DESCRIPTION OF SOILS AT THE R.R.I. EXPERIMENT STATION.

BY

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The following notes represent the results of the first attempt at an organised soil survey of the Institute's Experiment Station at Sungei Buloh. Previously, samples had been taken and examined from time to time for special purposes, but field and laboratory work have now been combined to produce a working classification of types and an accompanying map of their distribution.

The main area of the Experiment Station in the Forest Reserve at Sungei Buloh is flat, and is surrounded by slight elevations of one to two hundred feet. The clearing extends on to the lower slopes of these elevations to the east and to the west, as shewn towards the edges of Blocks 15 and 25, and Blocks 22 and 19. One steep hill exists, rising to three hundred and fifty feet in Block 24. Good natural drainage is afforded by two streams which run down the eastern and western boundaries of the present cleared area and join outside the boundary to the south. In the northern Blocks, where the natural drainage has been poor in the past, supplementary drains have been made, as indicated in the map. The soil texture everywhere is such as to permit rapid percolation of water.

The geological formation underlying the area is Quartzite and Shale (Triassic Period), according to the map given by Scrivenor.* This usually weathers to a brown-red clayey sand, showing a great readiness to compact and containing sharp coarse particles of quartz. Soil derived directly from the rock in situ is found only on the hill, the main flat area being covered by transported material of a coarse composition.

Broadly speaking there are three soil types to be distinguished, and their demarcations from one another are very distinct. They are (1) the hill soil, which presumably represents the product from parent rock which has weathered in situ, (2) a detrital soil on the flat which, after deposition, has suffered normal weathering under good drainage, and (3) a modification of (2) on the

* The Geology of Malaya (Macmillan & Co.), by J. B. Scrivenor, 1931.

lower parts of the flat area where poor drainage has led to an accumulation of organic matter. The last type will be spoken of as the swamp type, that term referring to its past history, for it must be understood that at the present time it is well drained. For these areas, therefore, drainage must be reckoned as one of the major alterations in environment produced by the process of opening and planting. In order to compile the required information, soil-profile pits were examined on each of the soil types, and the map of the area was compiled from examination of the surface and of auger borings made to a depth of three feet.

The Hill Soil.

The hill soil is essentially acid (pH 4.5) and sandy (70 per cent. of sand), but it is more compact and has a slightly higher clay content (22 per cent of clay) than the soils on the flat. The amount of clay gradually increases in the lower depths (below 4 feet—62 per cent. of sand; 33 per cent. of clay).

The top layer to the depth of about 2 inches is slightly stained with humus but below this the soil has a uniform tawny yellow colour down to 3 feet. Below this again a faint green mottling and black speckling begins to be noticeable, indicating less well aerated conditions. The organic matter content is surprisingly well maintained, 0.4 per cent. of carbon still being present below 4 feet. The larger quartz stones and particles which are a usual feature are absent in this profile. The nutrient concentrations are normal, and there are no indications that excessive leaching has occurred.

Numerous rock exposures occur on the hill road in Block 24, and these appear to be mainly shales, with some quartzite, being greyish yellow in colour and showing distinct laminations. Several weathered states of this occur—yellow brown and tawny brown sands, with occasional blood red iron concentrations and intrusions of quartz particles.

The Detrital Soil.

This profile shows an open textured acid soil, (80 per cent. of sand, 15 per cent. of clay, pH 4.2), yellow brown in colour, becoming redder below three feet, and of uniform consistency down to about five feet depth. At that depth there is an abrupt change to a heavy white clay (50 per cent. of clay, 40 per cent. of sand, pH 4.0). The content of organic matter and plant nutrients is low and of uniform distribution throughout the profile, which is a state to be expected where water movement is predominantly downward and excessive in amount. The low concentration of nutrients is partly compensated by the depth of soil which is open to root action by reason of good drainage and aeration.

The detrital nature of this soil type is indicated by its high sand content, by the local topography and by the abrupt differentiation between deposited sand and the underlying clay at five feet depth.

THE SWAMP SOIL.

The northern portion of the clearing lies rather lower and the soil is of the swamp type. One striking characteristic of this area is the large numbers of old termite mounds, which are not found elsewhere. The ants are presumably attracted by the larger amounts of woody material left in the ground and, building their nests above the reach of the water level, work downwards as the seasonal changes in the water level may permit. The original jungle conditions were not a true swamp, but a small stream which for long periods inundated the surrounding land to a shallow depth.

