RECONNAISSANCE SOIL SURVEY OF THE SOUTHWEST JOHORE COCONUT AREA

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Malayan Soil Survey Report No. 3/1965

Pengakap Ukor Tanah di-Negeri Johor Barat Daya, Kawasan Kelapa atau Nyior

Oleh

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Malaysia
Kuala Lumpur.

MALAYAN SOIL SURVEY REPORT

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RECONNAISSANCE SOIL SURVEY OF THE SOUTHWEST JOHORE COCONUT AREA.

Introduction

The above soil survey was carried out between October 1960 and July 1961. The survey was directed and the report has been largely compiled by the senior author, while the bulk of the field work was carried out by Inche Soo, assisted by Inche Nuruddin bin Ma'arof, with the senior author acting as soil correlator. Chemical analysis of selected soil samples was carried out mainly by Inche Nuruddin assisted by other members of the Soil Science Division Analytical Section.

The objects of the survey were to determine the soil pattern and describe the main soil types, and to gauge the fertility status of the various soils so identified, with particular regard to their suitability for coconut, which is the chief crop throughout most of the survey area.

General Description

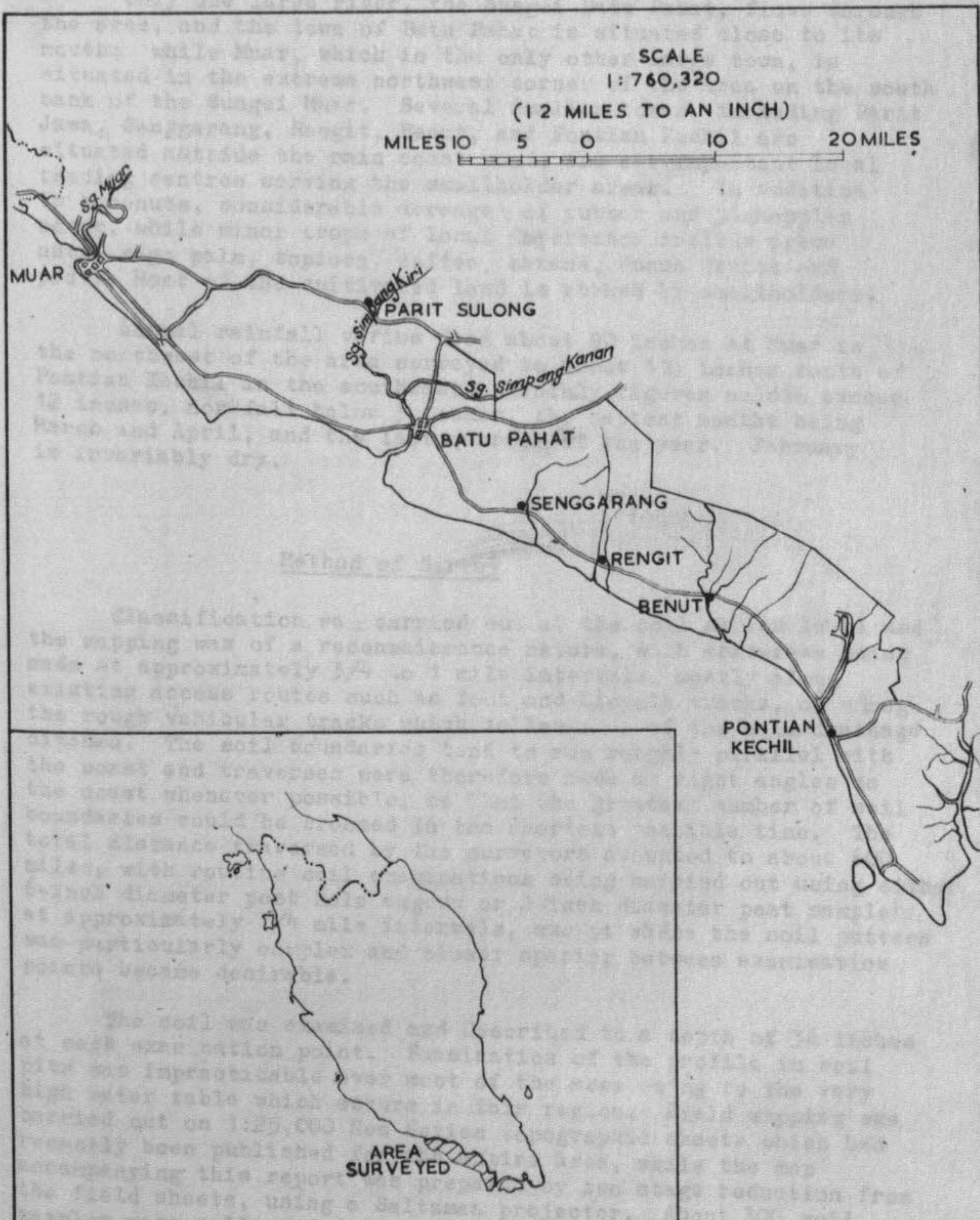
The area surveyed is a continuous belt of country about 87 miles long, bordering the southwest coast of Malaya within the State of Johore. The average width of this belt is about 8 miles, and the total area amounts to some 447,000 acres, or a little less than 700 square miles. Most of the soils in this region are developed over recent marine and estuarine deposits and riverine alluvium occurring only a few feet above mean sea level, and as coconuts are confined almost entirely to these soils the occasional areas of sedentary soil were omitted from the survey.

The survey area is bounded by the Straits of Malacca on the west and south and by main roads or district boundary lines on the north and east. The most intensively developed and oldest agricultural areas are close to the coast, while several large undeveloped patches of land under undisturbed swamp forest occur inland. The main lines of communication reflect this pattern of development, with the main road running roughly parallel and close to the coast from Kukup in the south to Muar in the north-west, and with numerous subsidiary roads and foot tracks serving the main developed areas.

FIGURE I

SKETCH MAP OF SOUTHWEST JOHORE COCONUT AREA

SHOWING MAIN TOWNS ROADS AND RIVERS.



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Only one large river, the Sungei Batu Pahat, flows through the area, and the town of Batu Pahat is situated close to its mouth; while Muar, which is the only other large town, is situated in the extreme northwest corner of the area on the south bank of the Sungei Muar. Several smaller towns, including Parit Jawa, Senggarang, Rengit, Benut, and Pontian Kechil are situated astride the main coast road, and are important local trading centres serving the smallholder areas. In addition to coconuts, considerable acreages of rubber and pineapples occur, while minor crops of local importance include areca nuts, sago palm, topioca, coffee, banana, dusun fruits and padi. Most of the cultivated land is worked by smallholders.

Annual rainfall varies from about 90 inches at Muar in the northwest of the area surveyed to about 110 inches south of Pontian Kechil in the southeast. Monthly figures seldom exceed 12 inches, nor fall below 3 inches, the wettest months being March and April, and the last quarter of the year. February is invariably dry.

Method of Survey

Classification was carried out at the soil series level and the mapping was of a reconnaissance nature, with traverses being made at approximately 3/4 to 1 mile intervals, mostly along existing access routes such as foot and bicycle tracks, or along the rough vehicular tracks which follow of the main drainage ditches. The soil boundaries tend to run roughly parallel with the coast and traverses were therefore made at right angles to the coast whenever possible, so that the greatest number of soil boundaries could be crossed in the shortest possible time. The total distance traversed by the surveyors amounted to about 600 miles, with routine soil examinations being carried out using either 6-inch diameter post hole augers or 2-inch diameter peat samplers, at approximately 1/4 mile intervals, except where the soil pattern was particularly complex and closer spacing between examination points became desirable.

The soil was examined and described to a depth of 36 inches at each examination point. Examination of the profile in soil pits was impracticable over most of the area owing to the very high water table which occurs in this region. Field mapping was carried out on 1:25,000 New Series topographic sheets which had recently been published for the entire area, while the map accompanying this report was prepared by two stage reduction from the field sheets, using a Saltzman projector. About 300 soil samples were collected from representatives examination points

and analysed in the Soil Science Division laboratories and a
... summary of the results of these analyses is attached.

