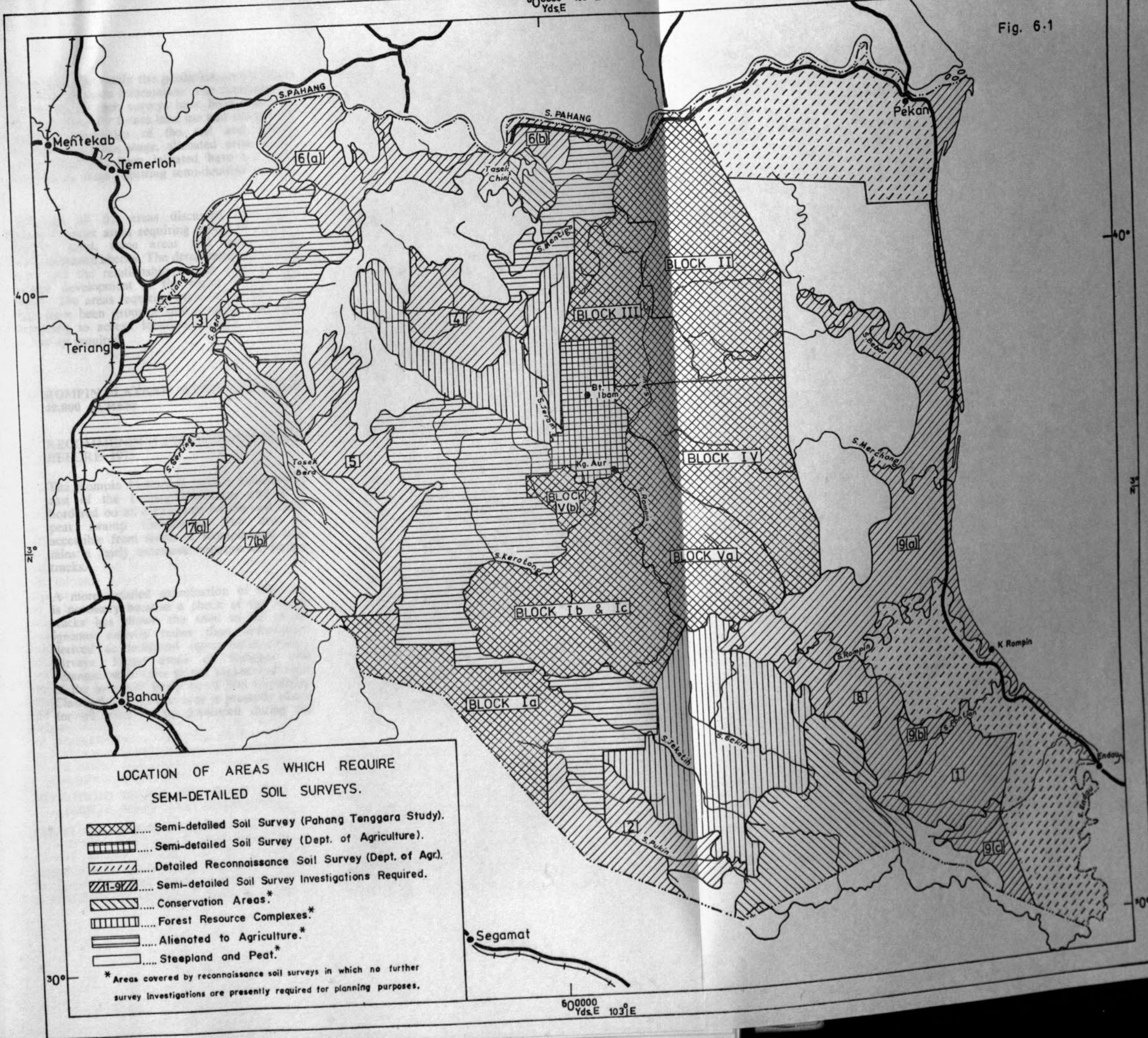


Fig. 6.1
600000 Yds.E 103°E
LOCATION OF AREAS WHICH REQUIRE SEMI-DETAILED SOIL SURVEYS.
..... Semi-detailed Soil Survey (Pahang Tenggara Study).
..... Semi-detailed Soil Survey (Dept. of Agriculture).
..... Detailed Reconnaissance Soil Survey (Dept. of Agr.).
1-9 ..... Semi-detailed Soil Survey Investigations Required.
..... Conservation Areas.*
..... Forest Resource Complexes.*
..... Alienated to Agriculture.*
..... Steepland and Peat.*
* Areas covered by reconnaissance soil surveys in which no further survey investigations are presently required for planning purposes.
S. PAHANG
Mentekab
Temerloh
Teriang
Bahau
Segamat
Pekan
K Rompin
Endau
Tasek Chini
Tasek Bera
Bt. Ibam
Kg. Aur
S. Teriang
S. Bera
S. Serting
S. Mentiga
S. Jeram
S. Rompin
S. Kerotong
S. Bebar
S. Merchong
S. Pontian
S. Endau
S. Tekatih
S. Selain
S. Pukin
BLOCK II
BLOCK III
BLOCK IV
BLOCK V(b)
BLOCK Va
BLOCK Ib & Ic
BLOCK Ia
6(a)
6(b)
3
4
5
7(a)
7(b)
8
9(a)
9(b)
9(c)
1
2
40°
3° N
30°

development to verify the predictions made from the reconnaissance information. The requirements and timing of such surveys have been based on the projections for future land use and the present state of knowledge of the soil and terrain conditions. At this stage, alienated areas where development has been initiated have not been included as areas requiring semi-detailed surveys.

Although all the areas discussed have been grouped under areas requiring survey at a semi-detailed level, some areas will require only reconnaissance checks. The detail required in each area and the relationship of the areas to the overall development of the region is provided below. The areas requiring more survey information have been grouped into 9 units (Fig. 6.1) according to access, location, phasing and type of survey required.

1. **ROMPIN PLATEAU (APPROXIMATELY 40,000 ACRES)**

   RECOMMENDED COMPLETION DATE: BEFORE 1975.

   The Rompin Plateau is located immediately east of the Lesong Highlands and it is bordered on all other sides by the east coast peat swamp formations. The area is accessible from south of Rompin and contains a fairly extensive network of timber tracks.

   A more detailed examination of this area is necessary because a check of the timber tracks has shown the soils to be mostly igneous derived rather than sedimentary derived as indicated from reconnaissance surveys. Large areas of Rengam and Jerangau soils exist in the region and most of the area will likely be of Soil Capability Classes I and II. The area is presently slated for oil palm to be developed during the Third Malaysia Plan, however, a semi-detailed soil survey should be completed to more accurately delineate the areas suitable for oil palm and possibly delineate areas suitable for diversified agriculture. It is expected that a small portion of this area will be suitable only for rubber.

2. **SOUTHWEST OF THE LESONG FOREST RESOURCE (APPROXIMATELY 50,000 ACRES)**

   RECOMMENDED COMPLETION DATE: BEFORE 1975.

   This area is located to the southwest of the Lesong Forest Resource. It is bounded on the north and east by Nucleus Estates and the Lesong Forest Complex, to the south by the Pahang-Johore border, and to the west by the southern portion of the semi-detailed soil survey area. The area is accessible along the western edge by a major timber track servicing the Nucleus Estates to the north.

   The soils in the central portion of the region are shown to be igneous rock derived, while soils on the eastern and western fringes are developed on sandstone-shale deposits. Although the central part of the area contains Rengam soils, the northeastern portion of this area has been designated as Class III agricultural land because of hilly terrain. The western segment has been designated as Class III due to soil conditions (Durian and Bungor Series) while the rest of the area is designated as Class I and III soils interdispersed.

   Most of the area is probably best suited to rubber production because of the hilly terrain. However, semi-detailed soil surveys would likely delineate significant areas suitable for oil palm.

### 3. NORTHWEST OF THE TASEK BERA AND WEST OF THE BERA FLDA SCHEME (APPROXIMATELY 45,000 ACRES)

RECOMMENDED COMPLETION DATE: BEFORE 1975.

