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A Study on some Alfisols and Ultisols in Ustic Soil Moisture Regime, Northeast Thailand

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ABSTRACT

Alfisols and Ultisols developed on sandy parent materials in ustic moisture regime, Northeast Thailand generally portray similar characteristics. The soils occupy similar undulating landscapes of alluvial terraces. Field morphologies of these soils are quite similar making it difficult to differentiate them effectively at higher categorical levels. These soils contain appreciable amount of sand and have a range of bulk density between 1.50-1.77 g/cc. Though base saturation in the order control section of the Alfisols is higher than 35 percent their other chemical properties indicate poor fertility status in a similar fashion with that of the Ultisols. Mineral composition of these soils consists mainly of quartz and kaolinite, but montmorillonite can dominate the clay fraction at depth. Argillic horizons of the Alfisols are generally present in the deep part of the profiles. Skeleton grains and clay bridges are predominant features in their thin section of the argillic horizons. These soils have a narrow available moisture range. Water management, fertilizer application program and suitable form of slowly released fertilizer are inevitably needed for these soils to sustain sufficient field crop production.

INTRODUCTION

Though Thailand is generally dominated by monsoon, most parts of the country are under tropical savanna climate (Aw) (Koppen, 1931 ; Vijarnsorn *et al.,* 1983). Thailand consists of six physiographic regions namely Central Plain, Southeast Coast, Northeast Plateau, Central Highlands, North and West Continental Highlands and Peninsular Thailand (Moormann and Rojanasoonthon, 1972). Out of these six physiographic regions only the Peninsular Thailand and part of the Southeast Coast have a relatively well distributed rainfall throughout the year. Upland soils of these two regions have been considered to have udic soil mositure regime (Kheoruenromne and Suddhiprakarn, 1984b; Moncharoen, 1980). The other regions including Northeast Plateau have a pronounced wet and dry seasonal cycle. A study had revealed that upland soils in these regions have ustic moisture regime (Moncharoen, 1980). That is, without irrigation, soils will have sufficient moisture for plant growth only in rainy season.

According to norm of occurrence of soils in the tropics, the ustic soil moisture regime is favorable for the formation of Alfisols and most extensive areas of Ultisols also belong to this soil mositure regime (Buol *et al.,* 1980 ; Sanchez, 1976; Soil Survey Staff, 1975). In general, Alfisols can form on young landscape with moderate leaching, or they may develop on relatively old land-

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scapes providing that leaching is ineffective or having some sources of additional bases during their development. Nevertheless, the effect of leaching should be sufficient for the translocation of clay to accumulate in the subsoil as an argillic horizon. Their pH should not be very low due to the presence of remaining bases in the soils.

On the contrary, Ultisols have been defined to be soils of middle to low latitudes having a horizon that contains substantial amount of illuviated clay but few bases. These soils can develope on a wide range of parent materials but mostly on old landscapes with effective drainage. The release of bases by weathering in the soils usually equal or less than the rate of removal by leaching. Base saturation in these soils should be decreasing with depth and they should have low pH values. Their other taxonomic properties have been defined (Buol *et al.*, 1980; Soil Survey Staff, 1975).

Under an extensive soil survey and classification program executed by the Department of Land Development, Ministry of Agriculture and Cooperatives of Thailand it was found that the Ultisols are most extensive in the country (Vijarnsorn and Jongpakdee, 1979). However, it is also common to find the Alfisols occurred in association with the Ultisols on similar landscapes (Kheoruenromne and Suddhiprakarn, 1984a). A report on soils of Thailand indicated that both Alfisols and Ultisols in Thailand can be subdivided into several great groups (Changprai, 1983). A scheme modified from a well known textbook in soil genesis and classification (Buol *et al.*, 1980) as illustrated in Figure 1 for the Alfisols and Ultisols found in Thailand indicates their abundance clearly. Figure 1 also demonstrates that Alfisols

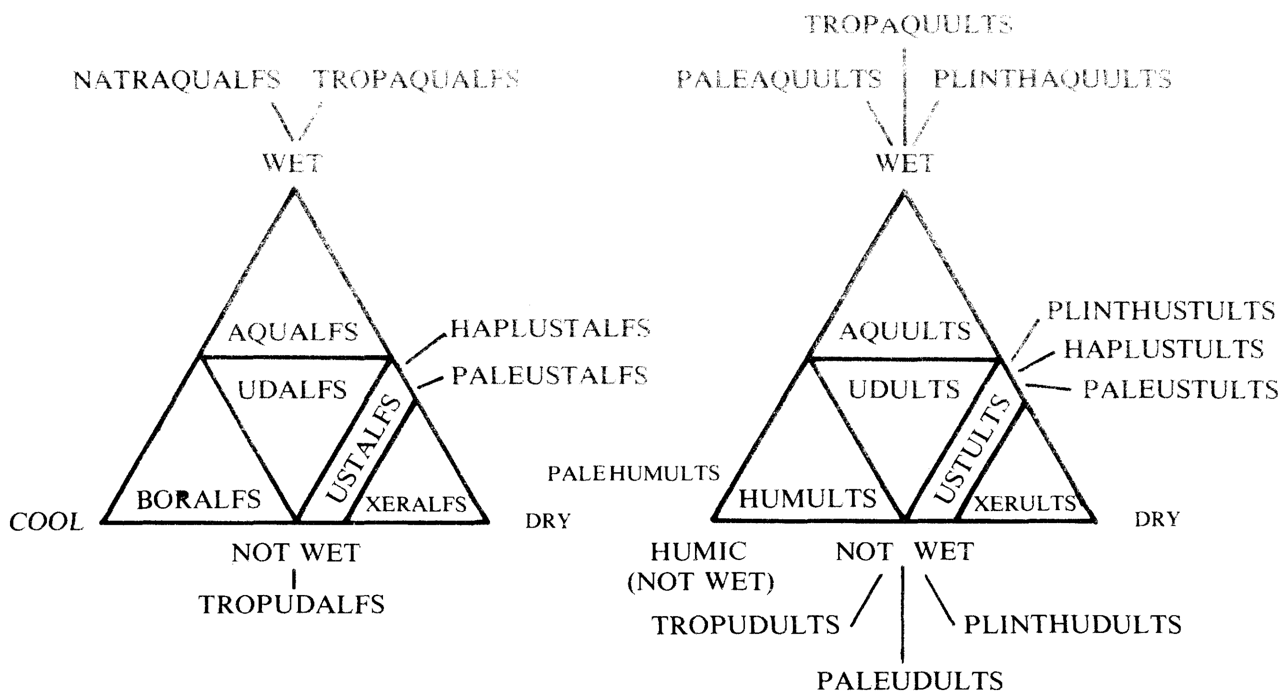

Figure 1 Great groups of Alfisols and Ultisols found inThailand(Suborder charts based on Buol *et al.*, 1980)

in Thailand develops only in either wet condition or in relatively dry one.