Soil Series Descriptions

The soils found during the survey have been classified into series, which are defined in accordance with the U.S. Department of Agriculture system of soil classification as "groups of soil possessing similar profile characters, apart from the texture of the surface soil, and developed from a particular parent material". The soil occurring in the area surveyed are all developed from alluvial parent material and are mostly clayey in texture, except for the soils in the peat and muck category which have been formed from residual organic material over the less well drained inland areas of the alluvial plain. Approximate acreage figures for the main series are given in the following table:-

Table I

Series	Approximate Area in Acres
Kranji	89,000
Selangor	117,000
Jambu	2,000
Linau	45,000
Briah	4,700
Muck and Organic Clay	14,000
Peat (0 - 2 foot deep)	12,000
Peat (2 - 5 foot deep)	18,000
Peat (over 5 foot deep)	133,000
Holyrood	5,400
Linau - Muck - Colluvial Sand Complex	2,200
Approximate Total	442,200

Short descriptions of the various series are given in the following paragraphs, together with brief comments on the general suitability of each soil for cultivation.

Kranji Series

These are immature soils developed over recent marine and estuarine muds which in their natural state are subject to flooding by tidal waters. They are juvenile soils with ill-defined profile characters and little horizonation. The profile is sulphurous at depth, and consists of a more or less uniform greenish grey or bluish grey structureless clay permeated by mangrove roots. In their natural state such soils are colonized chiefly by mangrove. In their undisturbed condition they have a neutral to alkaline reaction owing to the high proportion of dissolved salts which they contain.

This Series occurs in an almost uninterrupted bank along the coast, but seldom reaches inland for a greater distance than two miles, except along the tidal reaches of some of the main rivers. In certain areas these soils have been protected from inundation by the construction of coastal bunds, following which the leaching effect of rain water on the dissolved salts, together with the improved topsoil drainage conditions, has caused an improvement in the structure and other visual characters, and also altered the chemical characteristics of the soil. These altered soils have been recognised separately during the course of the survey and classified as Kranji Series, improved phase. Such soils can be used for agriculture, including coconuts, and there is every reason to believe that a further gradual improvement in soil fertility will take place over a longer period of time in those areas where effective bunds have been constructed, and are properly maintained.

Unfortunately, the protective bunds were neglected during the early nineteen forties in many places along the coast, and the influx of salt water caused a deterioration in many coconut stands growing on previously improved Kranji Series. (Plate IV) More recently the coastal defences have been strengthened and amelioration of the soil is again taking place over wide areas.

Chemical analysis results for samples from a typical profile of Kranji Series, and Kranji Series, improved phase, are given below:-

Table II

Analysis of Kranji Series Profile

Reg. No.	Depth (ins)	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/cm on soil extracts
RL.785	0- 6	6.2	6.0	0.14	1.05	13	4000	210	5.0
Sa	6-12	6.6	6.8	0.12	0.93	11.8	3650	220	5.0
Sb	12-18	7.0	6.6	0.25	1.38	11.6	5090	384	4.6
Sc	18-24	7.0	6.8	0.35	2.14	12.1	6560	439	6.3
Sd	24-36	7.2	5.6	0.72	1.82	17.3	8520	250	7.0

Table III

Analysis of Kranji Series, Improved Phase, Profile

Reg. No.	Depth (ins)	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/cm on soil extracts
RL.795T	0- 6	4.0	4.1	0.07	0.06	15.9	250	22	1
Sa	6-12	4.0	3.0	0.60	0.06	17.3	327	42	2.6
Sb	12-18	4.8	3.2	1.15	0.09	17.7	560	35	3.4
Sc	18-24	5.2	3.4	1.23	0.16	18.3	100	37	3.6
Sd	24-36	5.8	3.7	1.12	0.13	14.8	1000	42	4.3

Analysis results for eleven profiles, including the results for the two profiles given in Tables II and III, show that the conductivity varies from almost 9 M.Mhos/cm. to less than 1 M.Mhos/cm. and comparison of these results with the field records shows a strong correlation between conductivity levels and distance from the coast, while in the artificially drained areas the conductivity can be taken as a measure of the effectiveness of the protecting bunds. The better drained profiles, classed as Kranji Series, improved phase, during the survey, usually have a low conductivity in the topsoil, but this rises very rapidly at depths below twelve inches and may be as high as 4 M.Mhos/cm. at a depth of three feet. As would be expected, sodium chloride is the salt responsible for this high conductivity, and the percentage in the profiles liable to sea water inundation usually varies between 1 and 3.5, the latter figure being equivalent to the average value for sea water, while lower percentages, varying from nil to 1 per cent, are usual in the improved phase profiles.

Sulphate contents seldom rises above 1 per cent, and are slightly lower than values found in the Linau Series. The amounts vary from nil to 0.25 per cent in the topsoils, but rise rapidly in the subsoils, so that values above o.4 per cent are common at depths below 24 inches. Sodium is of course the the dominant cation in the salt solution.

Soil reaction varies from neutral or very slightly alkaline to acid, the lowest pH values being associated with the improved phases, which are also the soils which show the highest sulphate levels. Loss on ignition is usually between 10 and 20 per cent, and varies very little through the profile.

Selangor Series

This is a very common alluvial soil developed over recent marine deposits in many parts of the west coast of Malaya. It is a heavy textured soil of much above average fertility, and provided adequate drainage can be ensured, it proves almost ideal for a wide range of tree crops.

The profile consists of a dark brown surface horizon underlain by a light brownish grey or brownish grey subsoil which becomes increasingly mottled with yellow and either strong brown or reddish brown colours at depth. This gradually alters to a permanently moist blue-grey horizon which may possess a slight sulphurous odour. The depth at which the gley horizon is encountered varies from about 18 inches to 5 feet or more, according to local drainage conditions, thus giving rise to poor, medium, and well drained phases of this series. The poor to medium drained profiles are most common in West Johore, and well drained phases are restricted largely to the areas which are naturally well drained owing to the fact that they are a few feet higher than the level of the surrounding land (Plate I).

The Selangor Series occurs as an almost continuous band a mile or two in from the coast all the way from Kukup to Muar, and slight differences can be detected between the seaward and inland edges of this band. Close to the boundary with the Kranji Series, which usually separates the Selangor Series from the sea, the gley horizon reaches very close to the surface, and the amount of mottling in the subsoil is thicker and very much more organic than usual, producing an organic phase development close to the boundary with the peat soils. At the present time the best drained phases of this soil are to be found along the road between Muar and Parit Jawa, where the land is naturally better drained, and where the Selangor Series actually reaches the coast in places without a separating band of Kranji soils. At these points coastal erosion is taking place in contrast to the conditions in other areas where the land is slowly advancing at the expense of the sea, and good exposures of the soil profile can be seen in the eroded edge of the coastal platform. The rapid rate of erosion in these areas is apparent from the number of fallen trunks of coconut trees which litter the mud flats and can be seen at low tide (Plate II).

The marked improvement in drainage effected on these soils in the areas covered by recent D.I.D. drainage schemes should result in a much improved level of fertility during the next few years in all phases of this series, but poor drainage conditions are still general over most areas where these soils occur, and this factor is a contributory cause of the present low coconut yields on this series.

Typical analytical results for a Selangor Series profile are given below:-

Table IV

Analysis of Selangor Series Profile

Reg. No.	Depth (ins)	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/cm on soil extracts
RL.572T	0- 6	4.4	4.1	Nil	Nil	9	not done	13	1
Sa	6-12	3.9	4.1	"	"	8	"	9	1
Sb	12-18	3.8	3.9	"	"	8	"	13	1
Sc	18-36	3.8	3.7	"	"	8	"	19	1

Samples from nineteen profiles in the surveyed area were analysed, and from the results of these analyses it can be seen that while the conductivity is invariably below 1 M.Mhos/cm. in the upper part of the profile, values up to 4 M.Mhos/cm. were found in a few profiles at depths of between 18 and 36 inches. (Samples were not taken for analysis below this depth). High sulphate levels, generally between 0.4 and 1 per cent were correlated with the high conductivity values while sodium chloride percentages were very low in comparison, being usually between 0.01 and 0.04 in the same samples.

pH was normally between 3.8 and 5 in the wet soil samples, while pH of air dry samples usually showed a drop of between 0.5 and 1 pH unit in the case of subsoil samples having high conductivities. Loss on ignition varied from around 10 or 15 per cent in the topsoil to between 5 and 10 per cent in the subsoil, except in the case of the organic phase profiles, where values between 20 and 35 per cent were found to occur in the topsoil horizon.

Linau Series

Soils of the Linau Series are characterised by their highly sulphurous subsoils and their generally poor drainage. They contain a high proportion of partially decomposed organic material in the lower parts of the profile and their appearance, situation, and chemical characters point towards a brackish-water origin in lagoonal basins cut off from the sea in relatively recent geological times.