The top two to three feet of the profile are a black humic sand, (carbon 3 per cent, sand 80 per cent, pH 4.7), and below this is a horizon of white, highly leached sand and gravel, in which the concentration of nutrients is very low. The transition between these two horizons is remarkably abrupt. The white sandy layer extends several feet and in places contains a well defined layer of hardpan. Appreciable amounts of nitrogen and phosphorus appear to be combined in the top organic layer (0.15 per cent. N, 0.04 per cent. PO_4). These features have been produced by the site lying under water for a greater part of the time, a condition which leads to relatively slow decomposition of organic detritus and hence to its accumulation.

The bleached lower layer has been produced by the same process as the similar layer in the typical podsol, i.e. by constant leaching with water containing humic acid. In this case the texture is very open which permits of rapid water movement and, from the drainage levels and nearness to the central stream, it is inferred that movement has been largely in a horizontal direction.

In addition to the above three types of soil, there are one or two small patches of an "intermediate" type, which have points of resemblance with both the swamp soil and the detrital soil. There is a slight accumulation of organic matter in the top eighteen inches indicating a certain degree of flooding, but the soil below is the tawny orange sand of the detrital type. No leached subsoil is found.

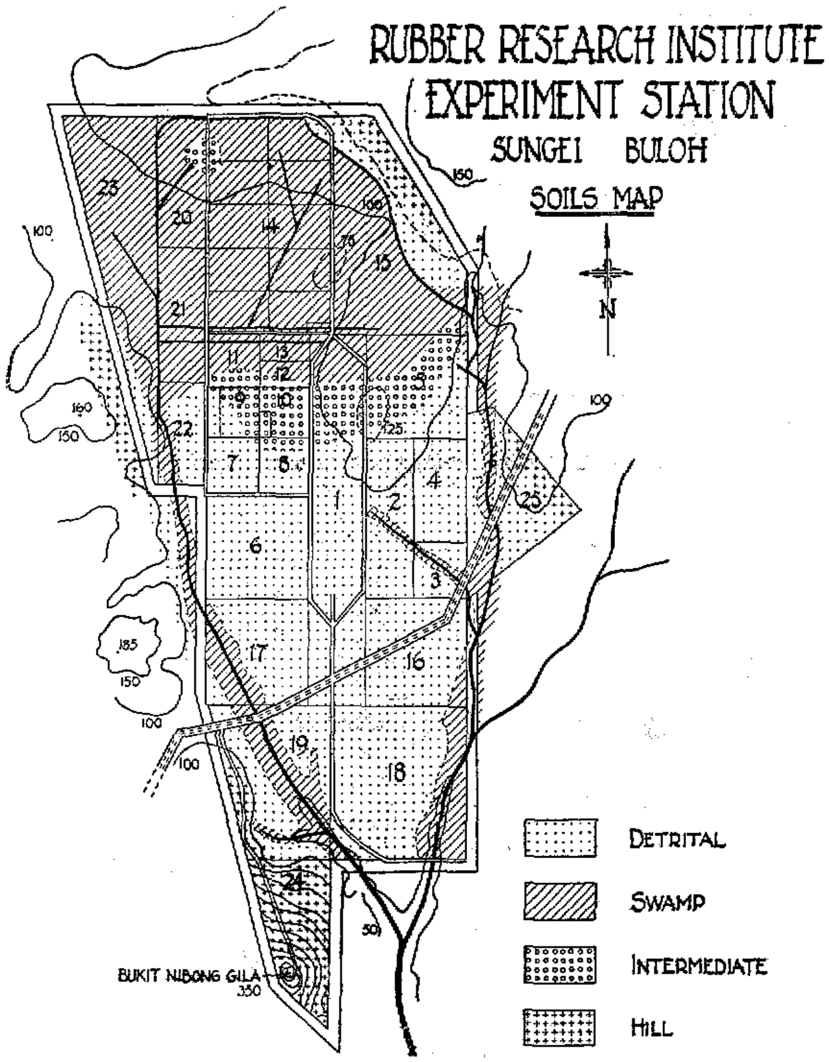
A hard pan has also been found in places, though its occurrence is so irregular that complete details of its extent are not known. It is certainly related to the swamp and intermediate types, and exposures of it were found in two drains—one running north and south between Block 21 (D) and (E) and Block 23, and the other running east and west between Block 14E and Block 11. A red and a black form occur. The former is found about three feet down, underlying a brown sand (intermediate type), and it varies in colour considerably, from a pale yellow to a dull crimson, (the last being very much harder). The black pan is found at five feet depth underlying a top three feet of humic sand and then two feet of leached, white, coarse sand. The cementing agent here seems to be humic material, as a laboratory test failed to reveal the presence of any considerable proportion of iron. The deposition of the hard pan is no doubt an example of the most commonly occurring type, in which the materials dissolved by the humic acid in the percolating water are deposited again at a lower level. The irregular and local character of the pan is to be expected, since the past history of the area will have held many events (exceptional floods, movements due to distant clearing or draining, etc.) which would disturb the exact conditions of the pan formation.