In the ustic moisture regime particularly in the Northeast Plateau region of Thailand, the Alfisols and Ultisols of similar groups can be found in association. These soils are usually dominated by low activity clay (Moncharoen and Vijarnsorn, 1979) and siliea-rich sand. Their field morphology and the geomorphic position are quite similar. They cover an extensive part of agricultural areas in the uplands of the region. Understanding of their nature and properties would enhance proper management practices for these soils. The major purposes of this report are to compare charactersistics and properties of some Alfisols and Ultisols occurring in association in ustic moisture regime Northeast Thailand and to evaluate their potential based upon their basic properties.

THE SOIL ENVIRONMENT

Landform and Geology

The Northeast Plateau is one of the largest among the six physiographic regions of Thailand (Moormann and Rojanasoonthorn, 1972). Major rocks of this region belong to Korat Group with ages range from Jurassic to Cretaceous. This rock group consists mainly of sandstone of various colors and textures (Geological Survey Division, 1982). The broad land form class of the region can be classified as plain with hills and tablelands or cuesta (Butzer, 1976; Hammond, 1964). Extensive alluvial terraces, divided uplands and massive uplands make surface morphology of the area undulating to slightly rolling except for the flat lowlands (Michael, 1981). Erosion surface appears to be widespread in the region.

Land Use and Hydrologic Condition

The uplands of this region had been under dry dipterocarp forest but have been cleared and used for upland crops such as sugar cane, cassava, jute and mung bean. The lowlands are generally under paddy rice. Irrigation of the area is limited. Most agricultural practices are under rainfed farming. Additional water comes from small reservoir and farm ponds which is generally insufficient.

THE STUDY AREA

The study area includes two large provinces in the Northeast Plateau. They are Khon Kaen and Nakhon Ratchasima provinces. They occupy the eastern portion of the region. Eight locations are included as illustrated in Figure 2. Two locations are in Khon Kaen and other six locations are in Nakhon Ratchasima. All locations are in the upland areas with undulating surfaces. Eight typical profiles, one for each location, were investigated in this study. The land use of these locations is upland rainfed field crop farming. Field crops mainly consist of cassava and sugar cane but some locations have been left idle under secondary shrub during the time of sampling (1982-1983). The two provinces are dominated by tropical savanna climate having a distinct dry period annually. Climatic data for a period of 30 years (1951-1980) reveal the relatively dry condition of the area well (Royal Meteorological Department, 1982). Khon Kaen has 1,196.7 mm mean annual rainfall, 2,083.9 mm mean annual evaporation (from evaporation pan), 27.7° C mean annual temperature and a mean annual relative humidity of 70 percent. Nakhon Ratchasima has a mean annual rainfall of 1,137.4 mm, mean annual evaporation of 1,915.5 mm, mean annual temperature of 26.4° C and a mean annual relative humidity of 73 percent. Trends on monthly mean variation of these climatic parameters are given in Figure 3. The trends demonstrate a long period of dryness which is a characteristic of tropical savanna climate. The soils under this kind of climate normally belong to ustic moisture regime.

METHOD OF STUDY

A taxonomic approach is used along with survey method to characterize soils in this study. This approach places emphasis on the identification of soil morphology in the field and laboratory analyses of soils to obtain set of criteria to classify soil according to soil taxonomy (Soil Survey Staff, 1975, 1981). Field study includes pedon analysis of the soils and sampling of soils based on genetic horizons. The laboratory work includes physical, chemical, mineralogical and micromorphological analyses of both disturbed and undisturbed soil samples according to accepted methods for taxonomic classification (Soil Survey Staff, 1982). Data obtained are then compiled and compared to key of taxonomic classes that the soils belong (Soil Management Support Services, 1983; Soil Survey Staff, 1975).

THE ALFISOLS AND THE ULTISOLS

According to soil taxonomy, soils of four locations (A1 to A4) have been classified as Paleustalfs whereas the others fall in the limit of Paleustults (U1 to U4). Except for their color, the soils of these two great groups are quite similar in the field. Their chemical characteristics show close resemblance. The difference on chemistry between these two great groups is the base saturation values. The base saturation values of A1 to A4 are consistently higher than 35 percent. In addition, the physical, mineralogical and micromorphological characteristics of these soils are also similar. On landscape, those soils cannot be differentiated easily. It may be use ful to discuss thier similarity and difference based upon four subjects. These include field morphology and physical characteristics, chemical properties, mineral composition and micromorphological features of the soils.

Field Morphology and Physical Characteristics

Field morphology of the Paleustalfs and Paleustults is summarized in Table 1. It is obvious that these soils occupy very similar landscape and identification at order level may be difficult due to the sandy nature of the soils. Though some of the Paleustults (such as U1, U2 and U3) show more yellowish or reddish colors than those of the Paleustalfs but other profile features are quite similar. Within the framework of ustic soil moisture regime, similar parent materials and present land use the inclusions of Paleustalfs in mapping units of Paleustults or vice versa are quite common in the field.