The topsoil is most commonly a very dark-brown silty clay, changing with depth to a brown or light brown colour below about 12 inches. Beneath this horizon a very distinct structureless dark blue grey clay containing perhaps 10 to 20 per cent partly decomposed organic matter, formed mainly from the roots of pre-existing vegetation, is present, and this horizon, which possesses a highly sulphurous odour, continues for a very considerable depth. (Plate III) Living roots do not normally penetrate for any great distance into this subsoil and the fertility of the soil appears to be largely determined by the depth to which drainage and aeration is possible, this being marked by the top of the sulphurous horizon. Analytical results for a typical profile in an area which has been shallow drained and cultivated for several years are given below:-

Table V

Analysis of Linau Series Profile

Reg. No.	Depth (ins)	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/cm on soil extracts
RL.823T	0- 6	4.0	4.0	-	-	35.5	27	22	1
Sa	6-12	4.2	3.7	0.04	0.02	16.8	20	45	1
Sb	12-18	4.4	3.4	0.36	0.02	18.2	27	35	2.6
Sc	18-24	4.8	3.2	1.11	0.03	16.1	67	70	4.6
Sd	24-36	5.0	3.5	1.16	0.05	16.1	320	70	5.8

This soil is confined in the area surveyed to the lower course of the Sungei Simpang Kanan and Sungei Simpang Kiri and an adjoining area to the north of Senggarang, but it is possible that a considerable extension of this soil type occurs along the upper reaches of these streams beyond the eastern boundary of the area.

The poor natural drainage, the high level of reduced sulphur compounds, and the acid reaction of this soil make it unattractive for agricultural development, but in spite of these disadvantages large areas have been planted to rubber. There is a need for considerable soil amelioration in these areas, and this will largely depend on drainage improvement, which will result in oxidation of the insoluble reduced sulphur compounds and the eventual removal by leaching of the soluble sulphates formed under the better drained conditions. Such improvements cannot be quickly accomplished as there is a time lag of many months or even years between the onset of the oxidation condition and the completion of the leaching process, and during this interval the acidity in the subsoil horizons can reach a dangerously high level, often between pH 2 and 3.

These extremely acid values can be harmful even to acid tolerant tree crops, and under such conditions the effect on the standing crop will depend partly on the depth of already oxidised soil above the reduced horizon, and partly on the depth to which the water table is depressed under the new drainage regime. In situations where the reduced horizon contains particularly large amounts of sulphide and occurs close to the soil surface, a policy of gradually lowering the water table in two or more stages over a period of years is likely to cause the least disturbance to the standing crop. Forested swamp areas containing these soils and intended for conversion to agricultural land should for preference be drained several years in advance of initial planting of perennial crops to permit adequate soil amelioration prior to cultivation.

Analysis of samples from twelve profiles showed conductivity values ranging from less than 1 to almost 6 M.Mhos/cm. on soil extracts, with the lowest values occurring in the surface horizon and with a sharp increase usually taking place at a depth of about 12 inches. Sulphate values in the subsoil layers are high, usually above .5 per cent and often between 1 and 1.5 per cent. In contrast to soils of the Kranji Series, chloride percentages are low, seldom exceeding 0.1 per cent.

Soil reaction of wet samples is usually in the range pH 3.5 to 5 with the higher values in the subsoil. The pH of air dry samples were usually much lower for samples taken from the same subsoil horizons, where values between pH2.6 and 4 were common illustrating the effect of oxidation on the reduced subsoil. Loss on ignition is usually between 10 and 40 per cent with variations down the profile.

Jambu Series

The Jambu Series is similar in general profile features to the Rudua Series, which is a common soil type occurring over recent beach sands along the east coast of Malaya. The Jambu Series however, appears to be confined to the west side of the Malayan mainland where it has a much more restricted distribution, being usually found some distance inland and separated from the sea by a more recently deposited succession of marine clays, which are often saline and carry mangrove swamp forest on Kranji Series soils.

In the present area the soil occurs in small patches close to the foot of the Bukit Banang hill mass while further north there is another development, ten miles from the present coast-line, running from the southern tip of the Bukit Payong ridge. The mode of occurrence of these sandy deposits indicates a marine beach origin, the beach having been formed in sub-recent geological times, when the west side of the Bukit Payong ridge formed part of the west coast of the Malayan mainland. During this period the Bukit Banang granite mass must have been an island situated in the Malacca Straits a mile or two from the mainland, occupying a comparable situation to Pangkor Island off the Perak coast at the present day.

A highly leached light grey coloured profile has developed on these marine sands in the course of time. The soil is very sandy, loose, structureless, and extremely free drained. Fertility is poor, and coconut is the only crop regularly planted on these soils. Yields are low, but this is one of the few crops which can produce even a tolerable yield on such poor soils. Fortunately, the extent of these soils is very limited in the area surveyed, and while some areas are abandoned and carry a low cover of scrub, other areas are utilized for housing sites, for which purpose they offer obvious advantages over the neighbouring clayey soils, which are often wet and sticky, and prone to occasional flooding.

Briah Series

This Series is not uncommon in the lower valley tracts and inland sections of the flood plains of the main Malayan west coast rivers. It is generally a poorly drained soil, often susceptible to flooding, which is developed over recent riverine alluvial deposits close to the banks of the present rivers. The heavy texture and lowlying topographic situation cause drainage to be the chief factor governing the suitability of this soil for cultivation. The soil was found in two separate places in the area surveyed, and the total area does not exceed 5,000 acres.

The topsoil in the area surveyed is characterised by either a pale brown or brown silty clay of moderate to strong, fine to medium crumb structure, and friable consistency, particularly when well drained and aerated. Its depth varies from 1 to 4 inches, except near the boundary with organic soils, when greater depths of topsoil may be developed.

The subsoil is a light grey or occasionally light brownish grey silty clay or clay with generally pronounced yellow mottles, up to half an inch in diameter, often variegated with either reddish yellow or strong brown iron oxide staining along former root channels. Structure, which may be only weakly developed, is moderate coarse blocky. The mottled zone is usually between 12 and 20 inches thick and changes gradually with depth to a light brownish grey or light grey structureless clay without mottles. Below a depth of about 30 inches a bluish grey or greenish grey sticky permanently moist silty clay horizon, occasionally possessing a slight sulphurous odour, occurs.

Provided drainage sufficient to lower the water table to about two feet or more below the surface is effected in situations where natural drainage is poor, this soil can be classed as suitable for a wide range of crops, although rubber is the main crop in the area surveyed.

Peat

Malayan peat soils are characterised by their coarse woody or fibrous texture, high moisture content, low weight to volume ratio, acid reaction, and limited crop suitability. They occur extensively along the eastern (inland) edge of the area surveyed, where they have apparently accumulated under anaerobic conditions in large depressions between the marine clay belt, which forms the present coast but which may previously have existed as an offshore mud bank, and the edge of the undulating to hilly terrain which occupies the central part of Johore. The pattern is similar in other parts of the west Malayan coastal strip, but the peat belt is not continuous being interrupted by riverine deposits which mark the meander belts along the lower reaches of the larger west flowing rivers.

Pit digging for soil examination purposes is normally impracticable owing to the waterlogged nature of the peat deposits, and previous experience has shown that the most useful method of classifying the peat in Malaya is into depth phases based on the thickness of the peat layer above the underlying mineral soil deposit, which was found to be clay in the area surveyed. The depth of the peat could be accurately determined using a standard 6-inch post hole or 1½ inch screw auger in the shallower areas but for depths greater than 3 feet the thickness was measured with the aid of a rigid wooden pole, about 10 feet long and between 2 and 3 inches in diameter, pointed at one end and having a deep notch cut an inch or two above the point. The depth of peat can be approximately measured by pushing the pole for varying depths into the peat and noting the depth at which the sample retained in the notch changes from peat to clay.

These primitive probing tools, usually cut each day from a suitable sapling and discarded after a day's use, proved more effective in measuring the peat depth and in obtaining samples of either peat or basal clay than hiller-type peat augers, which do not always collect satisfactory samples in the coarse woody peats characteristic of the Johore swamps, Even the wooden probes, however, could seldom be pushed more than 8 or 9 feet below the surface without meeting obstructions, assumed to be partially decayed roots or trunks, which in most cases prevented further penetration.

Boundaries have been extrapolated from the recorded data to show the areas of 0 to 2 feet, 2 to 5 feet, and more than 5 feet deep peat.

