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Mineralogy and Genesis of Soils in Uuiversiti Pertanian Malaysia, Serdang, Selangor

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RINGKASAN

Tanah di Universiti Pertanian Malaysia diukur dan dikaji untuk menentukan mineralogi dan pembentukannya. Keputusan kajian menunjukkan empat siri tanah yang utama dijumpai di Universiti Pertanian. Dua daripadanya, iaitu Siri Melaka dan Munchong dikelaskan sebagai Tropeptik Haplorthoks, dan dua lagi, iaitu Siri Serdang dan Bungor dikelaskan sebagai Tipik Paleudult.

Struktur tanah itu didapati lemah. Tekstur tanah Siri Melaka, Munchong dan Bungor ialah liat, manakala tanah Siri Serdang pula ialah lom liat berpasir. Siri Melaka yang mengandungi petroplinthit itu wujud sebagai tudong di atas bukit. Tanah Siri Munchong, Bungor dan Serdang wujud sama ada di atas cerun atau berada di tempat yang lebeh rendah daripada Siri Melaka.

Semua tanah tersangat luluhawa. Mineral liat yang utama ialah kaolinit, gibsit dan goethit. Mineral liat jenis 2:1 tidak terdapat, kecuali terdapat sedikit ilit di dalam Siri Melaka. pH rendah, begitu juga dengan kation tukarganti, KPK dan % ketepuan bes. Disebaliknya, Al dan H tukarganti sangat tinggi.

SUMMARY

Soils of Universiti Pertanian Malaysia were surveyed and studied in order to determine their mineralogy and genesis. The results of the study showed that there were four major soil series on the Universiti Pertanian farm. Two of these series, namely Melaka and Munchong Series, were taxonomically classified as Tropeptic Haplorthox, while the other two, namely Serdang and Bungor Series, were classified as Typic Paleudult.

The structure of the soils was found to be weak. The texture was clay in the case of Melaka, Munchong and Bungor Series and sandy clay loam in the case of Serdang Series. Melaka Series soil which contained petroplinthite occur as capping on top of hills. Soils of Munchong, Bungor and Serdang occur either on the slope or on the lower position than Melaka Series.

All soils were extremely weathered. The dominant clay minerals were kaolinite, gibbsite and goethite; 2:1 type of clay mineral was virtually absent, except possibly some illite in Melaka Series. The pH was low, and so were exchangeable cations, CEC and % base saturation. On the other hand, exchangeable Al and H were significantly high.

INTRODUCTION

Universiti Pertanian Malaysia, which is situated 22.5 km to the south of Kuala Lumpur, has an area of approximately 1200 ha, of which 1090 ha are reserved for farming activities. Soils of this farm have been surveyed previously (Panton, 1954; and Othman and Ahmad, 1971). Since those were rather general in nature, further studies were still needed to get a complete mineralogical and physico-chemical data. The soils of UPM farm had been remapped and characterized by Paramananthan *et al.* (1979).

At this moment the farm is planted with all kinds of fruit trees, plantation crops and grasses. A significant fraction of the farm is utilized for student sharefarms and research. With all this in mind, it has become increasingly necessary to re-obtain full information on soils on the University Farm. The object of this paper is to get physico-chemical and mineralogical data

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of the soils in the area in order to study their genesis.

MATERIALS AND METHODS

The farm was surveyed (Paramananthan *et al,* 1979) thoroughly and four soil series namely Serdang, Melaka, Munchong and Bungor Series were identified. These soil series were then classified according to Soil Taxonomy (USDA, 1975). A soil map, using series as mapping unit, was subsequently prepared *(Fig. 1).* Samples were collected for the four soil series according to their genetic horizons.