One of the interesting physical characteristics of these soils is the texture. The variation of soil texture with depth of these soils is shown in Figure 4. These soils are relatively sandy and the argillic horizon appears in the deep lower

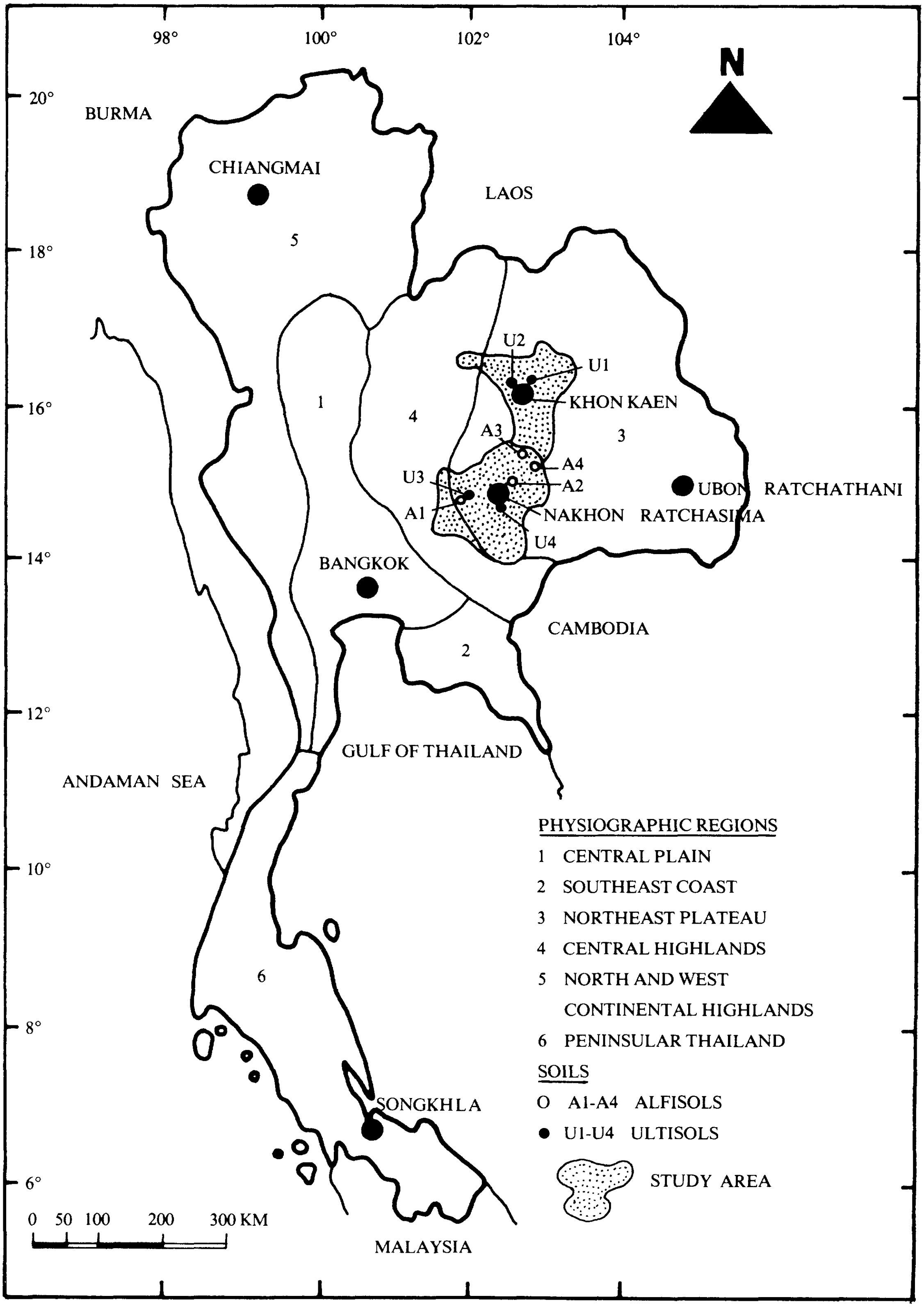

Figure 2 Location map of study areas with sampling locations. A1 to A4 are Alfisols and U1 to U4 are Ultisols. Physiographic regions of Thailand are included (Physiographic region are based on Moormann and Rojanasoonthon, 1972).