The soil map shows that only a small proportion of the total area of peat is included in the shallower phases, and the rapid rate at which the peat deepens from the edge of the peat swamps was particularly striking in the field. Unfortunately, no depth records were obtainable for the total thickness of the peat in the deeper areas, but depths of 20 or even 25 feet of peat have been recorded in other Malayan peat swamps in similar situations, and the evidence suggests that similar depths will occur in the area surveyed.

Agricultural development is spreading slowly inland from the western edges of the peat swamps, and most of the shallower peats are now planted to either coconut, rubber, or pineapple. The quality of the coconut and rubber is variable but usually poor, and apart from wide differences in the standard of management, the two most important factors governing the growth and yield appear to be the thickness of the peat layer and the depth to which the water table can be lowered by drainage. This is illustrated by the manner in which the intensity of land settlement decreases from the shallower to deeper peat areas, and the very noticeable deterioration in growth and appearance of the crops which occurs within a short distance from the edge of even the shallowest field drain. Pineapple is the only crop which, on the basis of experience, can be described as well suited to the deep peats, but even with this crop a modicum of artificial drainage is necessary to ensure satisfactory growth.

The gradual extension of the zone of cultivation into progressively deeper peat, in spite of the adverse conditions, is symptomatic of the acute shortage of alternative areas of land for smallholder development in the immediate neighbourhood, and a problem of some magnitude will undoubtedly arise in the future if clearing of the peat forest, drainage, and agricultural development, particularly with crops other than pineapple, is allowed to continue.

The need for good drainage, which in the case of tree crops means depressing the water table to at least 2 feet below the surface, inevitably leads to shrinkage and oxidation of the drained peat layers, causing a lowering of the land surface (Plate V). The lower surface level in turn necessitates further deepening of the drainage system to maintain the conditions necessary for even marginally satisfactory growth and yield of the crop, and so the sequence has to be repeated.

However, this cycle cannot continue indefinitely because the original peat surface is only a few feet at the most above sea level, while the bottom of the peat may be many feet below sea level. This raises questions regarding the feasibility of large pumping schemes, and whether the productivity of the crops grown on the peat will be sufficient to warrant the introduction of such expensive drainage measures.

A vigorous programme of research and experimentation into the cropping potentiality of peat soils is also urgently necessary, and any practical benefits from such investigations will almost certainly have direct applications on the already planted areas of peat in the area surveyed.

Table VI

Analysis of Deep Peat Profile

Reg. No.	Depth (ins)	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/cm on soil extracts
RL.556T	0- 6	3.5	3.6	Nil	Nil	92	30	13	1
Sa	6-12	3.4	3.5	"	"	93	30	13	1
Sb	12-18	3.5	3.4	"	"	99	75	7	1
Sc	18-24	3.4	3.4	"	"	96	30	7	1
Sd	24-36	3.4	3.4	"	"	94	50	7	1

Table VI gives a typical set of analysis figures for a deep peat profile. The very acid reaction and the high loss on ignition are particularly noteworthy.

Muck

For Malayan soil survey purposes muck soils are defined as soils having a loss on ignition of between 35 and 65 per cent, and for field classification purposes during the southwest Johore soil survey a muck soil was further defined as being a soil having a surface muck horizon at least 6 inches in thickness. Such soils were only found around the western edges of the peat swamps, where they occur mixed with organic clays in small patches along a transitional zone separating the peat soils from the mineral soils developed over the marine clay deposits fringing the coast. These organic clay and muck patches have for the most part been developed for agriculture, including coconuts, and provided adequate drainage is effected the growth is generally better than that attained on the neighbouring peats. The subsoils below the organic-rich horizon is generally a clay with a strong sulphurous odour.

Table VII

Analysis of Muck Profile

Reg. No.	Depth (ins)	pH wet	pH air dry	SO_4	NaCl	L.I.	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/cm on soil extracts
RL.568T	0- 6	3.6	4.0	0.07	0.07	60	70	25	1
Sa	6-12	3.6	4.1	0.08	0.02	38	85	13	1
Sb	12-24	4.1	3.9	0.71	0.03	26	267	52	3.8
Sc	24-36	4.0	4.5	0.49	0.03	17	450	91	3.8

Analysis results for five muck soil profiles indicate that high conductivity levels are characteristic of the underlying mineral soil horizons and that sulphates are the chief soluble salts responsible for the high conductivity. Sodium chloride percentage did not exceed 0.07 per cent in any of the samples analysed. Soil reaction in the wet samples varied between pH 3 and 5, while air dry samples often showed a drop of one pH unit for the subsoil horizons, indicating the presence of a high proportion of reduced sulphur compounds in a readily oxidizable form.

Organic Clay

The term Organic Clay has been applied to those soils having an organic surface horizon at least six inches deep and with loss on ignition between 20 and 35 per cent. As explained above, these soils occur intermixed with the muck soils and the two soil types have been grouped together for mapping purposes. Organic clays represent a transitional soil type between the muck and peat soil groups and the mineral soils developed on marine alluvium which can be classified into definite series on the basis of distinct horizon differentiation which is directly attributable to soil forming processes. In the field it was noticed that the presence of an organic clay surface horizon more than 6 inches thick usually signified a subsoil which resembled the parent material horizons found at greater depths

It appears likely that during this period the Bukit Baning granite mass was an offshore island occupying a similar situation to that of Pulau Pangkor off the Perak coast at the present day, and this supposition is borne out by the spasmodic occurrence of a pale grey or even white coloured fringe of coarse sand, suggestive of the Jambu Series, and apparently wave washed terrace residuum, often only a few feet in width along the terrace edges on the inland side of the hill mass near Sri Gading, and close to the main Ayer Hitam road where it traverses the foot of the hill between Batu Pahat and Sri Gading. A similar pattern of soils is known to occur in places behind the north Perak and Province Wellesley coast.

Soils of this series require heavy mixed fertilizer applications, including nitrogen, potassium, phosphorus and often magnesium for even tolerable growth and yield. Rubber is the main crop growing on this soil in the area surveyed.

Linau-Muck-Colluvial Sand Complex

About 2,200 acres of variable soils grouped together in the above category were located in the Bukit Payong area, about six miles north of Batu Pahat on the Yong Peng road. The soils have apparently formed over deposits accumulated in what was formerly a lagoonal depression behind a sand bank now marked by a thin band of Jambu Series soil, which was in existence when the coastline lay immediately to the west of the Bukit Payong ridge, and before the coastal deposits on which the more recent Selangor and Linau Series soils are developed had been accumulated.

The soils show strong variations within a small area, and no attempt was made to map the pattern of soil distribution within the boundary of the complex. Colluvial sands, apparently washed down from the neighbouring hills in comparatively recent times, appeared to be the most common soil type. Much of the area was abandoned at the time the area was surveyed and carrying a low cover of scrub, although rubber is also planted in places.

Conclusions

The soil survey showed up the details of the soil pattern in the southwest Johore coconut area for the first time and the map illustrates the very considerable variations in soil type which occur through this region. Observational evidence from the coconut stands in the area indicates a close relationship between management requirements and soil type, and suggests a strong correlation between soil, management and coconut yield. The better soils appear to be those of the Selangor Series, which occur as an almost continuous band running close to and parallel with the coast, and particularly the deeper drained phases. The poorer drained phases of this soil, including the organic phase which usually occurs on the inland side of the band close to the boundaries with the peat swamps, would benefit from improved drainage, and in some areas improvements of this nature have been made in recent years. Stabilization of the water table at a depth of three feet is considered to be a desirable optimum in this area.

Soils of the Kranji Series show considerable variation, owing to the improvement which has been effected in many areas as a result of bunding, leaching out of the chloride salts formerly present in the profile, and improved drainage. A marked deterioration was often noticeable in the condition of coconuts growing on the improved phases of this series near the coastal bunds, and this was usually correlated with increased salinity and a comparatively high water table in spite of the protective coastal bunds. Seepage of seawater either beneath or through the bunds is apparently taking place in these areas, which in some instances may be so lowlying as to preclude any further drainage improvements.

The Linau Series proved to be a soil possessing a naturally high water table and very high sulphide levels. Analysis give values exceeding 1 per cent sulphate at depths of only eighteen inches in some samples, and in one case even at a depth of twelve inches. Such extremely high levels combined with a very acid reaction, particularly on the air-dry sample, indicate a highly reduced subsoil at comparatively shallow depths, and this condition must be seriously affecting growth and yield of tree crops. Improvement could be effected by drainage, but extreme caution is called for when changes are made to the water-table level in soils of this nature, which carry recently planted or mature tree crops, and experience with these and similar soils in other areas suggests that a gradual lowering of the water table during successive years would be less likely to cause a temporary setback to established crops than a sudden lowering of the watertable brought about by rapid drainage improvements. A similarly cautious approach to amelioration may be necessary in other series, including the Selangor Organic Phase, in which highly reduced conditions, detectable in the field by a strong sulphurous odour, occur at shallow depths in the subsoil.