This area is located in the extreme northwestern part of the region just south of the S. Pahang. Access to the area is good via several roads servicing adjacent alienated areas. Illegal cultivation occupies over 4,600 acres of the area.

The area consists of poorer quality soils (mostly Batu Anam, Durian and Tavy Series) interdispersed with low-lying flooded areas. However, terrain conditions over most of the area, especially in the northern part, are favourable. The area has been designated as mostly Class III soil with some areas of Class IV in the southeastern portion. Most of the area is probably best suited for rubber but further surveys should be conducted to verify the soils mapped and establish more accurately the soil patterns to aid in planning of cropping programs. The area is presently slated for small-holdings with the intention of producing rubber and various other crops associated with smallholding agriculture. Some of the area in the southern segment may be best suited as a productive forest resource.

### 4. JERAM VALLEY (APPROXIMATELY 42,000 ACRES)

RECOMMENDED COMPLETION DATE: BEFORE 1980.

The Jeram Valley is located in the north-central part of the region in the central syncline of the Jeram Highlands. Except for a timber track into the northeastern part of the region, the area is presently inaccessible by road.

This area was shown by previous surveys to contain some of the most agriculturally favourable soils (Serdang, Jeram and Bungor Series) in the Pahang Tenggara Region and was classified as a Class I agricultural area. A check by this study along existing timber tracks, indicates that the soils are similar to those mapped, likely suitable for oil palm and perhaps other diversified crops. However, the area is largely inaccessible by road and proper checks of the entire region have not been conducted. Since the soils are derived from sedimentary rocks, a complex distribution of soil types, laterite occurrence and terrain is expected. The area should be surveyed in semi-detail to delineate these patterns to facilitate more precise land use planning. It is expected that significant areas may be suitable for only rubber production.

### 5. EAST OF TASEK BERA (APPROXIMATELY 75,000 ACRES)

RECOMMENDED COMPLETION DATE: BEFORE 1980.

This area is located between the Tasek Bera conservation area and the Keratong Nucleus Estates and Government Servant Cooperative alienations. The area is accessible in the northern part by timber tracks leading from the Bera FLDA scheme. A timber track servicing the Keratong Nucleus Estate schemes skirts the southeastern edge of the area.

The soils mapped in previous surveys are mainly of the Serdang and Bungor Series with minor inclusions of other associated soils. A large part of this area was shown as Class I soil with inclusions of Class II and III. Recent topographic maps indicate that the terrain is hilly in some of the northern part, probably downgrading that area from Class I to Class III soils. In addition, since the soils are sedimentary derived it is expected that a complex distribution of soil types with the occurrence of much laterite will be found over all of the area, further downgrading the original assessment. Semi-detailed surveys will likely show most of the area suitable for rubber with possibly a large area in the headwaters of the S. Bera and other scattered areas suitable for oil palm. The extreme southern portion of the area has been tentatively selected for livestock production. The suitability of this area for livestock production and the delineation of areas suitable for oil palm must await further survey results.

### 6. NORTH OF THE JERAM HIGHLANDS (APPROXIMATELY 80,000 ACRES)

RECOMMENDED COMPLETION DATE: BEFORE 1980.

The area is located north of the Jeram Highlands in a strip immediately south of the S. Pahang Access by timber tracks is possible in the western part via K. Kg. Bera and in the eastern part via the Batu Balek road. The central portion is inaccessible by road but can be approached from the S. Pahang.

The western part of the area is shown to contain poorer soils (Batu Anam-Bungor-Malacca Association), but the terrain conditions appear quite favourable. The central portion consists of better soils (Bungor, Munchong, Serdang and Jeram Series) and has been indicated as Class I, however, recent topographic maps show the area to contain unfavourable terrain conditions. In addition, the area is developed on sedimentary deposits and complex soil distributions are expected. It is probable that areas suitable for oil palm do exist in the central region but delineation of their location and extent should be established by semi-detailed soil surveys. The eastern part of the area contains mostly unfavoubable terrain and it is unlikely that it will be suitable for anything other than rubber production.

7. **SOUTHWEST OF THE TASEK BERA (APPROXIMATELY 50,000 ACRES)**

RECOMMENDED COMPLETION DATE: BEFORE 1980.

Most of this area is in the western catchment basin for the Tasek Bera conservation area. The area is accessible through a fairly extensive network of timber tracks.

The eastern part of the area contains poorer quality soils (mostly Batu Anam-Malacca-Tavy Association) and because of steep terrain it has been shown to be mostly Class IV suitability for agriculture. This area will likely be reserved for a Productive Forest Resource unit because of the low agricultural potential and its location in the Tasek Bera catchment area. If this area is to be opened for agriculture a semi-detailed soil survey should be conducted to assess soil suitability for rubber.

The western part of the area lies outside the Tasek Bera catchment area and contains somewhat better soils (Marang, Batu Anam and Bungor Series) but the terrain is generally hilly or rolling. The area is shown as mostly Class III with some Class IV. The area will likely support rubber but it is doubtful if better quality land for oil palm exists. More detailed analysis may indicate that this area should be left in forest, especially if the Productive Forest Resource option is chosen for the area immediately east of it.

8. **NORTHEAST OF THE LESONG HIGHLANDS (APPROXIMATELY 40,000 ACRES)**

RECOMMENDED COMPLETION DATE: BEFORE 1980.

This area is located northeast of the Lesong Highlands and north of the Rompin Plateau. The area borders the northeastern edge of the Lesong Highlands and is bounded on the northern edge by swamps. The area is presently inaccessible by road although it may be approached from the south via roads in the Rompin Plateau and from the north by the Rompin River.

Previous surveys indicated that the area is composed of sedimentary derived soils, mostly Bungor with some Malacca soils. The area has been designated as consisting of Class III soils with significant areas of Class II soils. The soils may be better than shown because timber track surveys in the Rompin Plateau have indicated adjacent soils to be igneous rather than sedimentary rock derived. Although the geological information does not indicate igneous rocks in this area, a semi-detailed soil survey should be conducted to verify the soils mapped and delineate more accurately the areas suitable for agriculture. The area will likely prove suitable for rubber production.

9. **COASTAL SANDS AND ORGANIC SOILS (APPROXIMATELY 200,000 ACRES)**

RECOMMENDED COMPLETION DATE: BEFORE 1980.

The sandy coastal soils and the organic soils of the swamp formation have been grouped into one area for purposes of further investigation. The sandy coastal areas are accessible from the Pekan-Endau highway, but because of their limited agricultural potential no further soil surveys are presently recommended. However, in the organic soil areas, exploratory surveys should be conducted in the swamp area between the S. Rompin and S. Merchong and around the

S. Bebar. These soils have been shown to be largely of the better quality organic clay and muck type. Findings of this study indicate that conditions are not favourable for the formation of such deposits in that area but exploratory surveys should be conducted to verify this. There may be some areas of marine clays in this complex, in which case more detailed surveys should be conducted to delineate them. Access to the organic soil area is possible from the Kuala Rompin to Bukit Ibam road and from the S. Rompin, S. Merchong and S. Bebar.

## 6.2.2 Detailed Soil Surveys

Semi-detailed soil surveys form a sound basis for land use planning, but more detailed surveys are required in order that operators may more readily administer efficient agricultural practices. The application of future crop research and yield data to a large extent will depend on detailed soil survey information. There is an immediate need for such surveys in nearly all areas which are scheduled for agricultural development but efficiency and accuracy of soil surveys are increased if they are carried out after clearing, probably in the first year of planting. In the context of expedient implementation of the regional plan, certain priorities are given:

(a) *MARDI Research Site (2,500 acres)*

RECOMMENDED COMPLETION DATE: Either before clearing commences or after the area is cleared. Timing of this survey will depend on timing of the MARDI program for the area.

This area should be surveyed to facilitate detailed planning of research programs (*see* Appendix 8.4).