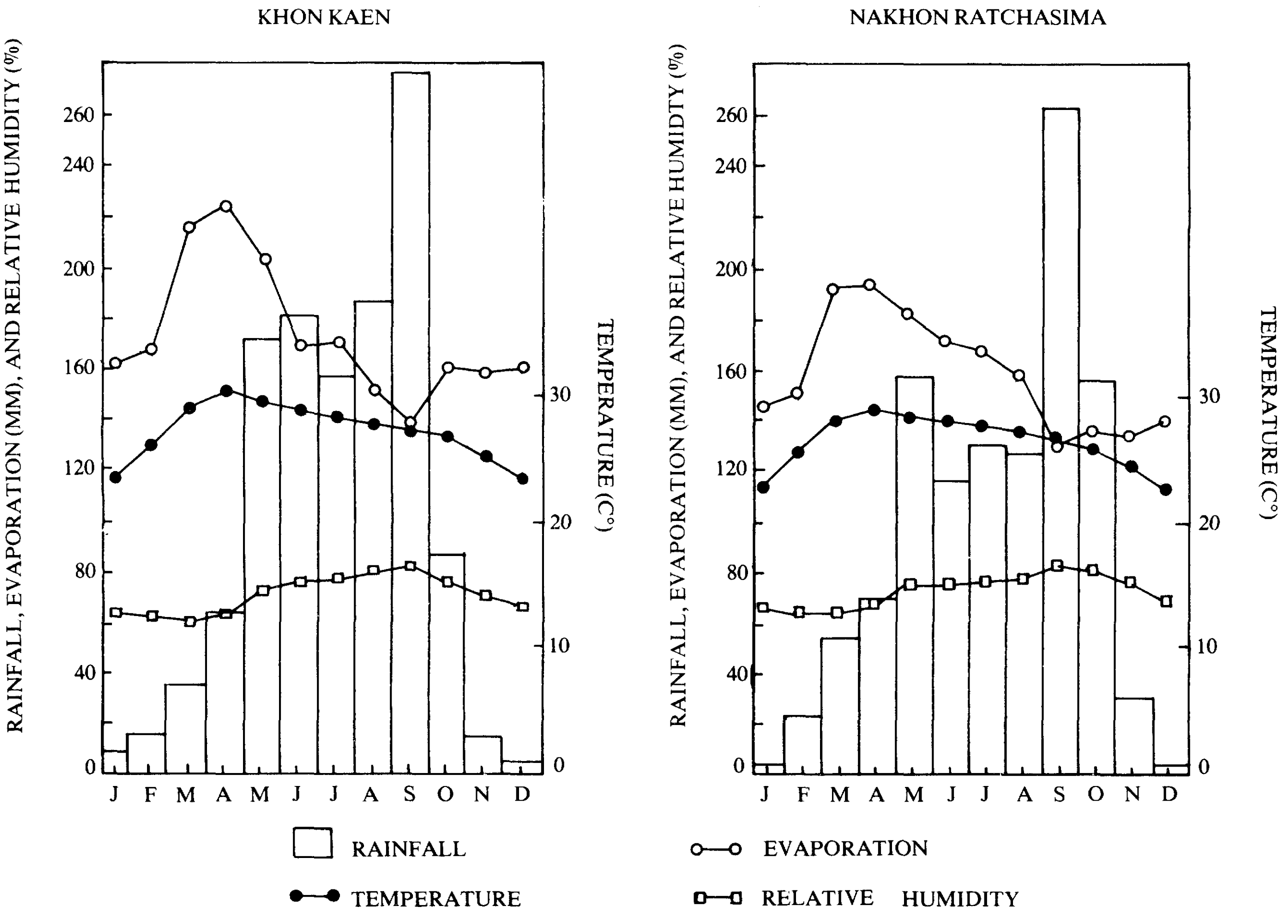

Figure 3 Seasonal variation of rainfall, evaporation, temperature and relative humidity of Khon Kaen and Nakhon Ratchasima Provinces, Northeast Plateau. Monthly average values are based on 30 years period (1951--1980) (Royal Meteorological Department, 1982

part of the profile. The fluctuation of sand and silt percentages in the profile indicates the nature of alluvium of different depositional episodes. The bulk density values of these soils range from 1.50-1.77 g/cc. These values are quite common for sandy Alfisols and Ultisols in the Northeast (Nilnond and Kheoruenromne, 1983).

Moisture characteristic curves of representative Alfisols (A1) and Ultisols (U3) are illustrated in Figure 5. The curves indicate that their water retention capacity is low and water management scheme for upland cropping must be devised for successful agricultural practices.

Chemical Properties

As far as the chemical data of these soils are concerned the soils do not differ appreciably

Table 1 Environment and field morphology of Paleustalfs and Paleustults in ustic moisture regime, Northeast Plateau, Thailand.

Pedon	Higher Category Classification	Landform: Elevation (MSL) (M)	Landform: Slope (%)	Landform: Surface form	Parent Material	Field Morphology: Effective depth (cm)	Field Morphology: Color Profile	Field Morphology: Textural Profile	Field Morphology: Structural Profile	Land Use
ALFISOLS										
A1	Oxic Paleustalfs	267	5	Top of middle terrac	Old alluvium	>150	Dark brown/ brown to light yellowish brown	Sandy loam throughout	Moderate subangular blocky/moderate to strong subangular blocky	Cassave
A2	Oxic Paleustalfs	170	3	Lower part of middle terrace	Old alluvium	>150	Dark yellowish brown/reddish yellow to light brown	Sand/loamy sand to sandy loam	Moderately weak subangular blocky/ moderate to weak subangular blocky	Cassave, *bambusa spp.* coconut
A3	Oxic Paleustalfs	200	2	Lower part of middle terrace	Old alluvium	>150	Dark yellowish brown/brown to reddish yellow	Sand/loamy sand to sandy loam	Moderate subangular blocky /moderate to weak subangular blocky	Sugar cane
A4	Oxic Paleustalfs	160	3	Lower part of middle terrace	Old alluvium	>150	Dark grayish brown/brown to light yellowish brown	Loamy sand/ sandy loam	Weak subangular blocky/moderate to weak subangular blocky	Cassava
ULTISOLS										
U1	Oxic paleustults	200	2	High terrace	Old alluvium	>150	Reddish brown/ yellowish red to red	Sandy loam throughout	Weak subangular blocky/moderately weak subangular blocky	Left idle under dipterocarpas species and *Eupatorium odoratum*
U2	Oxic Paleustults	195	3	Lower part of high terrace	Old alluvium	>150	Dark brown/ brown to yellowish red	Sandy loam throughout	Weak subangular blocky/moderately weak subangular blocky	Cassava and grasses
U3	Oxic Paleustults	180	3	Higher part of middle terrace	Old alluvium	>150	Yellowish red/ reddish yellow	Loamy sand/ sandy loam	Moderately weak subangular blocky/ moderate subangular blocky	Cassave
U4	Oxic Paleustults	190	3	Middle part of middle terrace	Old alluvium	>150	Very dark grayish brown/ to reddish yellow	Sandy loam thorughout	Weak subangular blocky/moderately weak subangular blocky	Cassava and *Eupatorium odratum*