CORRELATION OF VEGETATIVE GROWTH WITH SOIL DIFFERENCES.

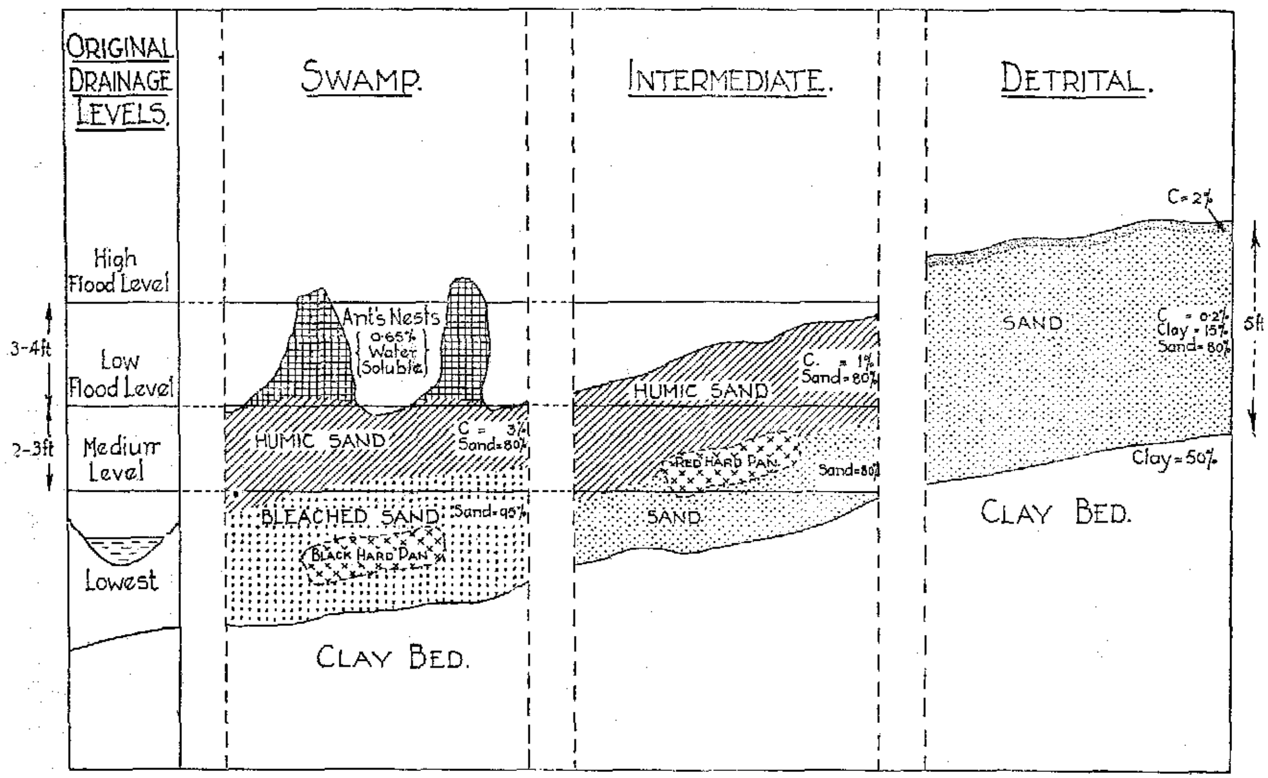
The growth of the rubber trees at the Experiment Station has not yet shown differences which can be definitely ascribed to soil variations. With the cover plants, particularly good growth has been obtained over the swamp soils, whilst on the hill areas it has been poor, but these differences are probably more closely related to water supply than to other soil conditions. For the same reason the rubber trees showed poor growth until their root development made them less dependent upon surface moisture, but after that, growth everywhere has been good. It is concluded that, although some areas have better reserves than others, all areas are at present furnishing adequate available nutrients.

General Discussion.

The question of soil conservation on the hill proved a difficult one for many months after clearing. On the lower slopes contour pits and bunds were put in, and, on the higher and steeper areas, terraces were cut with a steep cant into the hill side. In spite of careful work, constant repair of washouts was required owing to the unusually loose character of the soil. The assistance of covers was also lacking during the early months as no adequate growth was made in spite of careful and repeated planting. This



Note.—The swamp areas after having been drained are all suitable for planting.