(b) *Forest Research Institute Sites (five sites consisting of approximately 120 acres).*

RECOMMENDED COMPLETION DATE: As requested by FRI but not during clearing.

These areas should be surveyed to confirm that they contain soils representative of the main soil series in the Bukit Ibam and Lesong Forestry Complexes.

(c) *Agricultural Development Units*

RECOMMENDED COMPLETION DATE: After clearing but within the first year of planting.

In the agricultural development areas, the need and type of survey to be completed will depend to a large extent on the implementation agency in individual areas. Private holdings may be surveyed on a request basis through the Department of Agriculture, or privately. If surveyed privately the system used by the Department of Agriculture should be followed. It is assumed that governmental agencies such as FLDA will continue their policy of having detailed surveys carried out by the Soils and Analytical Services Branch, Department of Agriculture. Phasing of these surveys should follow the Masterplanning phasing for the agricultural development units. Priority should be given to areas designated for diversified agriculture as well as an area along the Rompin River where a detailed drainage study is being proposed.

## 6.3 SOIL SURVEY TECHNIQUES

More work on geomorphology and the relationship between soils and landforms should be done. This will greatly aid in speeding up soil surveys. In this regard the uses of the latest developments in aerial photography and remote sensing should be studied for applications to densely forested and swampy areas. The implementation of some of these advances should greatly speed up and thus reduce costs of soil surveys. A carefully designed program of research in this area should be implemented.

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## 8.0 GLOSSARY

(This is not a complete glossary but only contains those terms which are frequently used in the report.)

*Alluvium*—Deposit of water-borne sediments in valleys and on river floodplains, deltas, beaches, etc.

*Argillaceous*—Clayey.

*Argillic horizon*—An alluvial horizon in which silicate clays have accumulated to a significant extent.

*Arenaceous*—Sandy.

*Base Saturation*—The proportion of the cation exchange complex occupied by bases; namely K*, Na*, Ca** and Mg**.

*Cation exchange capacity* (*CEC*)—A measure of the soils potential to hold cations in a form which is easily exchangeable with other cations in soil solution and consequently easily absorbed by plant roots.

*Colluvium*—Heterogeneous sediments deposited at the foot of slopes by gravitational processes such as soil slips, slope wash, etc.

*Consistence*—Soil consistence comprises the attributes of soil material that are expressed by the degree and kind of cohesion and adhesion or by the resistance to deformation or rupture.

*Eluvial horizon*—A horizon which has materials leached out in solution and suspension. It is usually lighter in color than the underlying horizon, has lost clay minerals, organic matter, iron or aluminium, or all four with the resultant concentration of the more resistant minerals.

*Gleying*—The process of intense reduction characterized by the presence of ferrous iron and neutral gray colors that commonly change to brown upon exposure to the air. This process involves saturation of the soil with water for long periods in the presence of organic matter.

*Illuvial horizon*—This is the horizon in which materials have accumulated from an eluvial horizon. It is usually darker in color than the overlying horizon and has gained clay minerals, iron, organic matter or aluminium, or all four.

*Lattice structure*—The orderly arrangement of atoms in crystalline material (as in a clay lattice).

*Loss on ignition*—Loss in weight of a soil dried at 105°C., and then heated to 800°C.

*Morphological*—The features comprised in the form and structure of a soil or any of its part.

*Mottling*—Streaked or spotted color patterns in soil horizons caused by the oxidation of iron rich compounds under the influence of a fluctuating water table.

*Parent material*—The unconsolidated mass from which the soil profile develops.

*pH* (*Soil reaction*)—The negative logarithm of the hydrogen—ion activity of a soil. The degree of acidity (or alkalinity) of a soil as determined by means of a glass electrode or other suitable electrode or indicator at a specific moisture content or soil/water ratio and expressed in terms of pH scale.

*Sedentary soils*—Soils formed *in situ*.

*Spodic horizon*—An illuvial accumulation of free sesquioxides accompanied by appreciable amounts of organic carbon.

*Texture*—The relative proportions of the various size groups of individual soil grains in a mass of soil. Specifically it refers to the proportions of clay, silt, and sand below 2 millimeters in diameter.

*Variegations*—An intermixture of two or more colors, often strongly contrasting, where no single color is dominant so that it is difficult to nominate a matrix color. The strongly weathered material forming the C horizon of many shale-derived soils is commonly variegated.

## 9.0 LABORATORY METHODS

Laboratory analysis was done by the Soils and Analytical Services Branch, Department of Agriculture, Kuala Lumpur. Detailed methodology is contained in a revised version of the Research Branch Laboratory Manual, Department of Agriculture, Malaysia (Arnott, 1964).

Mechanical analysis was done by the pipette method using N NaOH. Particle size distributions were calculated on a gravel and stone free basis.

Soil pH was determined on a soil paste (1:2.5) with both distilled water and 0.01 N KCl using a glass electrode.

Carbon was analyzed by the Walkley-Black method and nitrogen by the micro-Kjeldahl method. Organic matter was calculated by multiplying the percentage carbon × 1.724.

Easily soluble potassium was determined by extracting the soil with 0.5 N acetic acid followed by estimation in a flame photometer. Easily soluble phosphorus was extracted by leaching the soil with 2N sodium chloride and 0.2N hydrochloric acid, then digesting in 0.1N sodium hydroxide using a steam bath (Saunder's Method). Chloromolybdate and stannous chloride were used to develop color.

Cation exchange capacity was determined by leaching the soil with 0.1N barium chloride and titrating with 0.02N EDTA. Exchangeable bases were determined by shaking with N $NH_4OAC$. $Ca^{++}$ and $Mg^{++}$ were determined by titrating with 0.02N EDTA. $Na^+$ and $K^+$ were determined by flame photometry. Base saturation was calculated as a percentage of the cation exchange capacity.

# 9.0 APPENDIX

## 9.0 LABORATORY METHODS

Laboratory analysis was done by the Soils and Analytical Services Branch, Department of Agriculturel, Kuala Lumpur. Detailed methodology is contained in a revised version of the Research Branch Laboratory Manual, Department of Agriculture, Malaysia (Arnott, 1964).

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Soil pH was determined on a soil paste (1:2.5) with both distilled water and 0.01 N KCl using a glass electrode.

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Easily soluble potassium was determined by extracting the soil with 0.5 N acetic acid followed by estimation in a flame photometer. Easily soluble phosphorus was extracted by leaching the soil with 2N sodium chloride and 0.2N hydrochloric acid, then digesting in 0.1N sodium hydroxide using a steam bath (Saunder's Method). Chloromolybdate and stannous chloride were used to develop color.

Cation exchange capacity was determined by leaching the soil with 0.1N barium chloride and titrating with 0.02N EDTA. Exchangeable bases were determined by shaking with N $NH_4OAC$. Ca†† and Mg†† were determined by titrating with 0.02N EDTA. Na† and K† were determined by flame photometry. Base saturation was calculated as a percentage of the cation exchange capacity.