The peats present a very different problem, and while drainage will undoubtedly benefit the shallow peats, these cover only a fraction of the total peat area, which in most places is well over five feet deep. There appears to be no easy solution to the problem of establishing vigorous and high yielding stands of tree crops, including coconuts, on the deeper peats, and in the absence of a proved technique for successfully developing such areas, it would be advisable to avoid further alienation of peat soils for agricultural settlement, and possibly assist the small holders already settled on this soil type with an intensive programme of agronomic research.

In view of the considerable differences which occur in the soil of the southwest Johore coconut area and in the light of the recently established coconut rehabilitation scheme, it is recommended that research to determine the correct techniques, including drainage needs and optimum fertilizer requirements for coconut growth on each of the more important soil types recognised and mapped during the survey, should be carried out.

APPENDIX

A large number of soil pit and 6 inch auger hole samples were analysed during the course of the survey and the results are given in the following pages.

The details of the laboratory methods used were as follows:-

pH

By tropicalised pH meter with wick type reference electrode and spear type glass electrode, using a 1 to 2.5 soil to water suspension.

Conductivity

By wheatstone bridge using a 1 to 5 soil to water suspension.

The following determinations were made on aliquots of the filtered solution prepared for the conductivity measurement:-

Chloride Determination

By titration with standard silver nitrate solution and chromate indicator.

Sulphate

By precipitation with barium chloride.

Sodium (water soluble)

By flame photometer, using a sodium filter.

Potassium (water soluble)

By flame photometer, using a potassium filter.

Kranji Series

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/cm on soil extract
RL.560T	0- 6	128d	6.5	5.4	0.15	1.23	11	3000	140	4.6
Sa	6-12		6.9	5.9	Nil	1.43	16	3450	217	4.2
Sb	12-18		6.9	6.5	0.288	1.94	14	300	150	5.0
Sc	18-24		7.2	6.5	Nil	1.65	14	3450	161	6.2
RL.561T	0- 6	128b 907591	6.0	4.2	0.21	1.16	13	2800	200	4.2
Sa	6-12		6.8	4.6	0.16	1.20	13	3000	176	5.0
Sb	12-24		7.3	4.8	0.29	2.08	17	3300	186	5.8
Sc	24-36		7.3	4.9	0.41	2.90	18	3300	246	6.2
RL.562T	0- 6	128b 912594	5.5	4.6	Nil	Nil	12	295	35	1
Sa	6-12		4.9	4.8	"	"	12	410	54	1
Sb	12-24		5.0	4.7	0.16	0.14	11	2160	105	2.4
Sc	24-36		6.3	6.0	0.28	.97	9	6840	246	5.2
RL.563T	0- 6	128b 916598	5.8	6.0	Nil	Nil	12	295	52	1
Sa	6-12		4.5	5.5	"	"	13	450	54	1
Sb	12-24		4.0	4.0	0.32	0.06	18	875	113	2.8
Sc	24-36		6.6	5.3	0.29	0.27	14	3200	195	2.9
RL.580T	0- 6	122f 663745	7.0	7.0	Nil	1.60	10	3100	440	1
Sa	6-12		7.2	7.0	"	1.69	12	3400	454	1
Sb	12-24		7.3	6.8	"	1.46	14	3650	760	3.0
Sc	24-36		7.4	6.0	0.44	2.03	18	3750	704	3.8
RL.581T	0- 6	122f 668754	4.6	4.8	Nil	Nil	8	560	7	1
Sa	6-12		4.9	4.8	0.04	0.19	8	800	7	1
Sb	12-24		5.0	5.0	0.03	0.28	7	1720	7	2.6
Sc	24-36		6.2	5.4	0.15	0.37	9	2080	18	3.8
RL.582T	0- 6	122f 676774	4.5	4.3	0.03	0.13	29	2840	30	1.0
Sa	6-12		4.2	4.1	0.20	0.67	21	5040	78	4.2
Sb	12-24		5.2	3.9	0.89	1.08	20	8000	206	5.8
Sc	24-36		6.3	4.5	0.36	0.84	13	7360	176	4.2

Kranji Series (continued)

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/cm on soil extract
RL.785T	0- 6	128d 010558	6.2	6.0	0.14	1.05	13	400	210	5.0
Sa	6-12		6.6	6.8	0.12	0.93	11.8	3650	220	5.0
Sb	12-18		7.0	6.6	0.25	1.38	11.6	5090	384	4.6
Sc	18-24		7.0	6.8	0.35	2.14	12.1	6560	439	6.3
Sd	24-36		7.2	5.6	0.72	1.82	17.3	8520	250	7.0
Kranji (Improved Phase)										
RL.786T	0- 6	128d 982556	3.4	3.8	0.11	0.20	11.6	950	Insufficient samples	1.7
Sa	6-12		4.6	4.7	0.35	0.61	11.7	2900		4.3
Sb	12-18		5.0	4.5	0.59	0.88	13.0	4300		5.2
Sc	18-24		5.4	4.0	1.08	0.92	16.6	4300		5.8
Sd	24-36		6.0	4.1	0.73	0.92	15.0	4300		5.0
RL.795T	0- 6	128d 041539	4.0	4.1	0.07	0.06	15.9	250	22	1
Sa	6-12		4.0	3.0	0.60	0.06	17.3	327	42	2.6
Sb	12-18		4.8	3.2	1.15	0.09	17.7	560	35	3.4
Sc	18-24		5.2	3.4	1.23	0.16	18.3	1000	37	3.6
Sd	24-36		5.8	3.7	1.12	0.13	14.8	1000	42	3.4
Kranji										
RL.849T	0- 6	122e 885437	5.8	7.0	0.23	1.98	13.3	8150	550	8.7
Sa	6-12		6.0	6.0	0.50	2.58	14.9	11200	850	8.7
Sb	12-18		6.2	5.1	0.82	2.85	18.2	10000	850	7.7
Sc	18-24		6.4	4.5	1.26	3.45	22.0	12250	650	7.7
Sd	24-36		7.0	4.3	1.22	3.46	20.7	11950	650	8.7

Selangor Series

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/ cm on soil extract
RL.565T	0- 6	128b	4.4	4.3	0.07	0.02	19	140	7	1
Sa	6-12	929609	4.1	4.2	0.07	0.05	13	235	22	1
Sb	12-24		4.0	3.9	0.40	0.07	18	545	74	2.8
Sc	24-36		6.0	5.4	0.22	0.15	10	610	91	2.8
RL.566T	0- 6	925605	4.0	3.9	0.07	Nil	21	95	18	1
Sa	6-12		4.0	3.9	Nil	"	16	85	18	1
Sb	12-24		3.8	3.8	0.18	0.02	11	155	40	2.0
Sc	24-36		4.9	4.8	0.41	0.05	11	640	91	3.0
RL.571	0- 6	931609	3.9	3.9	Nil	Nil	16	25	7	1<
Sa	6-12		3.8	3.5	"	"	16	15	7	1<
Sb	12-24		3.6	3.7	"	"	14	20	9	1<
Sc	24-36		3.4	3.5	0.18	0.01	10	45	30	1<
RL.572T	0- 6	831655	4.1	4.1	Nil	Nil	9	15	13	1<
Sa	6-12		3.9	4.1	"	"	8	12	9	"<
Sb	12-24		3.8	3.9	"	"	8	25	13	"<
Sc	24-36		3.8	3.7	"	"	8	37	19	"<
RL.573T	0- 6	121d	6.5	6.4	"	"	8	50	7	1<
Sa	6-12	615432	4.9	5.3	"	"	7	40	3	"<
Sb	12-24		4.6	4.6	"	"	8	45	7	"<
Sc	24-36		4.4	4.4	"	"	7	65	9	"<
RL.574T	0- 6	611429	4.5	4.6	Nil	Nil	9	30	3	1<
Sa	6-12		4.5	4.7	"	"	9	25	3	"<
Sb	12-24		4.5	4.8	"	"	9	60	9	"<
Sc	24-36		4.7	5.0	"	"	10	127	16	"<

Selangor Series (continued)