SCHEME SHOWING DEVELOPMENT OF SOIL TYPES.

was due to the very dry weather experienced during 1928-29. Conditions have now settled down and no further trouble is being experienced; the porosity of the soil (which is related to its looseness) is proving advantageous rather than otherwise.

The accompanying diagram shows in a highly schematic way the conception we have formed of the relationship of the soils in the flat area. The dominating influence has been the normal fluctuation in drainage levels. Other influences have been the direction and amounts of subsoil water movement, and the tendency for coarser material to form the deposit along the central streams of surface water movement. The higher central portion of the area has stood above the level of any normal flood level. Observations of the wells show that in rainy weather the water table rises to within two or three feet of the surface and sinks to 30 feet or more in dry seasons. The surface layers are therefore well aerated and, in consequence, decay of the surface vegetable detritus has always been rapid. The layer of humic soil is thus only a few inches deep, although a slight humic staining contributes to the soil colour to a considerable depth.

As the soil level falls towards the drainage centres we pass to the intermediate soil type in which there is a greater accumulation of humus due to periods of inundation. The subsoil conditions however, remain similar to the higher areas. Finally at the lowest levels we find a high accumulation of organic material in the surface, with a subsoil of very coarse, highly-leached material—practically a stream bed over which the growth of vegetation has spread and maintained an extra layer.

Although growth on the Experiment Station has been comparatively uniform owing to the freshly cleared state of the soil, there are obviously such differences latent that the future developments and changes under the conditions of cultivation will give scope for many interesting observations and experiments.

Profile descriptions and analytical data.*

1. *Hill Soil profile.*

(Profile No. 10, Sungei Buloh).

0—2 ins. Very slightly humic, fine sand, tawny orange, numerous roots, compact.

2—12 ins. Campact, tawny-orange sand, uniform colour and texture, few roots.

24—72 ins. Tawny-orange sand, very compact, with pale greenish patching and black speckling, becoming more pronounced towards the bottom of profile.

Analytical data see Table A.

2. *Detrital Soil Profile.*

(Profile No. 1. Sungei Buloh).

0— 2 ins. Humic, coarse sand, fawn-sepia colour, moist, few roots.

2—18 ins. Dirty yellow, brown, coarse sand, very few roots.

18—52 ins. Reddish yellow, brown sand, coarser.

52—57 ins. Hard, cemented, grey gravel; much damper.

57—73 ins. Grey-white clay, with gravel in upper portions; very stiff and dry.

Analytical data see Table B.

3. *Swamp Soil Profile.*

(Profile No. 6. Sungei Buloh).

0—2 ins. Humus material and sand, black-sepia colour, abundant surface roots.

2—22 ins. Brown-black, humic sand, roots plentiful.

Below 22 ins. Coarse, dirty white sand and gravel, very moist, no roots; (below water table lèvel).

Analytical data see Table C.

*NOTE.—The profile numbers refer to laboratory records. Other members of the series taken on typical soils elsewhere in Malaya are to be described later.

SUMMARY.

The topography of the Experiment Station is described and a soil map is reproduced. Three soil types are distinguished and described by means of soil profiles and tables of analysis. The development of the conditions found on the main flat area is explained by reference to a diagram showing the relationship to water levels.

TABLE A.

Sample number	Depth in inches	Loss on evaporation	Loss on ignition	Sticky* point	I. T.	Sand	Silt	Clay	Gravel	Acidity		Carbon	Acid extract		Nitrogen	Ratio C/N
										pH Colorimetric	pH Electrometric		K	PO_4		
		per cent	per cent	per cent		per cent	per cent	per cent	per cent			p.p.m.	p.p.m.	p.p.m.		
S.B. 37	2	0.7	4.9	16.4	2	69.7	4.3	19.7	6.3	5.6	4.29	10,380	1,033	225	749	13.85
S.B. 38	6	0.8	4.8	16.0	2	72.0	4.8	22.4	0.8	5.6	4.53	8,490	497	182	686	12.4
S.B. 39	12	1.0	4.9	15.4	1	73.7	4.6	20.8	0.9	5.6	4.66	7,540	540	165	539	14.2
S.B. 40	24	0.7	4.5	15.0	1	72.3	4.8	22.5	—	6.0	4.82	5,820	494	157	406	14.35
S.B. 41	36	0.8	4.5	15.5	1	70.8	5.0	23.9	—	5.8	4.53	5,580	412	163	511	11.5
S.B. 42	48	0.8	4.8	16.7	3	69.4	4.8	25.5	—	5.5	4.34	5,040	334	165	336	15.0
S.B. 43	72	1.4	5.7	15.9	3	62.8	3.2	33.4	0.6	4.6	4.15	4,010	593	160	280	15.3

* "An Index of Soil Texture," F. Hardy, J. Agric. Sci., 1928, XVIII, 252.