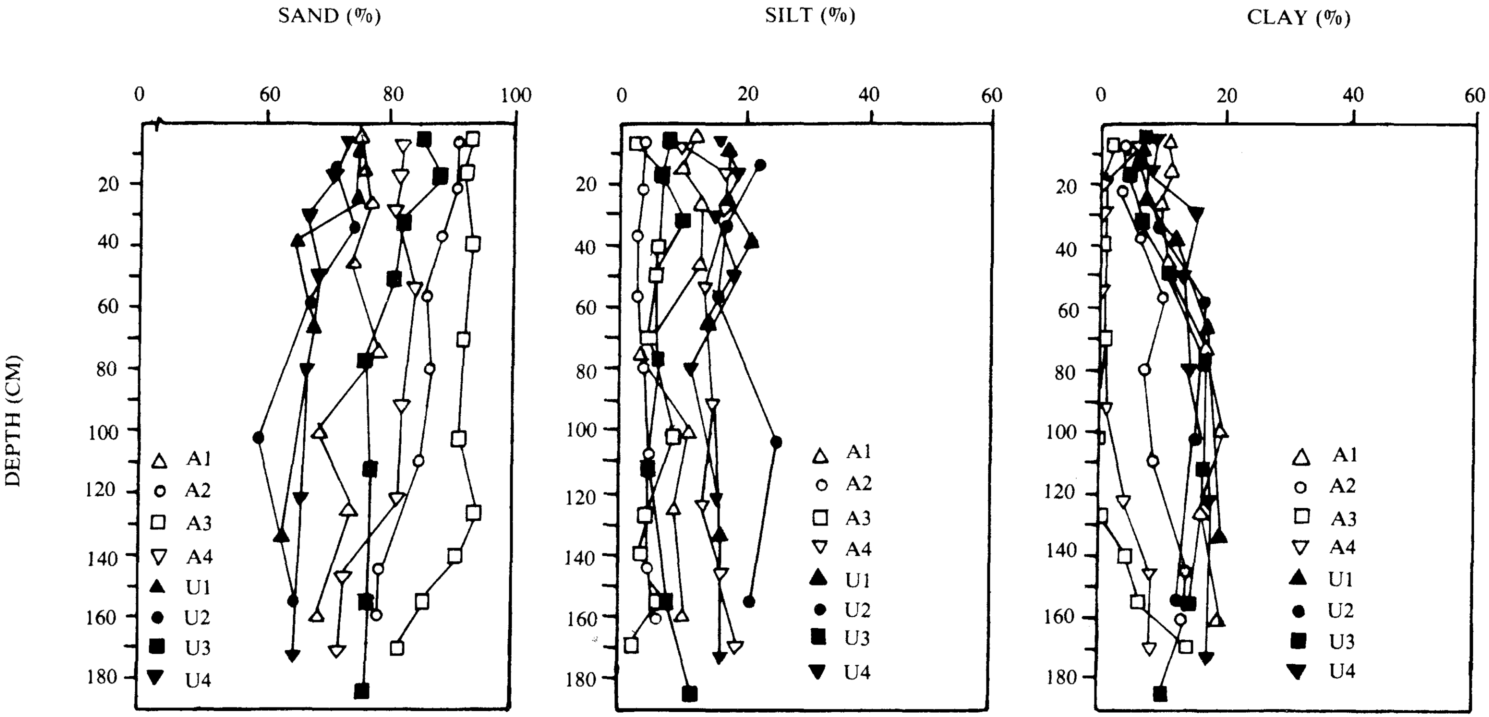

Figure 4 Variation of soil separate with depth for Alfisols (A1 to A4) and Ultisols (U1 to U4) in the ustic moisture regime, Northeast Plateau, Thailand.

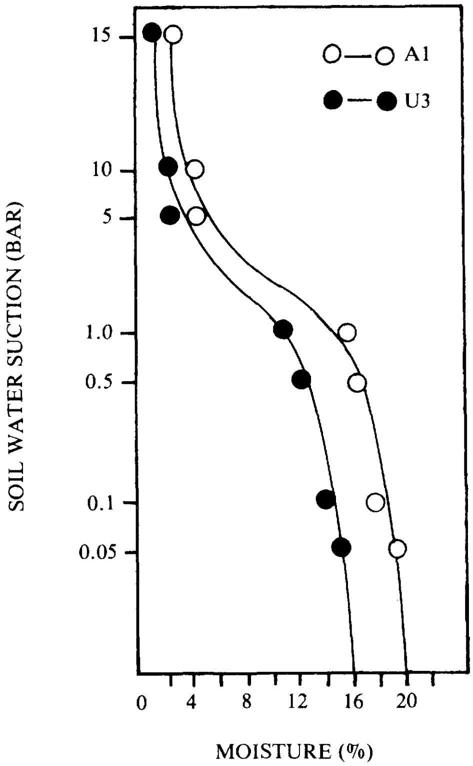

Figure 5 Moisture characteristics curves of representative Alfisols (A1) and Ultisols (U3) in Northeast Plateau, Thailand (at a depth of 50 cm).

on their chemical characteristics. Chemical data of the Alfisols are summarized in Table 2. These Paleustalfs have low pH values indicating a highly leached condition. Their organic matter contents, major nutrients, exchangeable bases and cation exchange capacities are low. The base saturation percentages of these soils however, are higher than 35 percent. The cause of the high base saturation of these soils is the low exchangeable acidity relative to exchangeable bases. The chemical data of these soils suggest the low activity clay and the low exchange capacity of the soil system.

The chemical data of the Ultisols as summarized in Table 3 are not totally different from that of the Alfisols. These Paleustults have low values of base, cation exchange capacity and major nutrient. Their pH values are also low. The base saturation percentages of these soils are lower than 35 percent in the order control section as specified in the keys to soil taxonomy (Buol *et al.,* 1980 ; Soil Management Support Services, 1983 ; Soil Survey Staff, 1975). These soils have a relatively higher range of exchangeable acidity than that of the Paleustalfs. Without any marked contrast with the Paleustalfs, the Paleustults show poor chemical characteristics for fertility management.

Table 2 Chemical Characteristics of the selected Paleustalfs in Northeast Plateau, Thailand.