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/cm on soil extract
RL.575T	0- 6	121d	3.7	4.0	Nil	Nil	20	30	9	1<
Sa	6-12	608426	3.5	3.8	"	"	13	25	16	"<
Sb	12-24		3.4	3.5	0.07	0.02	10	35	35	"
Sc	24-36		3.9	3.5	0.27	0.01	10	95	73	"
RL.805T	0- 6	128b	4.2	4.0	Nil	Nil	10.0	7	12	1<
Sa	6-12	910682	4.2	3.9	"	"	7.6	27	15	1<
Sb	12-18		4.8	3.7	"	"	8.5	27	12	1<
Sc	18-24		5.2	3.5	0.07	0.02	10.4	27	15	1
Sd	24-36		5.6	2.9	1.13	0.03	14.0	35	9	3.8
RL.806T	0- 6	128b 895683	4.4	4.3	Nil	Nil	7.9	7	20	1<
Sa	6-12		4.0	3.5	"	"	6.7	7	15	1<
Sb	12-18		4.0	3.6	"	"	7.9	10	15	1<
Sc	18-24		3.8	3.5	"	"	11.0	27	16	1<
Sd	24-36		3.8	3.1	0.74	0.04	23.7	72	35	3.5
RL.807T	0- 6	128b	4.4	4.4	Nil	Nil	10.6	7	12	1<
Sa	6-12	888684	4.4	4.3	"	"	9.6	17	19	1
Sb	12-18		4.0	4.1	"	"	12.0	60	22	1
Sc	18-24		4.0	3.3	0.67	0.03	13.9	80	37	3.1
Sd	24-36		4.2	3.7	0.76	0.03	12.9	22	50	3.8
RL.808T	0- 6	128b	3.4	4.2	Nil	Nil	12.3	30	22	1
Sa	6-12	880688	3.6	4.0	"	"	7.4	15	16	1<
Sb	12-18		3.8	3.9	"	"	11.7	70	30	1
Sc	18-24		4.0	3.3	0.46	0.01	13.3	30	65	3.3
Sd	24-36		4.2	3.1	0.57	0.02	14.9	30	16	4.6
RL.811T	0- 6	128a	4.6	4.8	Nil	Nil	17.0	10	16	1<
Sa	6-12	601157	4.4	3.9	0.18	0.02	32.6	30	19	1.0
Sb	12-18		4.8	3.9	0.42	0.02	17.0	27	40	2.6
Sc	18-24		5.0	3.8	0.42	0.01	14.0	27	50	2.8
Sd	24-36		5.0	3.8	0.51	0.02	13.1	30	54	3.1

Selangor Series (continued)

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH wet	pH air dry	SO_4	NaCl	L.I.	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/cm on soil extract
RL.813T	0- 6	122f	4.2	4.7	Nil	Nil	9.8	10	9	1<
Sa	6-12	764869	4.0	4.5	"	"	9.6	15	6	1<
Sb	12-18		4.2	4.2	"	"	9.8	15	6	1<
Sc	18-24		4.0	4.1	"	"	9.0	17	12	1<
Sd	24-36		3.8	3.6	0.15	0.02	9.1	25	37	1
RL.814T	0- 6	122f	4.0	4.4	Nil	Nil	20.4	15	27	1
Sa	6-12	759852	3.6	4.1	"	"	15.1	17	27	1
Sb	12-18		4.0	3.9	"	"	15.5	27	19	1
Sc	18-24		4.4	3.5	0.44	0.02	18.3	50	42	2.4
Sd	24-36		4.4	3.3	0.77	0.03	11.6	150	50	4.0
RL.820T	0- 6	122d	3.8	4.4	Nil	Nil	8.9	5	6	1<
Sa	6-12	713884	4.0	4.4	"	"	10.1	5	6	1<
Sb	12-18		4.6	4.5	"	"	13.8	17	6	1<
Sc	18-24		4.8	4.5	"	"	11.9	20	12	1
Sd	24-36		4.8	4.4	0.08	0.02	16.8	80	32	1
RL.822T	0- 6	122d	3.8	4.6	Nil	Nil	5.6	Nil	9	1<
Sa	6-12	721862	4.0	4.2	"	"	6.9	5	9	1<
Sb	12-18		4.4	4.1	"	"	7.8	15	12	1
Sc	18-24		4.6	4.3	"	"	5.9	15	12	1
Sd	24-36		5.0	4.4	"	"	5.1	6	18	1

Linau Series

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/cm on soil extract
RL.583T	0- 6	122f 675779	4.9	4.7	Nil	Nil	23	180	9	1
Sa	6-12		4.3	4.1	0.17	0.04	18	310	25	1.0
Sb	12-24		5.3	4.4	0.24	0.06	13	680	55	2.0
Sc	24-36		5.8	4.7	0.27	0.12	13	960	75	2.6
RL.584T	0- 6	122f 675794	5.0	4.0	Nil	0.05	39	475	27	1
Sa	6-12		5.0	3.8	0.51	Nil	36	855	64	1
Sb	12-24		6.2	4.5	0.56	0.11	32	2200	98	2.8
Sc	24-36		6.3	4.7	0.56	0.13	24	2280	123	2.8
RL.585T	0- 6	122f 673802	4.8	4.6	Nil	Nil	11	77	45	1
Sa	0-12		4.3	4.5	"	"	13	60	16	1
Sb	12-24		4.5	4.1	0.17	0.04	18	267	50	2.0
Sc	24-36		4.7	4.3	0.24	0.02	12	630	102	3.0
RL.586T	0- 6	122f 663823	4.3	4.2	Nil	Nil	36	155	20	1
Sa	6-12		4.4	3.7	0.31	0.07	24	212	25	2.6
Sb	12-24		4.8	3.6	0.36	0.06	29	450	38	4.2
Sc	24-36		5.2	3.9	0.85	0.02	22	855	85	5.0
RL.773T	0- 6	122f 686878	3.6	2.6	Nil	Nil	10.2	35	22	1<
Sa	6-12		3.8	377	"	"	9.6	20	22	1<
Sb	12-18		4.2	3.7	"	"	10.7	27	27	1<
Sc	18-24		4.4	3.7	1.16	0.029	15.4	20	20	3.3
Sd	24-36		4.8	2.6	1.09	0.026	18,04	67	22	3.5
RL.776T	0- 6	767866	3.8	3.4	NNil	Nil	14.0	115	12	0.3
Sa	6-12		4.0	3.4	"	"	3.7	75	7	1<
Sb	12-18		4.0	3.2	0.06	0.023	6.2	40	9	0.8
Sc	18-24		4.2	2.8	0.035	0.029	8.3	20	9	1.8
Sd	24-36		4.4	2.7	0.70	0.020	8.7	27	16	3.0

Linau Series (continued)

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH		SO_4	NaCl	L.I.	Water Extract		M.Mhos/cm on soil extract
			wet	air dry	%	%	%	Na p.p.m.	K p.p.m.	
RL.816T	0- 6	122f 734824	3.4	4.7	Nil	Nil	8.7	42	22	1<
Sa	6-12		4.2	4.7	"	"	11.2	185	22	1
Sb	12-18		4.6	3.5	0.85	0.04	16.2	327	30	3.6
Sc	18-24		4.8	3.7	0.91	0.04	15.2	445	37	4.6
Sd	24-36		5.2	3.7	0.85	0.05	14.0	500	37	4.6
RL.823T	0- 6	122f 725844	4.0	4.0	Nil	Nil	35.5	27	22	1<
Sa	6-12		4.2	3.7	0.04	0.02	16.8	20	45	1<
Sb	12-18		4.4	3.4	0.36	0.02	18.2	27	35	2.6
Sc	18-24		4.8	3.2	1.11	0.03	16.1	67	70	4.6
Sd	24-36		5.0	3.5	1.16	0.05	16.1	320	70	5.8
RM.60T	0- 6	122f 609789	4.4	4.8	1.355	.143	37.9	6550	500	7.6
Sa	6-12		4.4	4.2	Nil	Nil	14.5	85	65	1<
Sb	12-18		4.6	3.1	.311	0.06	18.7	150	176	1.7
Sc	18-24		4.8	2.8	.826	0.06	16.7	340	166	4.0
Sd	24-36		5.0	3.2	.797	0.07	12.4	705	220	4.6
RM.61T	0- 6	122f 708793	4.2	4.2	.020	0.12	14.0	520	44	1.0
Sa	6-12		4.2	4.2	0.056	0.10	13.9	705	65	1.5
Sb	12-18		4.6	2.8	1.411	0.21	19.9	845	25	5.0
Sc	18-24		4.8	2.8	1.310	0.13	17.1	890	38	5.0
Sd	24-36		5.2	3.6	1.243	0.15	23.2	1920	100	5.2
RM.71T	0- 6	122d 669925	4.6	4.0	Not Detn.	Nil	13.7	10	18	1<
Sa	6-12		4.8	3.9	"	"	5.9	trace	13	1<
Sb	12-18		5.0	3.7	"	"	9.0	30	13	1<
Sc	18-24		5.0	3.6	"	"	9.8	35	125	1
Sd	24-36		5.2	2.8	"	.025	14.4	50	176	3.7