## 9.1 MAPPING UNITS

**Table 9.1—Soil Mapping Units and Acreage Distribution in the Semi-Detailed Soil Survey Area**

| Mapping Unit | Terrain | Block Number | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ia | Ib | Ic | II | III | IV | Va | Vb | |
| AKB | 1 | | 4,372 | 193 | 3,104 | 1,046 | 4,068 | 12,120 | 2,049 | 26,952 |
| AKB-LAA | 1 | | | | | | 1,349 | 107 | | 1,456 |
| AKB-RVA | 1 | | 628 | | 51 | 1,587 | | 2,461 | | 4,727 |
| | | | | | | | | | Subtotal | 33,135 |
| ALC | 1 | | | | 5,803 | | 1,531 | 131 | | 7,465 |
| BGR | 1 | | 66 | | 312 | | 9 | | | 387 |
| BGR | 2 | 1,445 | 21 | 239 | 5,543 | 188 | 2,551 | 3,220 | 46 | 13,253 |
| BGR | 3 | 1,674 | 370 | 527 | 1,643 | 1,919 | 1,768 | 2,413 | | 10,314 |
| BGR | 4 | 186 | 163 | | 119 | 70 | 174 | 206 | | 918 |
| BGR-BGR/1 | 2 | 2,838 | | 577 | 716 | 319 | 897 | 1,122 | 21 | 6,490 |
| BGR-BGR/1 | 3 | 3,296 | 202 | 266 | 1,702 | 702 | 34 | 1,773 | | 7,975 |
| BGR-BGR/1 | 4 | 1,099 | | | | 673 | 364 | 53 | | 2,189 |
| BGR/1 | 2 | 343 | 63 | | 317 | 99 | 203 | | | 1,025 |
| BGR/1 | 3 | 532 | | | 209 | 200 | | | | 941 |
| BGR/1 | 4 | 22 | | | 410 | 87 | | | | 519 |
| BGR/1-BGR | 2 | | 486 | | | 158 | 483 | | | 1,127 |
| BGR/1-BGR | 3 | 361 | 1,615 | | 5 | 1,183 | | 496 | | 3,660 |
| BGR/1-BGR | 4 | 577 | 2,800 | | | 104 | | | | 3,481 |
| BGR-BGR/r | 3 | 348 | | | | | | | | 348 |
| BGR-BGR/r | 4 | 132 | | | | | | | | 132 |
| BGR-MCA | 2 | 591 | | | 691 | 72 | 2,648 | 245 | | 4,247 |
| BGR-MCA | 3 | 223 | 267 | | | 196 | 317 | 109 | | 1,112 |
| BGR-MCA | 4 | 910 | | | 686 | | | | | 1,596 |
| BGR/1-MCA | 2 | 322 | | | | 1,396 | 365 | 147 | | 2,230 |
| BGR/1-MCA | 3 | 382 | | | 233 | | | | 310 | 925 |
| BGR/1-MCA | 4 | | | | 333 | 279 | | | | 612 |
| BGR-SDG | 2 | 875 | 167 | | 188 | | 1,401 | 345 | | 2,976 |
| BGR-SDG | 3 | | 574 | | 1,121 | | 410 | 526 | | 2,631 |
| BGR-SDG | 4 | 227 | | | 36 | 288 | 207 | | | 758 |
| BGR/1-SDG | 2 | | 215 | | | | | | | 215 |
| BGR/1-SDG | 3 | | | | | 1,011 | | | | 1,011 |
| BGR-SDG/1 | 2 | 634 | | | | | | | | 634 |
| BGR-DRN | 2 | 2,651 | | | 48 | 304 | 779 | 332 | | 4,114 |
| BGR-DRN | 3 | | | | | | 9 | 734 | | 743 |
| BGR-DRN | 4 | | | | | 871 | | | | 871 |
| BGR/1-DRN | 2 | | | | | | | 252 | | 252 |
| BGR/1-DRN | 3 | | | | 161 | 125 | | | | 286 |
| BGR/1-DRN/1 | 4 | | | | 416 | | | | | 416 |
| BGR-JEM/1 | 2 | | | | | | | 371 | | 371 |
| BGR-JEM | 3 | | | | | | | 2,433 | | 2,433 |
| BGR-MRG | 2 | | | | | 257 | | | | 257 |
| BGR/1-MRG | 2 | | | | 370 | 441 | | | | 811 |
| BGR/1-PHI | 2 | | | | | 285 | | | | 285 |
| BGR/1-PHI | 3 | | | | | 802 | | | | 802 |
| BGR-PHI | 3 | | | | | 352 | 635 | 266 | | 1,253 |
| BGR-KTG | 2 | | | | | 105 | | | | 105 |
| BGR-JML | 2 | 279 | | | | | | | | 279 |
| BGR/1-KDH | 4 | | | | 48 | 209 | | | | 257 |
| BGR-DRN-BGR/1 | 3 | 1,334 | | | | | | | | 1,334 |
| BGR-BGR/1-SDG | 3 | | 86 | | | | | | | 86 |
| BGR-BGR/1-DRN | 4 | | | | | 656 | | | | 656 |
| | | | | | | | | | Subtotal | 87,317 |

## Table 9.1—Soil Mapping Units and Acreage Distribution in the Semi-Detailed Soil Survey Area—(*cont.*)

| Mapping Unit | Terrain | Block Number | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ia | Ib | Ic | II | III | IV | Va | Vb | |
| DRN | 2 | 487 | | | 210 | 170 | 416 | | | 1,283 |
| DRN | 3 | | | | | 303 | | 23 | | 326 |
| DRN | 4 | | | | | 442 | 286 | | | 728 |
| DRN/r | 3 | 68 | | | | | | | | 68 |
| DRN/l | 4 | | | | | 330 | | | | 330 |
| DRN-BGR | 2 | | | | | 609 | | | | 609 |
| DRN-BGR | 3 | | | | | | 249 | | | 249 |
| DRN-BGR | 4 | | | | | | 30 | | | 30 |
| DRN/l-BGR | 2 | | | | | 463 | | | | 463 |
| DRN/l-BGR | 3 | | | | | 239 | | | | 239 |
| DRN-BGR/l | 3 | | | | | 262 | | | | 262 |
| DRN/l-BGR/l | 3 | | | | | 865 | | | | 865 |
| DRN/l-BGR/l | 4 | | | | | 140 | | | | 140 |
| DRN-DRN/l | 2 | | | | 308 | | | | | 308 |
| DRN/l-DRN | 3 | | | | | 143 | | | | 143 |
| DRN-DRN/l | 3 | | | | | 241 | | | | 241 |
| DRN-DRN/l | 4 | 70 | | | | | | 87 | | 157 |
| DRN-MCA | 2 | | | | | | | 147 | | 147 |
| DRN-MCA | 3 | | | | | | | 102 | | 102 |
| DRN/l-MCA | 3 | | | | | 110 | | | | 110 |
| DRN/l-MCA | 4 | | | | | 480 | 116 | | | 596 |
| DRN-PHI | 2 | | | | | 37 | 315 | 352 | | 704 |
| DRN-PHI | 3 | | | | | | | 151 | | 151 |
| DRN/l-PHI/l | 2 | | | | 225 | | | | | 225 |
| DRN/l-PHI | 3 | | | | | | | 225 | | 225 |
| | | | | | | | | | Subtotal | 8,701 |
| DLD | 4 | | | | | 62 | | | | 62 |
| HMU | 1 | 215 | | | | | | 308 | 683 | 1,206 |
| HMU | 2 | 5,320 | 1,310 | 4,772 | | | 18 | 789 | | 12,209 |
| HMU | 3 | 970 | | 666 | | | | | | 1,636 |
| | | | | | | | | | Subtotal | 15,051 |
| HYD | 1 | | | 388 | 378 | 606 | 284 | 634 | | 2,290 |
| HYD | 2 | | | | 130 | 202 | 209 | 81 | | 622 |
| HYD-LNS | 1 | | | | 1,995 | 381 | 66 | 442 | 372 | 3,356 |
| HYD-LNS | 2 | | | | 968 | | | | | 968 |
| HYD-RSU | 1 | | | | | | | 990 | | 990 |
| | | | | | | | | | Subtotal | 8,126 |
| JML | 2 | 169 | | | | | | | | 169 |
| JML | 3 | 306 | | | 54 | | | 35 | | 395 |
| JML/f | 2 | 158 | | | | | | | | 158 |
| JML/l | 3 | 60 | | | | | | | | 60 |
| JML/l | 4 | | | | 51 | | | | | 51 |
| JML-BGR | 3 | | | | 210 | | | | | 210 |
| JML-MUN | 4 | | | | 175 | | | | | 175 |
| | | | | | | | | | Subtotal | 1,218 |
| JRA | 2 | 283 | | | | | | | | 283 |
| JRA | 4 | 142 | | | | | | | | 142 |
| JRA/l-BGR | 3 | 742 | | 1,189 | | | | | | 1,931 |
| | | | | | | | | | Subtotal | 2,356 |