Depth (cm)	Horizon	pH 1:1 H_2O	pH 1:1 KC1	Organic matter (%)	Total N	Avail. P (ppm)	Avail. K (ppm)	Exchangeable bases Ca	Mg	K	Na	Sum bases	Exch. acidity	C.E.C.	B.S (%)
								(me/100 g soil)							
A-1															
0-10	Ap1	6.4	5.7	0.95	0.05	3.9	92.5	4.7	0.7	0.2	0.3	5.9	1.3	6.4	82
10-20	Ap2	6.3	5.1	0.85	0.04	3.5	50.5	5.0	0.6	0.1	0.3	6.0	1.5	6.8	80
20-32	E	6.5	5.3	0.46	0.03	2.8	32.0	3.7	0.4	0.1	0.3	4.5	0.7	4.3	87
32-60	Bw	6.5	5.1	0.37	0.01	1.0	40.9	3.9	0.7	0.1	0.2	4.9	2.0	5.3	71
60-90	Bt1	4.7	3.4	0.41	0.03	1.3	59.7	2.6	1.7	0.2	0.3	4.8	2.7	3.6	64
90-110	Bt2	4.6	3.2	0.07	0.01	1.4	50.5	1.9	1.2	0.1	0.3	3.5	5.7	7.6	38
110-140	Bt3	4.9	3.2	0.22	0.02	0.9	40.9	2.5	0.9	0.1	0.4	3.9	4.0	6.4	49
140-180	Bt4	5.4	3.2	0.30	0.02	0.5	53.2	5.0	1.5	0.1	0.8	7.4	4.1	8.6	64
A-2															
0-15	Ap1	5.5	4.4	0.80	0.02	4.0	12.6	1.3	0.4	0.1	0.3	2.1	1.8	2.6	54
15-30	Ap2	4.7	3.7	0.59	0.02	1.8	12.6	0.7	0.2	0.04	0.3	1.2	1.8	2.5	40
30-45	Bw1	4.4	3.6	0.17	0.02	0.1	7.0	0.6	0.2	0.02	0.2	1.0	0.6	1.2	63
45-70	Bw2	4.4	3.4	0.20	0.01	1.3	8.5	0.8	0.3	0.02	0.2	1.3	1.8	2.3	42
70-90	Bw3	4.3	3.4	0.15	0.01	0.8	9.2	0.5	0.3	0.03	0.2	1.0	1.9	2.1	34
90-130	Bw4	4.3	3.4	0.25	0.01	1.7	8.5	0.6	0.5	0.03	0.2	1.3	1.9	2.7	41
130-160	Bt1	5.1	3.7	0.27	0.01	0.4	10.0	2.7	0.7	0.03	1.9	5.3	2.6	5.2	67
160-180	Bt2	5.5	4.2	0.02	0.01	0.5	10.0	2.3	0.7	0.03	2.6	5.6	0.9	5.0	85
A-3															
0-13	Ap1	5.3	4.7	0.41	0.01	2.8	23.0	0.8	0.4	0.1	0.3	1.6	0.9	1.4	64
13-21	Ap2	4.9	3.9	0.17	0.01	4.2	9.2	0.4	0.1	0.03	0.3	0.8	0.1	0.6	89.
21-60	E1	5.6	4.7	0.02	0.002	0.7	7.7	0.3	0.1	0.03	0.3	0.7	0.1	0.2	88
60-80	E2	6.5	5.8	0.03	0.003	0.8	7.0	0.3	0.1	0.02	0.3	0.7	0.1	0.3	88
80-125	E3	6.2	4.5	0.03	0.001	2.0	7.0	0.3	0.1	0.02	0.3	0.7	0.1	0.5	88
125-130	E4	6.0	4.4	0.03	0.002	0.8	6.0	0.3	0.1	0.02	0.3	0.7	0.1	0.3	88
130-150	Bt1	5.0	3.8	0.14	0.001	0.9	7.7	0.3	0.1	0.02	0.2	0.6	0.1	0.4	86
150-160	Bt2	4.5	3.4	0.07	0.01	1.0	24.8	0.8	0.4	0.1	0.3	1.6	0.6	2.0	73
160-180	Bt3	4.4	3.3	0.22	0.01	1.3	40.9	1.2	0.6	0.1	0.3	2.2	2.3	3.3	49
A-4															
0-14	Ap1	5.3	4.5	0.59	0.01	2.1	43.2	2.2	0.4	0.1	0.4	3.1	1.5	3.3	67
14-22	Ap2	5.1	4.0	0.42	0.02	0.8	23.0	1.5	0.4	0.1	0.2	2.2	1.1	2.4	67
22-36	E1	4.8	3.6	0.23	0.02	0.8	17.7	0.9	0.3	0.1	0.4	1.7	0.8	2.0	68
36-72	E2	4.4	3.3	0.15	0.01	0.8	14.3	0.3	0.2	0.03	0.2	0.7	1.1	1.3	39
72-112	E3	4.2	3.2	0.12	0.01	0.8	18.5	0.6	0.3	0.1	0.3	1.3	1.5	1.0	46
112-135	Bt1	4.1	3.1	0.17	0.01	0.7	17.7	0.7	0.2	0.04	0.3	1.2	1.1	1.7	52
135-160	Bt2	4.0	3.0	0.27	0.01	1.6	22.2	2.7	0.9	0.1	0.4	4.1	3.8	5.4	52
160-180	Bt3	4.0	3.0	0.32	0.03	2.0	16.9	3.4	1.1	0.04	0.3	4.8	3.2	6.5	60

Table 3 Chemical characteristics of the selected Paleustults in Northeast Plateau, Thailand.