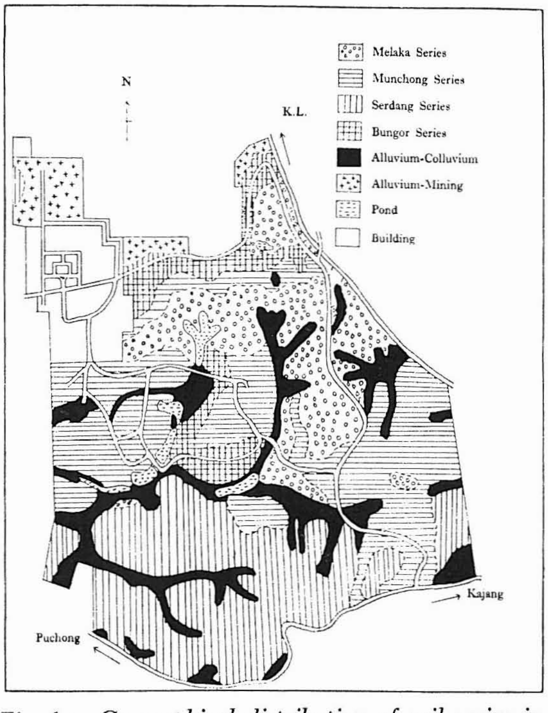

Fig. 1 : Geographical distribution of soil series in UPM, Serdang, Selangor (after Paramananthan *et al,* 1979)

The samples were air-dried and ground to pass through a 2mm sieve. Soil pH (H_2O) was subsequently measured at 1:2.5 soil. Granulometric analysis was carried out by pipette method of Day (1965). Exchangeable cations were extracted by NH_4OAc at pH 7 (Chapman, 1965); Na and K were determined by flame photometer, and Ca and Mg were determined by atomic absorption spectrophotometer. CEC was determined by the NH_4OAc method at pH 7 following the method of Chapman (1965) and exchangeable Al and H were determined by method of Maclean (1965). Lime requirement was estimated by titration method (Dunn, 1943). X-ray diffraction (XRD) was carried out following the method of Whittig (1965) and lastly the organic carbon was estimated by Walkley-Black method of Allison (1965).

RESULTS AND DISCUSSION

General Characteristics

The geographical distribution of soils of the University farm is complex. However, from the survey carried out some broad geomorphic relationship between the soils can be made. Generally, the northern part of the farm consists of soils developed over iron-rich parent materials (mainly schist and shale), while the southern part is developed from sandstone and quartzite interbedded with schist. Four soil series namely Melaka, Munchong, Serdang and Bungor Series were recognised, the distribution of which is given in Figure 1. The taxonomic classification of these soils is given in the later part of the discussion (Table 4).

In general, the highest part of the farm consists of lateritic soils of Melaka Series (Fig. 2). However, on the lower hills and footslope, soils of Munchong series occur as topographically related soils. Soils of Serdang and Bungor Series occur on the areas underlain by sandstone and shale (schist), but also mixed with some materials derived from erosion of soils of Melaka Series (Fig. 2).

Mineralogical Characteristics

The four soil series under investigation were studied by x-ray diffraction (XRD) analysis. The clays of each series were each treated with Mg, Mg-saturated with glycerol, K and K heated to 500°C. The diffractograms of soils of each treatment are given in Figure 3. In general, all soil series manifested strong reflections at 7.15 Å, 4.86 Å and 4.26 Å. The presence of 7.15 Å and 3.57 Å showed the presence of kaolinite, while the presence of 4.86 Å and 4.26 Å spacing indicated the respective presence of gibbsite and quartz (Whittig, 1965). Further proof for the presence of gibbsite was the presence of reflection at 4.37 Å.

By the same argument it could be presumed that soil of Serdang Series contained kaolinite and gibbsite, and possibly some illite and quartz. The presence of some quartz and illite in Serdang Series was shown by the faint reflection at 3.34 Å. There was no goethite in Serdang Series as there was no reflection at 4.18 Å.

Soils of Bungor, Melaka and Munchong Series gave reflections at 7.15 Å (3.57 Å), 4.26 Å,