**Table 9.1—Soil Mapping Units and Acreage Distribution in the Semi-Detailed Soil Survey Area—(*cont.*)**

| Mapping Unit | Terrain | Block Number | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ia | Ib | Ic | II | III | IV | Va | Vb | |
| KKR | 1 | | | 250 | 1,147 | | 351 | 175 | | 1,923 |
| KDH | 4 | 152 | 667 | | 115 | 9 | | 22 | | 965 |
| KDH-SDG | 4 | | | | | | | 292 | | 292 |
| KDH-BGR | 4 | | 105 | | | 325 | | 102 | | 532 |
| | | | | | | | | | Subtotal | 1,789 |
| KMG | 2 | | | | | | 83 | | | 83 |
| KMG | 4 | | | | | | 122 | | | 122 |
| KMG-MCA | 4 | | | | | | | 465 | | 465 |
| | | | | | | | | | Subtotal | 670 |
| KTG | 2 | | | | | 219 | | | 67 | 286 |
| KTG | 3 | | | | | 991 | | | | 991 |
| KTG | 4 | | | | | 252 | | | | 252 |
| KTG/l | 2 | | | | | | 61 | | | 61 |
| KTG/l | 4 | | | | 229 | | 70 | | | 299 |
| KTG-MCA | 2 | 55 | | | 165 | | | | | 220 |
| | | | | | | | | | Subtotal | 2,109 |
| LAA | 1 | 1,821 | 600 | 4,734 | 2,132 | 665 | 2,874 | 2,283 | 537 | 15,646 |
| LAA-AKB | 1 | | | | | | 1,476 | 1,860 | | 3,336 |
| LAA-LNS | 1 | | | | 779 | | | | | 779 |
| | | | | | | | | | Subtotal | 19,761 |
| LNS | 1 | 769 | | | 563 | 368 | 305 | 83 | 30 | 2,118 |
| LNS | 2 | | | | 80 | | | | | 80 |
| LNS-HYD | 1 | | | | 4,325 | 306 | | | | 4,631 |
| LNS-HYD | 2 | | | | 631 | | | | | 631 |
| LNS-LAA | 1 | | | | 1,930 | | | | | 1,930 |
| LNS-RSU | 1 | | | | 1,572 | | 13 | | | 1,585 |
| | | | | | | | | | Subtotal | 10,975 |
| MCA | 2 | 1,332 | 1,264 | | 1,189 | 83 | 1,742 | 1,345 | | 6,955 |
| MCA | 3 | 594 | 966 | 112 | 306 | 454 | 2,197 | 1,740 | | 6,369 |
| MCA | 4 | | 165 | | 514 | 2,035 | 429 | 737 | | 3,880 |
| MCA-BGR | 2 | 110 | | | | 133 | 198 | 98 | | 539 |
| MCA-BGR | 3 | 193 | | | 973 | | | 261 | | 1,427 |
| MCA-BGR | 4 | | | | | | | 112 | | 112 |
| MCA-BGR/l | 2 | | | | 4,431 | | 23 | 87 | | 4,541 |
| MCA-BGR/l | 3 | | 1,930 | | 756 | 84 | 590 | 633 | | 3,993 |
| MCA-BGR/l | 4 | | 13 | | | 45 | 29 | | | 87 |
| MCA-DRN | 3 | | | | | 380 | 277 | | | 657 |
| MCA-DRN | 4 | 42 | | | | | 88 | 44 | | 174 |
| MCA-DRN/l | 3 | | | | | 125 | 1,063 | | | 1,188 |
| MCA-PHI | 3 | | | | | 260 | | | | 260 |
| MCA-PHI | 4 | | | | | 362 | | | | 362 |
| MCA-PHI/l | 4 | | | | | 395 | | | | 395 |
| MCA-MRG | 2 | | | | 55 | | | | | 55 |
| MCA-MRG | 4 | | | | 193 | | | | | 193 |
| MCA-RGM | 2 | | | | | | 749 | | | 749 |
| MCA-RGM | 3 | | | | | | 795 | | | 795 |
| MCA-RGM/l | 2 | | | | | | 228 | 77 | | 305 |
| MCA-SDG | 2 | | | | | | 435 | | | 435 |
| MCA-RSU | 2 | | | | 164 | | | | | 164 |
| MCA-RGM-RGM/l | 2 | | | | | | 690 | | | 690 |
| | | | | | | | | | Subtotal | 34,325 |

**Table 9.1—Soil Mapping Units and Acreage Distribution in the Semi-Detailed Soil Survey Area—(*cont.*)**

| Mapping Unit | Terrain | Block Number | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ia | Ib | Ic | II | III | IV | Va | Vb | |
| MRG | 2 | | | | 1,329 | 1,884 | 97 | | | 3,310 |
| MRG | 3 | | | | 78 | 610 | | | | 688 |
| MRG | 4 | | | | | 752 | | | | 752 |
| MRG-PHI | 2 | | | | | 1,107 | | 257 | | 1,364 |
| MRG-PHI | 3 | | | | 330 | 1,881 | | | | 2,211 |
| MRG-PHI | 4 | | | | | 1,911 | 523 | | | 2,434 |
| MRG-MCA | 2 | | | | 361 | 552 | | | | 913 |
| MRG-MCA | 4 | | | | 401 | 172 | | | | 573 |
| | | | | | | | | | Subtotal | 12,245 |
| MUN | 2 | | | | | 72 | | | | 72 |
| MUN-BGR | 3 | | | | | | 133 | | | 133 |
| | | | | | | | | | Subtotal | 205 |
| OCM | 1 | | | | 269 | | 89 | | | 358 |
| PET/m | 1 | | 514 | | 2,091 | | 481 | 230 | | 3,316 |
| PET/d | 1 | | | | 36,447 | | 24,320 | 586 | | 61,353 |
| | | | | | | | | | Subtotal | 64,669 |
| PHI | 2 | | | | 52 | 684 | | 355 | | 1,091 |
| PHI | 3 | | | | | 450 | 451 | 297 | | 1,198 |
| PHI | 4 | | | | 479 | 497 | 307 | | | 1,283 |
| PHI-PHI/l | 2 | | | | | | | 190 | | 190 |
| PHI-PHI/l | 3 | | | | | 180 | 678 | 276 | | 1,134 |
| PHI-PHI/l | 4 | | 446 | | | | | 153 | | 599 |
| PHI/l-PHI | 3 | | | | 213 | 862 | | | | 1,075 |
| PHI/l-PHI | 4 | | | | | 107 | | | | 107 |
| PHI-BGR | 2 | | | | | 838 | | | | 838 |
| PHI-BGR | 3 | | | | | 231 | | | | 231 |
| PHI-BGR/l | 3 | | | | 214 | 165 | | | | 379 |
| PHI-BGR/l | 4 | | | | | 2,117 | | | | 2,117 |
| PHI/l-BGR | 4 | | | | | 79 | | | | 79 |
| PHI-DRN | 2 | | | | 183 | 27 | | | | 210 |
| PHI-DRN/l | 2 | | | | 10 | 148 | | | | 158 |
| PHI-DRN/l | 3 | | | | | | | 121 | | 121 |
| PHI-DRN/l | 4 | | | | | 267 | | | | 267 |
| PHI-MRG | 2 | | | | | | 194 | 381 | | 575 |
| PHI-MRG | 3 | | | | | 1,128 | 205 | 198 | | 1,531 |
| PHI-MRG | 4 | | | | | 287 | | | | 287 |
| PHI/l-BGR/l | 3 | | | | | 835 | | | | 835 |
| PHI-MCA | 2 | | | | | | | 226 | | 226 |
| PHI-MCA | 3 | | | | | 153 | | 134 | | 287 |
| PHI-MCA | 4 | | | | 176 | 826 | | 560 | | 1,562 |
| PHI/l-MCA | 4 | | | | | | 165 | | | 165 |
| | | | | | | | | | Subtotal | 16,545 |
| RSU | 1 | 1,832 | 580 | 983 | 237 | 2,399 | 282 | | 401 | 6,714 |
| RSU | 2 | 170 | | 727 | | 100 | 303 | 225 | | 1,525 |
| RSU-LNS | 1 | | 212 | | 222 | | 468 | 808 | 2,798 | 4,508 |
| RSU-LNS | 2 | | | | | 40 | | | | 40 |
| RSU-HYD | 1 | | | | 725 | | 1,124 | 483 | 128 | 2,460 |
| RSU-BGR/l | 2 | | | | 865 | | | | | 865 |
| RSU-RVA | 1 | | | | | | | 434 | | 434 |
| RSU-LAA | 1 | | | | | | 427 | | | 427 |
| | | | | | | | | | Subtotal | 16,973 |