Linau Series (Continued)

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH		SO_4	NaCl	L.I.	Water Extract		M.Mhos/ cm on soil extract
			wet	air dry	%	%	%	Na p.p.m.	K p.p.m.	
RM.215T	0- 6	123f	4.0	3.7	"	.019	40.3	20	90	1<
Sa	6-12	201228	4.6	3.8	"	.029	40.9	30	85	1<
Sb	12-18		4.8	3.2	0.76	.011	15.4	85	85	2.9
Sc	18-24		4.8	3.8	0.59	.022	13.0	135	117	2.6
Sd	24-36		5.0	3.8	0.98	.031	12.3	200	133	3.2

Briah Series

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/ cm on soil extract
RM.213T	0- 6	128e 955717	3.6	4.2	Nil	Nil	15.1	20	25	1<
Sa	6-12		3.4	4.2	"	"	7.9	80	180	1<
Sb	12-18		3.8	4.3	"	"	8.0	110	180	1
Sc	18-24		4.2	4.2	"	"	7.7	30	25	1<
Sd	24-36		4.6	4.2	"	"	7.7	55	13	1<
RM.216T	0- 6	123f 274243	3.8	4.3	"	"	16.0	30	13	1<
Sa	6-12		4.0	4.5	"	"	10.8	60	18	1<
Sb	12-18		4.2	4.3	"	"	8.6	110	55	1
Sc	18-24		4.4	4.1	"	.050	8.8	315	50	1
Sd	24-36		4.6	3.5	"	.080	9.5	550	85	1
RM.222T	0- 6	123f 223244	4.4	3.6	"	.012	10.7	trace	32	1
Sa	6-12		4.4	3.8	"	Nil	9.1	"	18	1<
Sb	12-18		4.6	3.7	"	"	7.8	"	25	1<
Sc	18-24		4.8	3.5	"		8.1	15	38	1<
Sd	24-36		5.0	2.6	trace	.022	9.5	10	32	3.7
RM.275T	0- 6	129 Sect.4 934294	4.0	4.6	Nil	Nil	10.7	35	7	1<
Sa	6-12		4.2	4.7	"	"	9.6	50	38	1<
Sb	12-18		4.4	4.7	"	"	10.1	40	25	1<
Sc	18-24		4.6	4.8	"	"	9.4	80	60	1<
Sd	24-36		4.8	4.2	"	.029	10.5	330	60	1.2

Peat

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Ka Ka p.p.m.	Water Extract N p.p.m.	M.Mhos/cm on soil extract
RL.556T	0- 6	128c 984674	3.5	3.6	Nil	Nil	92	30	13	1<
Sa	6-12		3.4	3.5	"	"	93	30	13	1<
Sb	12-18		3.5	3.4	"	"	99	75	7	1<
Sc	18-24		3.4	3.4	"	"	96	30	7	1<
Sd	24-36		3.4	3.4	"	"	94	50	7	1<
RL.557T	0- 6	128c 985666	3.9	3.9	"	"	85	140	13	1
Sa	6-12		3.7	3.6	"	"	99	130	7	1
Sb	12-18		3.8	3.6	"	"	99	90	13	1
Sc	18-24		4.3	4.0	"	"	90	330	32	1
Sd	24-36		5.4	4.5	"	"	14	360	75	1
RL.577T	0-6	121d 766601	3.7	3.6	"	"	87	20	16	1<
Sa	6-12		3.5	3.4	"	"	94	180	13	1
Sb	12-24		3.7	3.7	"	"	96	170	9	1
Sc	24-36		5.2	4.6	0.02	0.06	95	140	16	1
RL.578T	0- 6	121d 783604	3.9	4.1	"	"	68	50	37	1
Sa	6-12		3.8	3.8	"	"	78	60	13	1
Sb	12-24		4.0	3.8	"	"	93	80	13	1
Sd	24-36		4.2	3.7	"	"	92	80	18	1
RL.569T	0- 6	128b 948645	4.0	3.8	Nil	Nil	67			
Sa	6-12		4.3	3.9	"	"	49	122	7	1
Sb	12-24		4.9	4.2	"	"	29	135	13	1
Sc	24-36		5.9	4.4	0.41	0.03	19	630	78	2.8

Peat 1'/Organic Clay

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Ka Ka p.p.m.	Water Extract N p.p.m.	M.Mhos/cm on soil extract
RL.775T	0- 6	122f 775862	3.8	3.3	Nil	Nil	65.3	50	55	1
Sa	6-12		4.0	3.2	"	"	49.0	75	27	1.2
Sb	12-18		4.2	3.0	0.15	0.02	18.0	62	22	2.2
Sc	18-24		4.4	2.5	0.55	0.05	32.2	165	20	2.9
Sd	24-16		4.8	2.7	0.84	0.03	17.7	155	16	2.9

Peat (Continued)

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/cm on soil extract
RL.873T	0- 6	122e	3.4	3.5	Nil	Nil	91.8	15	13	1
Sa	6-12	526855	3.4	3.3	"	"	81.4	15	13	1
Sb	12-18		3.6	3.7	"	"	90.9	15	7	1
Sc	18-24		3.8	4.2	"	"	87.7	50	7	1
Sc	24-36		4.0	4.5	"	"	76.2	85	7	1
Peat 6"/Organic Clay										
RM.287T	0- 6	129	3.4	3.4	0.31	.214	77.5	590	100	3.7
Sa	6-12	Sect.8 272452	3.4	3.5	Nil	.077	23.9	170	44	1.1
Sb	12-18		3.8	3.7	0.33	.045	17.9	180	70	1.8
Sc	18-24		4.0	3.9	0.29	.075	14.2	330	104	3.7
Sd	24-36		4.0	4.0	0.21	.049	12.9	255	133	2.4
Peat 1'/Organic Clay										
RM.53T	0- 6	122f	3.6	3.5	0.10	0.33	85.7	845	129	2.5
Sa	6-12	619775	3.8	4.1	Nil	Nil	38.0	70	32	1
Sb	12-18		4.0	4.2	.252	0.02	27.0	85	50	2.6
Sc	18-24		4.4	3.9	.583	0.02	18.5	95	104	2.8
Sd	24-36		4.6	3.8	.645	0.01	15.7	85	129	3.1
Peat 2'/Organic Clay										
RM.281T	0- 6	129	3.4	3.4	Nil	.034	75.5	55	60	1
Sa	6-12	Sect.5 254528	3.4	3.2	"	.023	66.8	50	32	1
Sb	12-18		3.8	3.0	0.19	.028	34.6	85	55	2.0
Sc	18-24		3.8	3.5	0.28	.023	21.3	145	80	2.4
Sd	24-36		4.0	3.8	0.28	.027	14.8	210	108	2.1
Peat 1'/Organic Clay										
RL.874T	0- 6	122e	3.2	3.1	Nil	Nil	89.8	15	18	1<
Sa	6-12	524845	3.4	3.3	"	"	51.6	15	25	1<
Sb	12-18		3.6	3.9	Nil	Nil	19.5	50	13	1<
Sc	18-24		3.6	3.6	0.12	0.01	14.9	15	25	1
Sd	24-36		4.0	2.7	1.24	0.04	9.7	30	25	1

Mucks

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/cm on soil extract
RL.782T	0- 6	128c 035582	3.8	3.4	0.14	0.03	60.7	73	56	1
Sa	6-12		4.0	4.0	Nil	Nil	35.7	47	16	1<
Sb	12-18		4.4	3.8	0.17	0.02	17.9	95	30	1
Sc	18-24		4.6	2.9	0.84	0.02	18.4	210	70	3.5
Sd	24-36		5.0	3.0	0.80	0.03	13.0	327	90	4.3
RL.800T	0- 6	128c 047626	3.6	3.6	Nil	Nil	39.7	15	22	1<
Sa	6-12		4.0	3.6	"	"	19.3	30	22	1<
Sb	12-18		4.4	3.3	0.11	0.01	13.7	27	40	1
Sc	18-24		4.8	3.0	0.84	0.02	14.0	27	50	3.6
Sd	24-36		5.2	3.3	0.86	0.03	11.7	27	100	3.8
RL.802T	0- 6	128c 961676	3.2	3.7	Nil	Nil	40.1	17	27	1
Sa	6-12		3.2	3.7	"	"	31.5	17	19	1
Sb	12-18		3.0	3.2	0.32	0.01	50.1	20	37	2.1
Sc	18-24		3.6	3.1	0.76	0.01	12.8	35	55	3.5
Sd	24-36		4.4	3.3	0.86	0.02	13.2	95	85	3.6