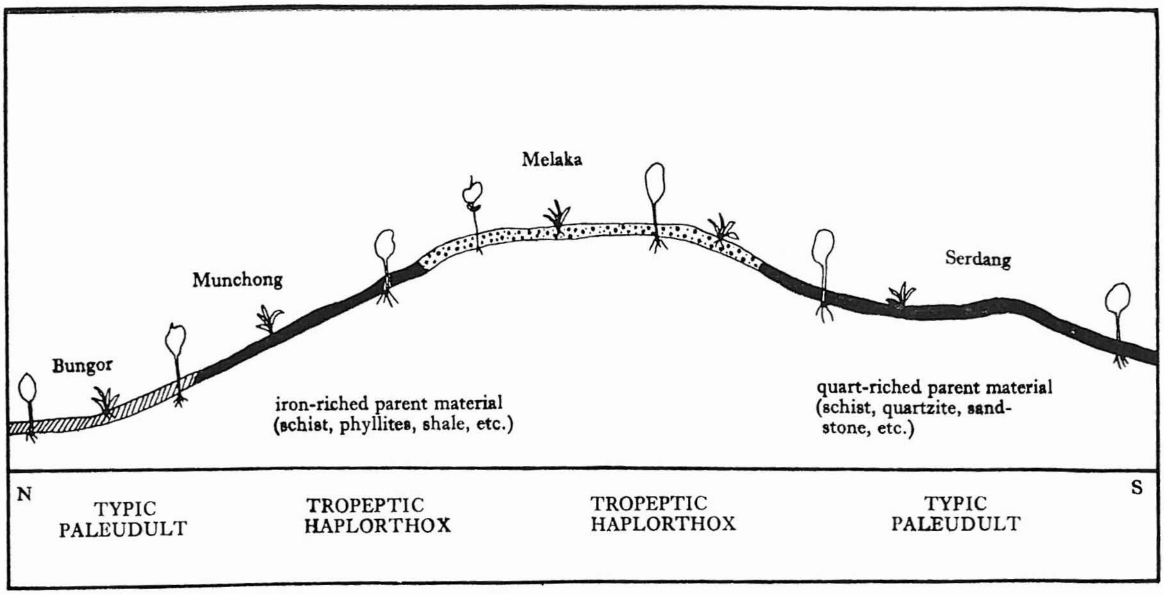

Fig. 2: Topographic distribution of soils in UPM farm, Serdang, Selangor.