**Table 9.1—Soil Mapping Units and Acreage Distribution in the Semi-Detailed Soil Survey Area—(*cont.*)**

| Mapping Unit | Terrain | Block Number | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ia | Ib | Ic | II | III | IV | Va | Vb | |
| RGM | 1 | | | | 297 | | 242 | 28 | | 567 |
| RGM | 2 | 5,693 | | 18,538 | 2,083 | 415 | 8,214 | 8,470 | | 43,413 |
| RGM | 3 | 2,675 | | 29,456 | 127 | | 10,759 | 4,731 | | 47,748 |
| RGM | 4 | 249 | 152 | 2,952 | 72 | | 1,437 | 1,546 | | 6,408 |
| RGM/l | 2 | | | | | 17 | 289 | | | 306 |
| RGM/l | 3 | | | | 90 | | 96 | | | 186 |
| RGM/co | 2 | | | | 410 | | 20 | | | 430 |
| RGM/co | 3 | | | | 286 | | 497 | | | 783 |
| RGM/co | 4 | | | | | | 483 | 42 | | 525 |
| RGM-RGM/l | 2 | | | | | | 2,324 | 2,738 | | 5,062 |
| RGM-RGM/l | 3 | | | 2,547 | | | 1,249 | 622 | | 4,418 |
| RGM-RGM/l | 4 | | | | | | 54 | 882 | | 936 |
| RGM/l-RGM | 2 | | | 170 | | | | | | 170 |
| RGM/l-RGM | 3 | | | | | | 280 | | | 280 |
| RGM-RGM/co | 2 | | | | | | | 426 | | 426 |
| RGM-RGM/co | 3 | | | | | | | 345 | | 345 |
| RGM-RGM/co | 4 | | | | | | 59 | | | 59 |
| RGM/co-RGM | 3 | | | | | | 384 | | | 384 |
| RGM-MCA | 2 | | | | | | 757 | | | 757 |
| RGM-MCA | 3 | | | 1,284 | | | | | | 1,284 |
| | | | | | | | | | Subtotal | 114,487 |
| RVA | 1 | 4,727 | 510 | 854 | 293 | 2,440 | 504 | 256 | | 9,584 |
| RVA-AKB | 1 | | | | 223 | 46 | | 216 | | 485 |
| | | | | | | | | | Subtotal | 10,069 |
| SDG | 2 | 843 | | | 996 | | 260 | 59 | 443 | 2,601 |
| SDG | 3 | | 753 | | 3,216 | | 492 | | | 4,461 |
| SDG | 4 | 40 | | | 1,732 | 400 | 343 | | | 2,515 |
| SDG/l | 4 | | | | 110 | | | | | 110 |
| SDG-SDG/l | 2 | 936 | | | | | | | 756 | 1,692 |
| SDG-SDG/l | 3 | | | | 474 | | | | | 474 |
| SDG/l-SDG | 3 | 439 | | | | | | | | 439 |
| SDG/l-SDG | 4 | | | | 84 | | | | | 84 |
| SDG-BGR | 2 | 755 | | | 1,855 | | 537 | 216 | 87 | 3,450 |
| SDG-BGR | 3 | 592 | | 583 | 4,870 | 495 | | | 289 | 6,829 |
| SDG-BGR | 4 | | | | 654 | 68 | | | | 722 |
| SDG-BGR/l | 2 | | | | | | 560 | | | 560 |
| SDG-BGR/l | 3 | | | | 75 | | | | | 75 |
| SDG-BGR/l-SDG/l | 4 | | 287 | | | | | | | 287 |
| SDG/l-BGR/l | 2 | | | | 154 | | | | | 154 |
| SDG-MCA | 3 | | 297 | | | | | | | 297 |
| SDG/l-MCA-BGR/l | 4 | | | | 388 | | | | | 388 |
| SDG-SDG/r | 4 | | | | 146 | | | | | 146 |
| SDG/c | 2 | | | | | | 830 | | | 830 |
| SDG/c-SDG/cl | 2 | | | | | | 1,816 | | | 1,816 |
| SDG/cl-MCA | 2 | | | | | | 157 | | | 157 |
| SDG-SDG/l | 4 | | | | 103 | | | | | 103 |
| | | | | | | | | | Subtotal | 28,190 |
| SGT | 3 | | | | | 64 | | | | 64 |
| SGT | 4 | | | | | 199 | | | | 199 |
| SGT-KTG | 2 | 1,170 | | | | | | | | 1,170 |
| SGT/l-KTG | 2 | 140 | | | | | | | | 140 |
| | | | | | | | | | Subtotal | 1,573 |

**Table 9.1—Soil Mapping Units and Acreage Distribution in the Semi-Detailed Soil Survey Area—(*cont.*)**

| Mapping Unit | Terrain | Block Number | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ia | Ib | Ic | II | III | IV | Va | Vb | |
| SRK | 1 | 948 | | 7,647 | 63 | 535 | 28 | | | 9,221 |
| SRK | 2 | | | 468 | | | | | | 468 |
| | | | | | | | | | Subtotal | 9,689 |
| STP | | 5,711 | 12,234 | 931 | 9,035 | 9,954 | 4,266 | 4,841 | | 46,972 |
| TMG | 1 | 276 | 905 | 586 | | 324 | 319 | 753 | 39 | 3,262 |
| TMG/f | 1 | | | | 792 | | | | | 792 |
| | | | | | | | | | Subtotal | 4,054 |
| TPI | 2 | | | | 142 | | | | | 142 |
| UTM | 3 | 89 | | | | | | | | 89 |
| | | 62,624 | 36,065 | 81,639 | 124,572 | 65,869 | 104,582 | 76,729 | 9,056 | 561,136 |

## 9.2 SOILS CRITERIA FOR CROPS

Evaluations of crop performance within the different soil capability units has been based on the limits of each soil property that a crop can tolerate. Ideally most crops grow best on deep, friable, well-drained soils that respond well to management, but many soils fall short of this optimum. Since crops vary in their tolerance to adverse soil conditions, generalized guidelines to assist in assessing crop behavior on different soils have been made (Table 8.2). These criteria make no attempt to predict productivity and have been used mainly to evaluate the relative effect of soil properties on different crops. The criteria also do not take into account interaction effects when more than one adverse condition is present.

The ranges for the different soils criteria are those currently used in mapping and classifying the soils and as such can be applied directly to the soil capability units.

*Soils criteria used*

(1) Slope—mappable, important from mechanization and conservation viewpoints.

(2) Effective soil depth—mappable, important for root penetration, nutrient and water holding capacity.

(3) Soil texture-structure—mappable, important for water release, workability, aeration and root penetration.

(4) Drainage—mappable, important for mechanization, aeration, water supply.

(5) Water release—mappable from texture and structure, important for crop water uptake.

(6) Salinity—can be approximated for soil series, important for plant growth.

(7) pH—can be approximated for soil series, important in fertility, minor element deficiencies, toxicity effects of certain elements, plant disease resistance and liming requirements.

(8) Depth to acid sulfate—mappable, important due to effects on pH, salt concentration, and root penetration.

(9) Thickness of peat—mappable, important for mechanization, tree crop stands and shrinkage.

(10) Workability—mappable, important for cultivation of annuals and certain tree crops.