Muck/Organic Clay

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/cm on soil extract
RL.568T	0- 6	128b 945633	3.6	4.0	0.07	0.07	60	70	25	1
Sa	6-12		3.6	4.1	0.08	0.02	38	85	13	1
Sb	12-24		4.1	3.9	0.71	0.03	26	267	52	3.8
Sc	24-36		4.0	4.5	0.49	0.03	17	450	91	3.8
RL.576T	0-6	121d 756596	3.4	3.4	Nil	Nil	64	80	55	1
Sa	6-12		3.4	3.2	0.08	0.01	48	80	37	1
Sb	12-24		3.4	3.2	0.68	0.02	27	220	73	3.8
Sc	24-36		4.7	3.8	0.52	0.02	22	330	85	4.2

Mucks(continued)

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/cm on soil extract
RL.567T	0- 6	128b 942622	3.5	3.8	0.05	0.02	38	55	52	1
Sa	6-12		3.2	3.6	0.08	0.02	25	67	27	1
Sb	12-24		3.2	3.5	0.57	0.04	24	220	66	2.8
Sc	24-36		5.0	4.1	0.42	0.07	13	630	107	3.0
RL.570T	0- 6	128b 947662	3.4	3.4	Nil	Nil	36	40	3	1<
Sa	6-12		3.5	3.5	"	"	25	30	3	1<
Sb	12-24		3.8	3.9	"	"	25	55	3	1<
Sc	24-36		4.2	3.9	0.22	0.02	15	205	22	1.8
Muck 6"/Organic Clay										
RM.52T	0- 6	122f 634777	4.0	3.7	Nil	Nil	56.3	30	38	1<
Sa	6-12		4.2	3.6	"	"	13.6	35	50	1<
Sb	12-18		4.4	3.4	"	"	10.5	40	50	1<
Sc	18-24		4.8	3.1	"	0.02	10.7	35	80	1
Sd	24-36		5.0	3.0	"	0.07	11.1	145	60	3.5
Muck										
RL.866T	0- 6	121d 814574	3.4	4.2	Nil	Nil	57.6	85	60	1<
Sa	6-12		3.4	4.3	"	"	62.2	35	25	1<
Sb	12-18		3.6	4.0	"	"	54.1	5	18	1<
Sc	18-24		3.8	4.2	0.03	0.04	65.3	Insufficient samples		1
Sd	24-36		4.0	4.0	0.05	0.02	59.7	50	13	1
RM.66T	0- 6	122e 646904	4.0	3.0	.023	0.03	63.8	70	32	1
Sa	6-12		4.0	3.5	Nil	Nil	11.4	trace	7	1<
Sb	12-18		4.4	3.7	"	"	8.4	"	7	1<
Sc	18-24		4.6	4.4	"	"	7.1	30	18	1<
Sd	24-36		5.0	5.1	"	"	6.3	55	32	1<
RM.63T	0- 6	122e 860473	4.2	3.5	.031	0.05	35.8	145	32	1
Sa	6-12		4.4	3.2	.059	0.01	21.3	80	38	1
Sb	12-18		4.6	2.8	.124	0.02	20.6	60	25	3.6
Sc	18-24		4.8	3.2	.950	0.05	17.7	400	32	4.0
Sd	24-36		5.0	4.2	1.101	0.11	16.1	1295	104	4.0

Organic Clay

Reg. No.	Depth (ins)	Map Sheet and Grid Ref.	pH wet	pH air dry	SO_4 %	NaCl %	L.I. %	Water Extract Na p.p.m.	Water Extract K p.p.m.	M.Mhos/ cm on soil extract
RM56T	0- 6	122c 539888	4.6	3.5	Nil	Nil	31.0	35	7	1<
Sa	6-12		4.8	3.7	"	"	23.1	50	7	1<
Sb	12-18		4.8	3.8	"	"	20.1	55	7	1<
Sc	18-24		5.0	3.9	"	"	20.0	35	7	1<
Sd	24-36		5.2	4.1	"	"	23.5	85	13	1<
RM240T	0- 6	129	3.8	3.7	not detn.	Nil	31.1	10	38	1<
Sa	6-12	Sect.7 226496	3.8	3.5	"	"	14.1	20	25	1<
Sb	12-18		4.0	3.6	"	"	10.9	10	25	1<
Sc	18-24		4.2	3.0	"	.015	10.8	10	65	1
Sd	24-36		4.4	3.1	"	.162	10.8	40	85	1

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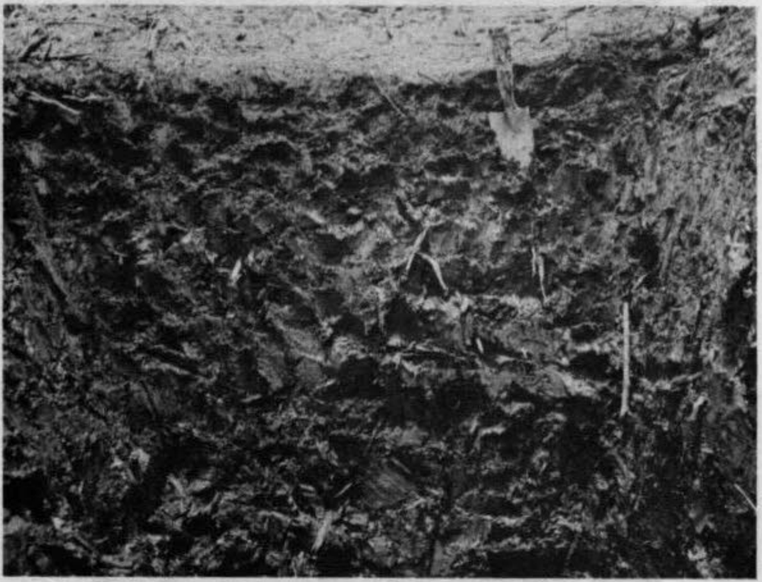
PLATE I

Selangor Series, well drained phase. A particularly well drained example of the most fertile alluvial soil type in the area surveyed. Roots penetrate to a greater depth in this phase than in other phases of the same soil, in which penetration is restricted by the high water table.

PLATE II

Effects of coastal erosion in naturally well drained Selangor Series soil, the surface of which was a foot or two above high tide level. At other parts of the coast deposition is the rule and the Selangor Series soils are separated from the shoreline by a band of Kranji Series soils developed over recent marine mud, and covered by mangrove.

PLATE III



Linau Series, illustrating the high proportion of dead root remains. The darker horizon in the lower half of the photograph possesses a strong sulphurous odour.

PLATE IV

These coconuts are growing on soil of the Kranji Series which is subject to frequent inundation by sea-water, caused by deterioration in the coastal bunds. This state of affairs is gradually being remedied by drainage improvements, but such measures will be too late to bring about a worthwhile recovery of the coconut stand shown in the photograph.

PLATE V

A mixed stand of mature and young coconuts growing on peat 30 inches deep. Drainage in this area has been particularly effective in altering the original swamp condition of the soil, and the surface may have dropped as much as two feet due to shrinkage and oxidation of the peat, as evidenced by the protruding root masses of the older palms.

PLATE VI

A typical example of a poorly tended coconut holding, which is an all too common sight in the southern Johore region. The thick ground cover is almost impenetrable on some holdings. This particular plot is sited on adequately drained Selangor Series soil, and considerable yield increases could be expected from a sound rehabilitation programme.

PLATE VII

Parit Haylam, a recently constructed main drain near Senggarang. This drain has assisted in lowering the water table over large areas of Selangor Series, peat, and muck soils, which are all extensively planted to coconuts. Improved drainage is a prerequisite to satisfactory rehabilitation of existing coconut holdings over large parts of the area surveyed.

PLATE VIII

An example of a rehabilitated coconut stand on an agricultural station. The old stand has been underplanted with selected seedling nuts and interplanted with madarin oranges. A vigorous leguminous cover of stylo (Stylosanthis gracilis) has been established below the coconut trees.