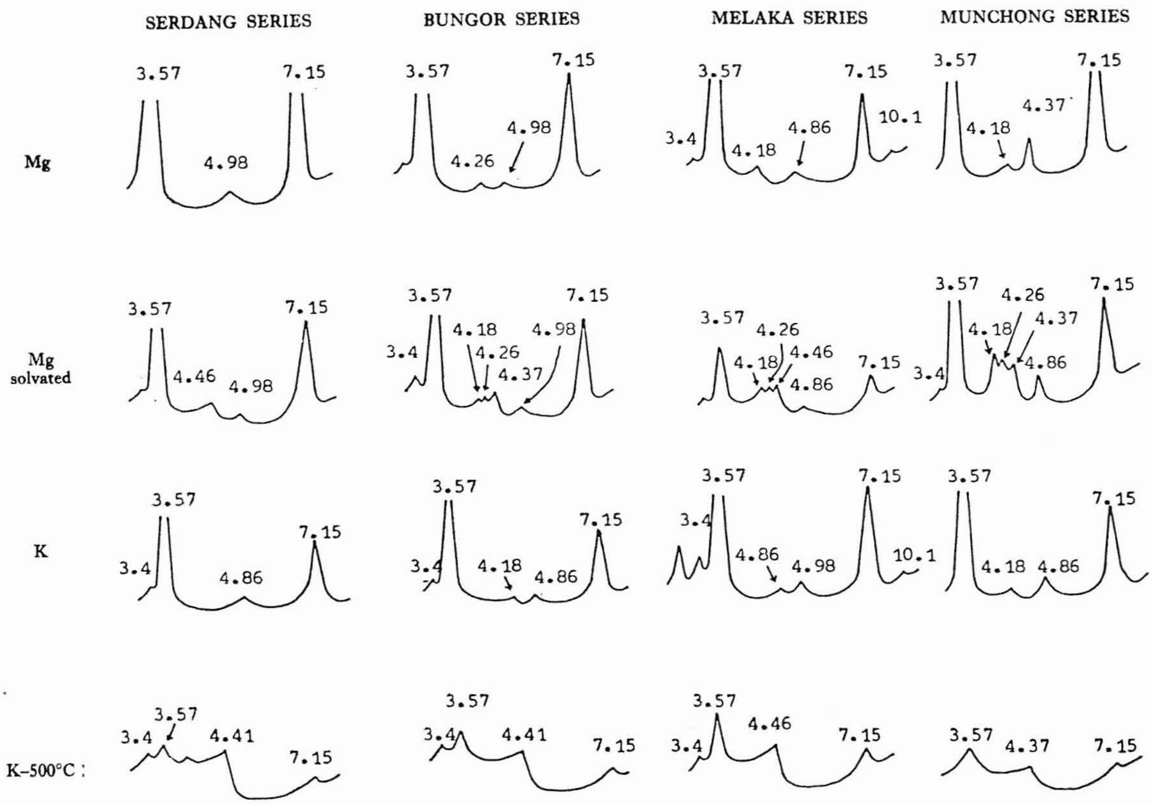

Fig. 3: X-ray diffractograms of Serdang, Bungor, Melaka and Munchong Series under different treatment.

4.18 Å, and 4.86 Å which point to the presence of kaolinite, quartz, goethite and gibbsite, respectively. The presence of illite was not well manifested except for Melaka Series in which reflection at 10 Å was produced when it was treated with Mg and K *(Fig. 3)*.

In general, when the samples were heated to 500°C, reflections at 7.15 Å were destroyed, indicating the absence of chlorite. The absence of chlorite was also shown by the absence of reflection at 14 Å. Montmorillonite was considered absent because there was no reflection at 14 Å (Mg-saturated) and 18 Å (Mg-saturated, glycerol solvated). The presence of vermiculite was also not clearly manifested.

The presence of kaolinite, gibbsite and goethite showed that soils of Melaka, Munchong, Serdang and Bungor have undergone extreme weathering. The soils were highly leached, so much so that exchangeable bases, pH CEC and % base saturation were low (Table 1). This fact will be discussed later.

Chemical Characteristics

Tables 1 and 2 summarise the chemical characteristics of soils under investigation. The texture of Melaka, Munchong and Bungor Series was clay, while that of Serdang Series was sandy clay loam (Table 1). Generally, the amount of exchangeable cations (especially that of K) decreased with depth. While K was found be reasonably high, with 0.17, 0.13 and 0.23 me/100g soil in Melaka, Serdang, and Bungor Series respectively, Ca and Mg were low. The CEC of the soils was low. However, the CEC of topsoils was higher than those of subsoils. This was probably due to the presence of more amounts of organic matter in the topsoils than the subsoils (Table 1).

The pH of the soils was less than 4.6 (Table 2). Under this condition, Al^{+++} and H^{+} were present in significant amounts both in the soil solution and on the exchange sites (Sanchez, 1976). Hydrolysis of aluminium tends to produce more hydrogen, which decreased the pH even further. The amount of exchangeable aluminium in the top soils was found to be about 2.60, 2.10, 2.55 and 3.70 me/100g soil in Melaka, Munchong, Serdang and Bungor Series respectively. This amount, in general, decreased with depth. Similarly, exchangeable hydrogen decreased with depth.

Lime requirement, which was estimated by method of Dunn (1943), showed that Melaka, Munchong, Serdang and Bungor Series needed about 2.8, 2.7, 2.9 and 2.9 ton/ha, respectively, to change their pH to 5.5. The pH of 5.5 was taken into account because it was considered that at pH 5.5 most of the aluminium in the soil solution would be precipitated (Sanchez, 1976; Eswaran *et al,* 1977). Further increase of pH would result in unavailability of certain micronutrient, notably Fe and Mn.

Low exchangeable cations, CEC and % base saturation showed that the soils were highly leached. As it was shown earlier, these soils were dominated by kaolinite and sesquioxides (Fig. 3). These minerals do not have the capacity to hold nutrients, so whatever nutrients applied to the soils, would be leached by water. The leaching of these nutrients would then make the soils Al^{+++} and H^{+} saturated (Table 2).