Depth (cm)	Horizon	pH H_2O	1:1 KCl	Organic matter (%)	Total N (%)	Avail P (ppm)	Avail K (ppm)	Exchangeable bases Ca	Mg	K	Na (me/100 g soil)	Sum bases	Exch. acidity	C.E.C.	B.S. (%)
U-1															
0-18	Ap	5.6	4.2	0.77	0.03	5.8	36.5	0.7	0.5	0.1	0.3	1.6	1.8	2.2	47
18-33	AB	4.6	3.6	0.28	0.02	2.1	13.7	0.4	0.2	0.03	0.3	0.9	1.9	1.6	32
33-45	Bw	4.6	3.5	0.21	0.01	1.5	13.7	0.5	0.4	0.02	0.1	1.0	2.1	1.9	32
45-88	Bt1	4.6	3.5	0.19	0.03	1.1	11.2	0.5	0.7	0.03	0.2	1.4	2.1	2.1	40
88-180+	Bt2	4.7	3.5	0.03	0.02	0.7	12.5	0.4	0.5	0.03	0.2	1.1	3.1	2.2	26
U-2															
0-28	Ap	4.9	3.8	0.73	0.04	1.4	11.2	0.8	0.3	0.02	0.2	1.3	2.1	1.9	38
28-40	E	5.1	4.0	0.54	0.03	0.9	9.0	1.1	0.3	0.01	0.1	1.5	1.8	1.9	45
40-77	Bt1	5.0	3.8	0.38	0.03	1.0	12.5	1.0	0.5	0.01	0.1	1.6	2.1	2.2	43
77-130	Bt2	4.6	3.7	0.12	0.02	0.7	8.0	0.6	0.2	0.01	0.2	1.0	2.3	1.9	30
130-180+	Bt3	4.7	3.7	0.10	0.02	0.7	6.5	0.6	0.2	0.02	0.2	1.0	2.1	2.0	32
U-3															
0-10	Ap1	6.0	4.6	0.49	0.02	3.1	53.2	0.8	0.4	0.1	0.2	1.5	0.69	1.7	68
10-25	Ap2	5.5	4.5	0.02	0.01	1.4	19.2	1.3	0.4	0.1	0.3	2.1	0.52	1.4	81
25-40	Bw	5.5	4.2	0.19	0.01	1.4	16.0	0.9	0.3	0.04	0.3	1.5	1.46	1.2	50
40-60	Bt1	4.6	3.6	0.08	0.01	1.3	15.1	0.9	0.2	0.04	0.3	1.4	0.69	1.3	67
60-95	Bt2	4.2	3.2	0.23	0.01	1.3	23.9	0.3	0.4	0.1	0.3	1.1	1.25	1.3	46
95-130	Bt3	4.2	3.2	0.17	0.01	0.7	23.0	0.2	0.4	0.1	0.2	0.9	4.56	2.7	16
130-180	Bt4	4.1	3.1	0.07	0.01	1.9	19.2	0.3	0.2	0.1	0.3	0.9	2.95	2.8	23
180-190+	BC	4.1	3.1	0.17	0.01	0.7	18.5	0.3	0.2	0.1	0.3	0.9	3.06	3.0	23
U-4															
0-12	Ap	6.1	5.3	0.98	0.05	3.8	26.2	1.7	1.2	0.1	0.2	3.2	0.8	2.6	80
12-21	E	4.7	3.7	0.81	0.05	2.0	13.7	0.9	0.7	0.03	0.1	1.7	2.8	2.9	38
21-39	Bw	4.3	3.3	0.38	0.03	0.7	12.5	0.3	0.4	0.02	0.1	0.8	4.7	4.0	15
39-61	Bt1	4.3	3.3	0.31	0.03	0.9	11.2	0.3	0.4	0.02	0.2	0.9	4.6	3.9	16
61-99	Bt2	4.3	3.3	0.21	0.02	0.5	10.0	0.3	0.4	0.02	0.2	0.9	3.9	3.1	19
99-146	Bt3	4.3	3.2	0.07	0.01	0.6	12.5	0.6	0.5	0.02	0.3	1.4	4.2	4.1	25
146+	BC	4.1	3.2	0.14	0.01	0.6	13.7	1.0	0.8	0.02	0.2	2.0	3.9	4.3	34

Mineral Composition

In the argillic horizons of these soils, sand and silt fractions are dominated by quartz. Traces of anatase can be found in silt fraction of some Paleustalfs (A3 and A4). In the clay fraction, kaolinite, montmorillonite and quartz are the major minerals found. The relative abundance of these mineral for these soils varies. The montmorillonitic clay seems to predominate or take equal share with the kaolinite in most of Paleustalfs (20-40% in A1, A2 and A4). However, kaolinite is the controlling clay species in all Paleustults and in A3. Quartz appears to be accessory mineral species ($\simeq$ 20%) in the clay fraction of these soils (Nilnond, 1983 ; Sindhusen, 1984). A comparison on x-ray diffraction patterns of the representative Paleustalfs (A1) and Paleustults (U4) is shown in Figure 6. The presence of montmorillonite should be accounted for the higher base saturation percentages of the Paleustalfs as compared to that of the Paleustults. Traces of 14 Å group of clay minerals are also present in these soils. In red and yellow Paleustults (U1, U2 and U3), hematite and goethite can also be detected in small quantities. Quartz in the clay fraction of these soils should suggest the nature of sandy parent materials and the highly weathered condition within the soils. As indicated previously, the argillic horizons of these soils sometimes appear at the deeper part of the soil profiles. Therefore, the mineral in the family control section (25-100 cm depth) of these soils can be predominantly quartz.

Micromorphological Features of the Soils

The most obvious micromorphology of these soils is the skeleton grains which are mostly subround quartz. Other skeleton grains are traces of tourmaline, epidote and some quartzite fragments. Runi-quartz can also be frequently found indicating transportation presumably as alluvium. The plasmic fabrics of the Paleustalfs are generally granular sepic plasmic fabric with locally gefuric plasmic fabric and vo-sepic plasmic fabric. Clay coating is mostly less than one percent in the upper subsoils and increasing to two or three percent in the lower subsoils to be justified as argillic horizon. Most of the illuviated clay is kaolinite but locally mixed clay can be present. The plasmic fabric of the Paleustults is generally patchy argillan or ferri-argillan with kaolinite as major material. Vo-sepic and skel-sepic can also be observed and the clay coating is more obvious in the upper part of the profile as compared to that of the Paleustalfs. Most of the pedologic features in these soils are chert nodules. Pores are generally packing voids associated with vughs (Brewer, 1960, 1964, 1968 ; Buol *et al.*, 1980). The micromorphological features of these soils suggest strongly that they are highly developed soils on old alluvial deposits.