## Table 9.2—Major Criteria Used in Assessing the Soil Suitability for Crops

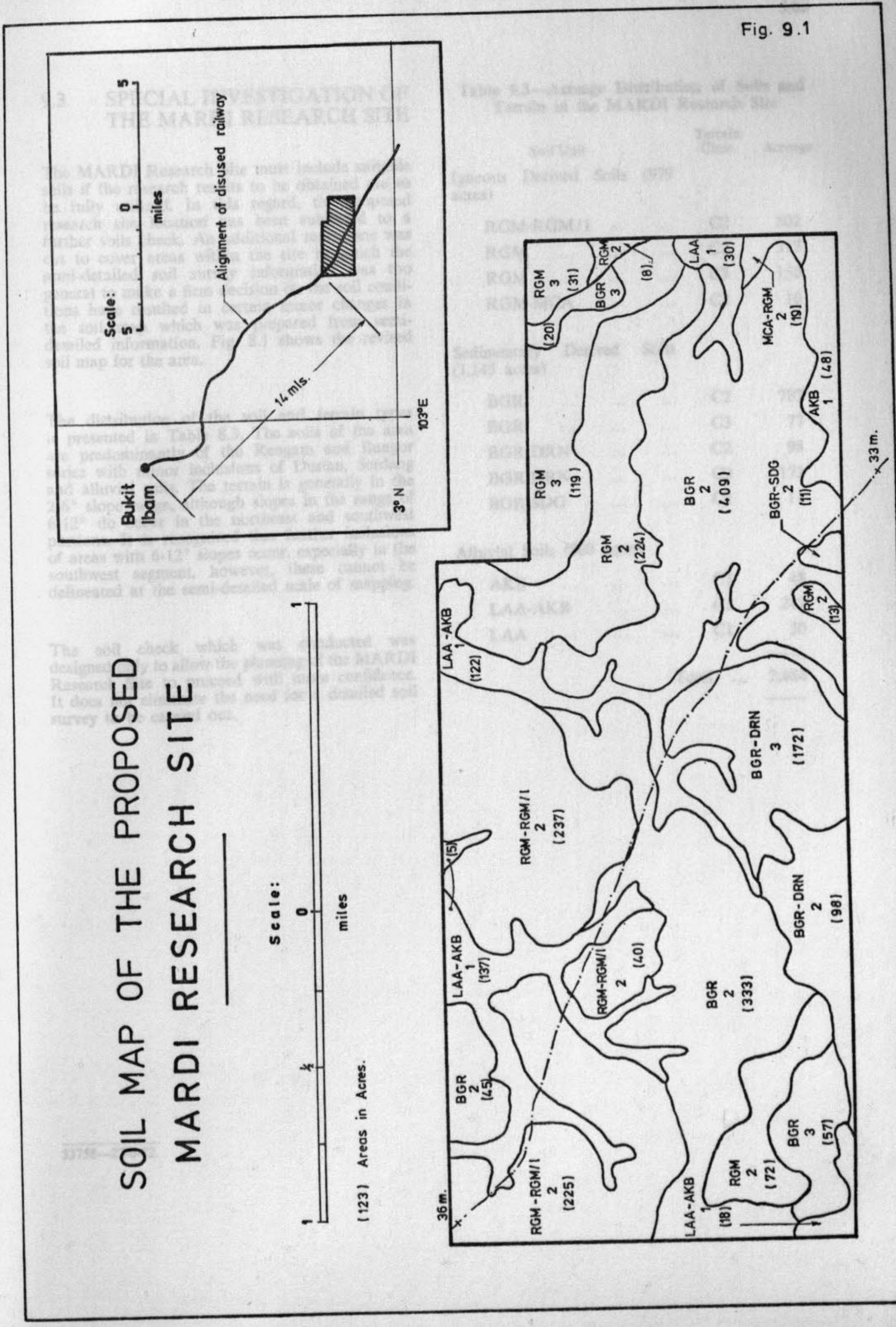
| Crop Group | Crop | Slope | Effective Soil Depth | Soil Texture Structure | Drainage | Water Release | Salinity mmhos/cm at 25°C | pH | Depth to Acid Sulphate | Thickness of Peat (drained) | Workability |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SOIL CRITERIA | | | | | | | | | |
| A. Rubber .. | Rubber .. | 0-20° | >125cm | Exclude LS or coarser | Exclude poorly drained | All year .. .. | <2 mmhos in top 150cm | .0-6.0 | >150cm | <50cm | N.I.[1] |
| B. Oil Palm .. | Oil Palm .. | 0-16° | >125cm | Exclude SL or coarser | Some temporily poorly drained | All year .. .. | <2 mmhos in top 150cm | 4.0-6.5 | >100cm | <100cm | N.I. |
| C. Sago Palm | Sago Palm .. | 0-2° | >100cm | Exclude SL or coarser | Very poorly to poorly only | — | <2 mmhos in top 150cm | 4.0-6.0 | >125cm | <50cm | N.I. |
| D. Tapioca .. | Tapioca .. | 0-6° | >50cm | Exclude clays and poor structures | Exclude poorly drained | All year .. .. | <2 mmhos in top 100cm | 4.3-7.3 | >50cm | No restriction | No restrictions allowed |
| | Sweet Potatoes | 0-6° | >50cm | Exclude clays and poor structures | Exclude poorly drained | All year .. .. | <2 mmhos in top 100cm | 4.3-6.0 | >50cm | No restriction | No restrictions allowed |
| | Soyabeans .. | 0-6° | >25cm | Exclude clays and poor structures | Well to imperfectly only | Throughout growing season | <4 mmhos in top 50cm | 5.5-6.5 | >50cm | <25cm | No restrictions allowed |
| | Chillies .. | 0-6° | >25cm | Exclude clays and poor structures | Well to imperfectly .. | Throughout growing season | <4 mmhos in top 50cm | 5.0-6.8 | >50cm | <25cm | No restrictions allowed |
| | Vegetables .. | 0-6° | >25cm | Exclude clays and poor structures | Well to imperfectly .. | Throughout growing season | <4 mmhos in top 50cm | 4.5-6.5 | >50cm | No restriction | No restrictions allowed |
| E. Tea .. | Lowland Tea | 0-20° | >100cm | Exclude sands, clays .. | Well to imperfectly .. | All year .. .. | <2 mmhos in top 150cm | 4.0-6.0 | >25cm | No peat .. | N.I. |
| F. Grass .. | Grasses (Cut) | 0-12° | >25cm | Exclude LS and coarser | Well to poorly .. | All year .. .. | <4 mmhos in top 50cm | 4.3-7.0 | >50cm | No restriction | No restrictions allowed |
| | Stylo .. .. | 0-12° | >25cm | Exclude sands .. | Well to poorly .. | All year .. .. | <4 mmhos in top 50cm | 4.3-7.0 | >50cm | Not known | No restrictions allowed |
| G. Citrus .. | Citrus .. | 0-20° | >125cm | Exclude sands and heavy clays | Well, some imperfectly | All year .. .. | <2 mmhos in top 150cm | 5.0-7.0 | >150cm | <50cm | No stones |
| | Chiku .. | 0-20° | >125cm | Exclude sands and heavy clays | Well to imperfectly .. | All year .. .. | <2 mmhos in top 150cm | Not known | >150cm | <50cm | No stones |
| | Mangosteen .. | 0-20° | >125cm | Exclude sands and heavy clays | Well to imperfectly .. | All year .. .. | <2 mmhos in top 150cm | Not known | >150cm | <50cm | No stones |
| H. Papaya .. | Papaya .. | 0-12° | >50cm | Exclude LS or coarser | Well to imperfectly .. | All year .. .. | >2 mmhos in top 100cm | 5.0-6.5 | <100cm | No peat .. | No stones |
| | Pineapple .. | 0-6° | >25cm | All textures .. .. | Well to imperfectly .. | All year .. .. | <2 mmhos in top 100cm | 4.5-5.5 | >50cm | No restrictions | No stones |
| | Passion fruit.. | 0-12° | >50cm | Exclude sands and heavy clays | Well to imperfectly .. | All year .. .. | <2 mmhos in top 100cm | 4.5-6.5 | >100cm | <50cm | No stones |
| | Guava .. | 0-12° | >50cm | Exclude LS or coarser | Well to imperfectly .. | All year .. .. | <2 mmhos in top 100cm | 4.5-6.5 | >100cm | <100cm | No stones |

N.I.[1]—Not important.