Genesis

Soils are formed by the action and interaction of climate, vegetation and topography on parent rocks. The type and nature of parent rocks are important because they determine the rate of weathering on the one hand, and the chemical composition of the soils on the other. Soils on the Universiti Farm are developed over rocks of three formations, namely Kenny Hill, Kajang and Kuala Lumpur Formation (Table 3). Kenny Hill Formation, which is of Permo-Carboniferous age is composed of quartzite and phyllite. Kajang Formation is composed of schist with minor intercalation of limestone and phyllite, whereas Kuala Lumpur Formation is composed of limestone with minor intercalation of phyllite (Yin, 1976). The geographical distribution of these rocks is given in Figure 4.

Average annual rainfall for the farm, taken over a period of seven years (1972 – 1978) is approximately 2070 mm. The least monthly rainfall is recorded in June, while the highest is in March – April *(Fig. 5)*. Rain of this nature causes serious erosion. Soil materials on higher areas will be washed and deposited in the valleys, forming alluvial soils of mixed series. Heavy rainfall coupled with high temperature *(Fig. 5)* cause a high degree of weathering, resulting in the removal of silica and accumation of Al and Fe. This condition prefers the formation of 1:1 of clay (kaolinite) and sesquioxides (goethite and gibbsite). Removal of exchangeable cation by leaching results in low CEC and % base saturation (Table 1).

Figure 2 shows the topographic distribution of soils on the University Farm. In general, the hills are occupied by soils of Melaka Series, which contain petroplinthite within 50 cm of the

TABLE 1

Granulometry, exchangeable cations, CEC, % base saturation and % organic carbon of Melaka, Munchong, Serdang and Bungor Series

Series	Horizon	Depth (cm)	Granulometry (%) (C-Sand	F-Sand	Silt	Clay)	Exchangeable Cation (me/100g) (Na	K	Ca	Mg)	CEC (me/100g)	B.S(%)	O.C(%)
Melaka	Ap	0–3	16.7	5.5	17.6	60.2	0.06	0.17	0.19	0.11	12.3	4.30	1.44
	B210X	3–19	15.5	7.7	14.5	62.3	0.08	0.10	0.13	0.05	7.72	4.66	1.10
	B220X	19–96	12.4	7.9	11.9	67.8	0.07	0.08	0.20	0.03	4.49	8.46	0.62
Munchong	Ap**1**	0–10	7.7	27.8	13.3	51.2	0.09	0.09	0.14	0.07	13.7	2.85	2.35
	Ap**2**	10–31	9.4	19.8	12.5	58.3	0.08	0.05	0.13	0.03	6.11	4.75	1.15
	B210X	31–110	7.2	23.7	11.0	58.1	0.10	0.04	0.12	0.04	5.76	5.21	0.68
Serdang	Ap	0–15	35.1	31.9	7.4	25.6	0.09	0.13	0.06	0.04	6.72	4.76	1.30
	B21t	15–57	29.3	37.3	6.8	26.6	0.06	0.05	0.03	0.02	4.29	3.73	0.53
	B22t	57–84	26.9	37.7	3.1	32.3	0.07	0.05	0.09	0.01	3.16	6.96	0.36
	B23t	84–115	22.8	32.4	5.9	38.9	0.03	0.04	0.03	0.01	3.08	3.57	0.29
Bungor	Ap	0–15	16.8	53.1	11.4	18.7	0.07	0.23	0.31	0.10	8.71	8.15	2.46
	B1	15–31	13.9	47.0	19.5	19.6	0.06	0.23	0.09	0.06	4.33	10.2	0.98
	B2t	31–50/62	13.8	31.5	16.6	38.1	0.04	0.22	0.09	0.06	5.69	7.21	0.70
	11**B31**cn	50/62–120	13.2	21.8	20.5	44.5	0.05	0.07	0.12	0.02	6.10	4.26	0.24
	11**B32**cn	120–144	16.4	21.9	14.5	47.2	0.04	0.03	0.03	0.02	6.35	1.89	0.16
	111C	114	17.1	22.1	17.0	43.8	0.04	0.04	0.02	0.01	5.15	2.14	0.05

TABLE 2

pH, exchangeable aluminium, exchangeable hydrogen, exchange acidity and lime requirement of Melaka, Munchong, Serdang and Bungor Series