LOWER CATEGORY CLASSIFICATION

Since the base saturation of all Paleustalfs is higher than 35 percent at a depth of 1.8 m below the soil surface and they have cation exchange capacity of the argillic horizons less than 24 me/100 g clay (by NH_4 OAc) the soils belong to Oxic Paleustalfs. Their other characteristics also justify the criteria specified in soil taxonomy (Soil Management Support Services, 1983; Soil Survey Staff, 1975). All of them can also be classified into coarse-loamy, siliceous, acid, isohyperthermic family. All of the Paleustults also fall into Oxic subgroup and their family is also coarse-

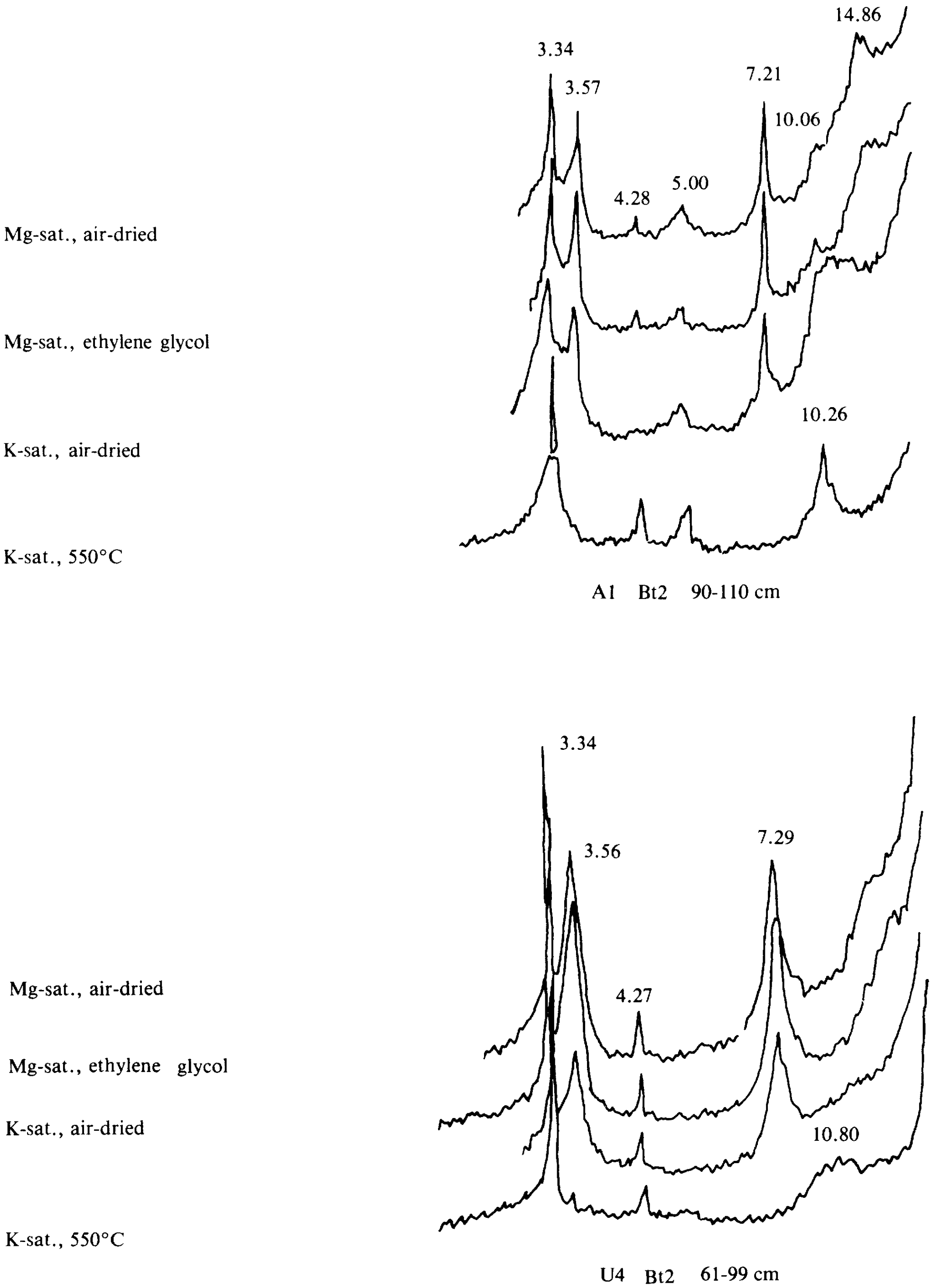

Figure 6 X-ray diffraction patterns (in Angstrom) of clay fraction in the B horizons of representative Paleustalf (A1) and Paleustult (U4), Northeast Plateau, Thailand.

loamy, siliceous, isohyperthermic. At series level U1, U2, U3 and U4 correspond with Yasothon series, Warin series, Satuk series and Korat series respectively. They are typical Paleustults of the Northeast Plateau in Thailand. The Oxic Paleustalfs associating with them should be Korat-high base variant. Without chemical analysis results, they certainly cannot be differentiated from Korat soils.

POTENTIAL USES OF THE PALEUSTALFS AND PALEUSTULTS

Under a relatively dry climate and without good water retention capacity these soils have a quite limited potential use. Their chemical characteristics are poor for agricultural production but their physical properties show that they are manageable soils. The properties in the family control section of these soils are not favorable for normal field crop practices. The sandy nature and the abundance of quartz sand reflected clearly on their exchange capacity. Therefore, most of these soils have been used for cassava and sugar cane in rainfed area. Though their suitability for upland crops falls into class N-IIIsm[1], production of cassava and sugar cane on these soils generally attains an acceptable yield. In limited areas where irrigation practice is applied more varieties of field crops can be grown on them with satisfactory production. However, due to their low exchange capacity and available potassium, traditional form of fertilizer does not give an effective response. The authors believe that irrigation and potassium fertilizer are essential for yield crop practices in the areas of these soils. In addition, slowly released form of fertilizer should also be recommended to obtain sufficient nutrient supply throughout cropping season. Also, tree crop production can be one of good ways to increase agricultural production in the area.

CONCLUSION

Under the ustic soil moisture regime in the Northeast Plateau, Thailand, Alfisols and Ultisols developed on sandy alluvium have similar characteristics. They are Oxic Paleustalfs and Oxic Paleustults. These soils are chemically and physically poor but manageable. Most serious problems for agricultural production of these soils are their low exchange capacity and low moisture retention capacity. Mineralogy of these soils particularly in the family control section is dominated by quartz and kaolinite. Since they are highly leached soils, fertilizer application program and form of fertilizer must be considered seriously in field crop practices. Due to the existing problem on available moisture in the surface soil during dry season for a rather extended period, it seems that tree having deep root should be quite suitable crop on these soils. Nevertheless, a research for proper management methods must be carried out in such a case.

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