## Table 9.2—Major Criteria Used in Assessing the Soil Suitability for Crops—(*cont.*)

| Crop Group | Crop | Soil Criteria: Slope | Effective Soil Depth | Soil Texture Structure | Drainage | Water Release | Salinity mmhos/cm at 25° | pH | Depth to Acid Sulphate | Thickness of Peat (drained) | Workability |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Salak .. | 0-12° | >50cm | Exclude LS or coarser | Well drained .. .. | All year .. .. | <2 mmhos in top 100cm | Not known | >100cm | No peat .. | No stones |
| I. Bananas .. | Bananas .. | 0-12° | >125cm | Exclude LS or coarser | Well to imperfectly .. | All year .. .. | <2 mmhos in top 100cm | 5.0-7.0 | >125cm | <25cm | No stones |
| | Durian .. | 0-12° | >100cm | Exclude LS or coarser; firm soils; oxisolic soils | Well to imperfectly .. | All year .. .. | <2 mmhos in top 100cm | 4.5-6.5 | >100cm | No peat .. | N.I. |
| | Rambutan .. | 0-12° | >100cm | Exclude LS or coarser | Well to imperfectly .. | All year .. .. | <2 mmhos in top 100cm | 4.5-6.5 | >100cm | <100cm | No stones |
| | Langsat .. | 0-12° | >100cm | Exclude clays and sands | Well drained .. .. | All year .. .. | <2 mmhos in top 100cm | Not known | >100cm | No peat .. | N.I. |
| | Duku.. .. | 0-12° | >100cm | Exclude clays and sands | Well drained .. .. | All year .. .. | <2 mmhos in top 100cm | Not known | >100cm | No peat .. | N.I. |
| | Soursop .. | 0-6° | >100cm | Exclude clays and sands | Well drained .. .. | All year .. .. | <2 mmhos in top 100cm | Not known | >100cm | No peat .. | N.I. |
| | Jackfruit .. | 0-12° | >100cm | Exclude LS or coarser | Well to imperfectly .. | All year .. .. | <2 mmhos in top 100cm | 4.5-6.5 | >100cm | <100cm | No stones |
| | Chempedak .. | 0-12° | >100cm | Exclude LS or coarser | Well to imperfectly .. | All year .. .. | <2mmhos in top 100cm | Not known | >100cm | No peat .. | N.I. |
| | Avacado .. | 0-12° | >100cm | Exclude LS or coarser | Well to imperfectly .. | All year .. .. | <2 mmhos in top 150cm | 5.5-6.5 | >125cm | >No peat .. | N.I. |
| | Kundangan .. | 0-12° | >100cm | Exclude clays .. | Well drained .. .. | All year .. .. | <2 mmhos in top 150cm | Not known | >125cm | No peat .. | N.I. |
| J. Cashew .. | Cashew .. | 0-20° | >100cm | Exclude clays .. | Well to imperfectly .. | 9 month .. .. | <2 mmhos in top 150cm | 4.0-7.3 | >150cm | <100cm | N.I. |
| K. Cocoa .. | Cocoa .. | 0-12° | >150cm | Exclude SL or coarser | Well to imperfectly .. | High all year .. | <2 mmhos.. | 5.0-7.5 | >150cm | < 50cm | N.I. |
| | Coffee .. | 0-12° | >125cm | Exclude sands .. | Well to imperfectly .. | All year .. .. | <2 mmhos in top 150cm | 4.5-6.5 | >100cm | <125cm | N.I. |
| L. Coconut .. | Coconut .. | 0-6° | >100cm | Exclude LS or coarser | Well to imperfectly .. | All year .. .. | <2 mmhos in top 150cm | 4.5-7.5 | >100cm | <100cm | N.I. |
| M. Maize .. | Maize .. | 0-6° | >50cm | Exclude sands and clays | Well to imperfectly .. | Good in growing seasoh | <2 mmhos in top 50cm | >5.0 | >125cm | No restriction | No restrictions allowed |
| | Sorghum .. | 0-6° | >50cm | Exclude sands .. | Well to imperfectly .. | Good in growing season | <4 mmhos in top 50cm | >5.0 | >125cm | No restriction | No restrictions allowed |
| | Groundnut .. | 0-6° | >25cm | Exclude sands and clays | Well to moderately well | Good in growing season | <4 mmhos in top 50cm | 5.5-7.0 | >50cm | No peat .. | No restrictions allowed |
| N. Rice .. | Lowland Rice | 0-2° | >25cm | SCL or finer .. .. | Drainage control necessary | Dry during harvest | <4 mmhos in top 25cm | >4.0 | >25cm | No peat .. | No restrictions allowed |

Fig. 9.1


SOIL MAP OF THE PROPOSED
MARDI RESEARCH SITE
Scale:
1
½
0
1
miles
(123) Areas in Acres.
Bukit Ibam
Alignment of disused railway
14 mls.
3°N
103°E
Scale:
5
0
5
miles
36 m.
33 m.
RGM-RGM/I 2 (225)
BGR 2 (45)
LAA-AKB 1 (137)
RGM-RGM/I 2 (40)
(5)
RGM-RGM/I 2 (237)
LAA-AKB 1 (122)
LAA-AKB 1 (18)
RGM 2 (72)
BGR 3 (57)
BGR 2 (333)
BGR-DRN 2 (98)
BGR-DRN 3 (172)
RGM 2 (224)
RGM 3 (119)
RGM 3 (31)
(20)
BGR 3
RGM 2
(8)
LAA 1 (30)
MCA-RGM 2 (19)
AKB 1 (48)
BGR 2 (409)
BGR-SDG 2 (11)
RGM 2 (13)

## 9.3 SPECIAL INVESTIGATION OF THE MARDI RESEARCH SITE

The MARDI Research Site must include suitable soils if the research results to be obtained are to be fully utilized. In this regard, the proposed research site location has been subjected to a further soils check. An additional rentis line was cut to cover areas within the site in which the semi-detailed soil survey information was too general to make a firm decision on the soil conditions have resulted in certain minor changes in the soil map which was prepared from semi-detailed information. Fig. 8.1 shows the revised soil map for the area.

The distribution of the soil and terrain types is presented in Table 8.3. The soils of the area are predominantly of the Rengam and Bungor series with minor inclusions of Durian, Serdang and alluvial soils. The terrain is generally in the 2-6° slope range, although slopes in the range of 6-12° do occur in the northeast and southwest portions. It is recognized that further inclusions of areas with 6-12° slopes occur, especially in the southwest segment, however, these cannot be delineated at the semi-detailed scale of mapping.

The soil check which was conducted was designed only to allow the planning of the MARDI Research Site to proceed with more confidence. It does not eliminate the need for a detailed soil survey to be carried out.

**Table 9.3—Acreage Distribution of Soils and Terrain in the MARDI Research Site**

| Soil Unit | Terrain Class | Acreage |
|---|---|---|
| Igneous Derived Soils (979 acres) | | |
| RGM-RGM/1 ... ... | C2 | 502 |
| RGM ... ... ... | C2 | 317 |
| RGM ... ... ... | C3 | 150 |
| RGM-MCA ... ... | C2 | 10 |
| Sedimentary Derived Soils (1,145 acres) | | |
| BGR ... ... ... | C2 | 787 |
| BGR ... ... ... | C3 | 77 |
| BGR-DRN ... ... | C2 | 98 |
| BGR-DRN ... ... | C3 | 172 |
| BGR-SDG ... ... | C2 | 11 |
| Alluvial Soils (360 acres) | | |
| AKB ... ... ... | C1 | 48 |
| LAA-AKB ... ... | C1 | 282 |
| LAA ... ... ... | C1 | 30 |
| | Total ... | 2,484 |

53758—27-6-72.