Series	Horizon	pH (H2O)	Exch. Aluminium (me/100g)	Exch. Hydrogen (me/100g)	Exch. Acidity (me/100g)	Lime Requirement (ton/ha) pH = 5.5
Melaka	Ap	4.6	2.60	1.55	3.65	2.8
	B210X	4.8	2.65	0.55	3.20	
	B220X	4.8	2.10	0.50	2.65	
Munchong	Ap1	4.6	2.10	1.05	3.15	2.7
	Ap2	4.5	2.10	1.00	3.10	
	B210X	5.1	1.05	0.50	1.55	
Serdang	Ap	4.5	2.55	1.05	3.60	2.9
	B21t	4.7	2.05	1.00	3.05	
	B22t	4.9	2.05	1.05	3.10	
	B23t	5.1	2.05	3.05	5.10	
Bungor	Ap	4.6	3.70	1.05	4.75	2.9
	B1	4.9	2.60	0.55	3.15	
	B2t	4.9	2.65	1.05	3.70	
	11B31cm	4.9	2.10	0.08	2.90	
	11B32cn	5.0	1.85	0.08	2.65	
	111C	4.9	1.80	0.08	2.60	

TABLE 3

Classification of parent rocks of soils in UPM, Serdang, Selangor (Yin, 1976)

Age	Formation	Lithology
Permo-Carboniferous	Kenny Hill	Quartzite and phyllite
Middle-Upper Silurian	Kajang	Schist with minor intercalation of limestone and phyllite
Middle-Upper Silurian	K.L.	Limestone with minor intercalation of phyllite

surface. Lower down the slope, an almost similar soil but without petroplinthite, soils of Munchong Series occur. Both Melaka and Munchong Series are derived from same parent materials, that is iron-riched schist, shale and phyllite *(Fig. 2)*.

Soils of Serdang Series largely occur to the south of Melaka and Munchong Series *(Fig. 1)*; it is topographically on the lower areas than Melaka Series *(Fig. 2)*. Because the parent material of Serdang Series is siliceous in nature,

TABLE 4

Taxonomic classification of soil in UPM, Serdang, Selangor (Paramananthan *et al.*, 1979).

Series	Subgroup	Family
Melaka	Tropeptic Haplorthox	Clayey-skeletal, oxidix, isohyperthermic
Munchong	Tropeptic Haplorthox	Clayey, kaolinitic, oxidic isohyperthermic
Serdang	Typic Paleudult	Fine loamy, kaolinitic, isohyperthermic
Bungor	Typic Paleudult	Clayey, kaolinitic, isohyperthermic

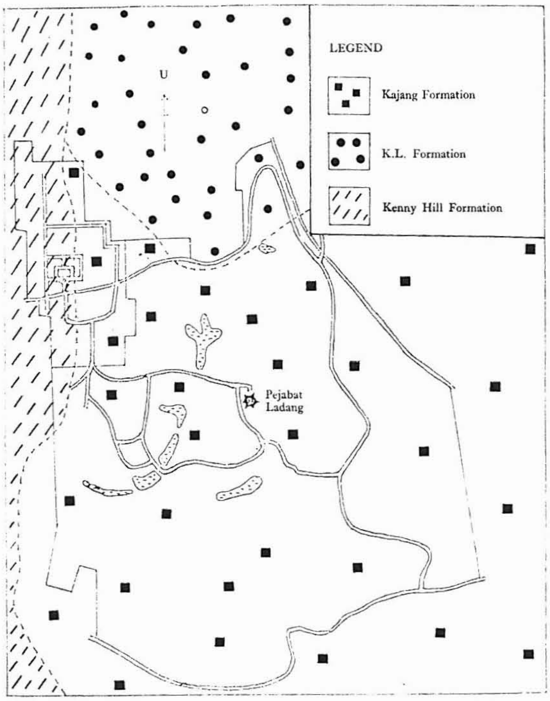

Fig. 4: Geographical distribution of parent rocks of soils in UPM, Serdang, Selangor (Yin, 1976).