"Sticky Point" is the percentage of moisture in a soil sample in such a state that when kneaded in the palm of the hand it just does not stick.

$$\text{I.T.} = \text{Index of Texture} = \left[\text{Percentage Moisture Sticky Point} - \frac{\text{Percentage of sand}}{5} \right]$$

p.p.m.=parts per million.

TABLE B.

Sample number	Depth of lower horizon	Loss on evaporation	Loss on ignition	Sticky point	I.T.	Sand	Silt	Clay	pH Electrometric	Carbon	Acid extract		Water extract	
											K	PO_4	K	PO_4
	ins.	per cent	per cent			per cent	per cent	per cent		p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
S.B. 1	¾	11.9	5.38	18.2	1	85.2	3.2	11.6	3.80	19,380	94	222	34.3	0.49
S.B. 2	1¾	11.9	5.0	16.9	2	75.6	8.0	16.4	4.90	12,390	99	201	31.2	0.41
S.B. 3	4¼	12.2	4.3	17.4	2	77.2	6.4	16.4	4.83	7,590	105	150	30.4	0.28
S.B. 4	8¼	12.4	3.5	17.7	1	82.0	4.9	13.1	4.40	3,240	110	128	69.7	0.26
S.B. 5	13¼	12.4	3.0	15.7	0	82.0	4.9	13.1	4.47	2,430	83	130	79.9	0.24
S.B. 6	18¾	12.7	3.6	16.3	0	78.8	6.5	14.7	4.28	2,430	118	116	53.2	0.31
S.B. 7	26¼	11.8	4.0	15.7	1	74.2	6.4	19.4	4.22	2,280	122	121	22.5	0.27
S.B. 8	35¾	11.0	4.0	15.1	0	77.2	6.5	16.3	4.31	1,170	140	112	39.1	0.36
S.B. 9	44¾	10.5	4.1	14.1	0	77.2	8.1	14.7	4.12	1,200	87	114	25.2	0.24
S.B. 10	52¾	7.6	1.9	12.4	0	83.8	8.0	8.2	4.36	1,200	71	101	34.6	0.47
S.B. 11	57¼	7.3	1.6	13.1	0	74.2	8.0	17.8	4.36	810	97	126	30.5	0.31
S.B. 12	61¼	14.6	4.9	22.6	10	63.0	3.2	33.8	4.24	2,340	151	179	22.8	0.63
S.B. 13	73¼	19.3	7.5	28.9	21	41.4	6.6	52.0	3.90	2,820	250	172	28.1	0.24

TABLE C.

Sample number	Depth of lower horizon (ins.)	Loss on evaporation per cent	Loss on ignition per cent	Sticky point per cent	I.T.	Sand per cent	Silt per cent	Clay per cent	pH Colorimetric	pH Electrometric	Carbon p.p.m.	Acid extract K p.p.m.	Acid extract PO_4 p.p.m.	Water extract K p.p.m.	Water extract PO_4 p.p.m.	Nitrogen p.p.m.	Ratio C/N
S.B. 31	2	6.6	35.4	40.6	25	75.8	13.7	10.5	5.6	4.42	131,400	319	640	27	2.5	6,580	20.0
S.B. 32	6	3.2	15.3	27.4	12	76.6	13.3	10.1	6.2	4.89	35,460	170	450	34	2.0	2,072	13.0
S.B. 33	11	2.2	14.7	28.7	13	76.9	13.1	10.0	6.2	5.05	27,300	135	420	23	2.5	1,386	19.7
S.B. 34	13	2.4	13.4	27.5	11	82.2	12.8	5.0	5.8	5.05	17,640	238	310	16	1.0	1,050	16.8
S.B. 35	22	3.0	14.3	27.3	11	83.8	9.6	6.6	6.0	5.01	23,220	174	450	12	0.5	1,176	19.8
S.B. 36	Below 22	0.0	0.3	9.7	...	96.4	3.2	0.4	5.8	4.98	1,560	55	100	5	0.2	84	18.6

TABLE D.

	Loss on ignition	Water soluble per cent	Acid soluble per cent	pH Colorimetric	pH Electrometric	Acid extract K p.p.m.	Acid extract PO_4 p.p.m.	Nitrogen p.p.m.	Calcium p.p.m.	Carbon p.p.m.
Ants' nest	17.78	0.65	15.65	5.1	4.15	50	505	1,400	1,400	24,540