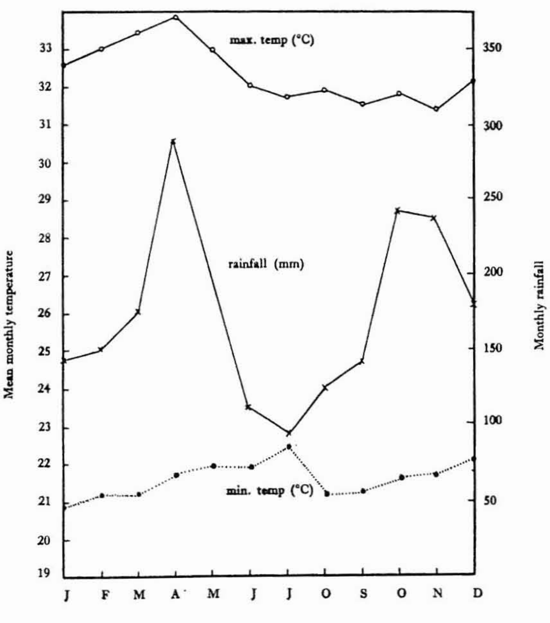

Fig. 5: Mean monthly temperature (1975–77) and monthly rainfall (1972–77) for UPM, Serdang, Selangor.

the soil is rather sandy and friable. Soils of Bungor Series on the contrary, are derived from schist and shale and sometimes from colluvium of Melaka and Munchong Series. This soil series is comparatively less weathered than either the Melaka or Munchong Series. In the valleys are soils of series which are collectively known as alluvium-colluvium *(Fig. 1)*.

Both Melaka and Munchong Series are highly weathered and extremely leached as a result of high temperature and rainfall, and good drainage. This condition promotes laterization processes, where silica is eluviated and sesquioxide and 1:1 type of clay accumulated. Consequently, soils with little horizon differentiation and red-brown in colour containing oxic horizons are formed. On the other hand, soils of Serdang and Bungor Series are comparatively less weathered than either Melaka or Munchong series. These soils, instead, have undergone lessivage, which is shown by the presence of clayskins in the B-horizons. This difference in the mode of profile development could be attributed to differences in iron-content of the parent materials.

Of the four soils studies only the Melaka series showed the presence of illite. The presence of these weatherable mineral is probably due to it being preserved in the iron-coated laterized shale and schist fragments which constitute the gravels in this soil.

Agricultural Limitations

All four soils (Melaka, Munchong, Serdang, Bungor) on the farm are poor for agriculture. Not only are their structures weak, their pH, CEC, water retaining capacity and nutrient retaining capacity are low. Melaka and Munchong Series are Oxisols. They are dominated by 1:1 clay, goethite and gibbsite. Soils of these nature will fix a lot of phosphate, but they do not retain applied potassium. Furthermore, Melaka Series soils have petroplinthite at the surface, which hinder root penetration. All soils do not contain 2:1 type clay, except possibly some illite which occur in Melaka Series. The absence of 2:1 clay is reflected by the low CEC value.

At present, Melaka Series soil is being planted with rubber, oil palm and fruit trees. Under the present management system, the soil may be good for rubber, but they are too poor for oil palm. This is because oil palm need a lot of nutrients and can not stand water stress. Much of Munchong Series is being utilized for pasture with a reasonable level of production under a heavy N fertilizer programme. Soils of Serdang and Bungor Series are utilized for rubber. Recently an attempt has been made to grow cocoa on Serdang Series, a soil not normally planted with cocoa.

CONCLUSION

Four soils belonging to Melaka, Munchong, Serdang and Bungor Series were identified on University Farm, at Serdang, Selangor. Melaka and Munchong series soils are classified as Tropeptic Haplorthox, while Serdang and Bungor Series soils are classified as Typic Paleudult. These four soils are highly weathered, thus they are dominated by 1:1 clay and sesquioxides. The present of these minerals result in the low agricultural status of the soils, showing by low exchangeable cations, CEC and % base saturation. Leaching of bases result in low pH and high Al and H saturation.

Soils of Melaka and Munchong are derived from iron-rich parent materials, while soils of Serdang Series are derived from quartz-rich parent materials. Normally, Melaka Series occur on the top of hills. Munchong, Serdang and Bungor Series occur on topographically lower position than Melaka Series. All soils are weakly structured.

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