Characteristics of Soils of Lowland Areas in the Philippines with Special Reference to Parent Materials and Climatic Conditions

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Abstract

In order to understand the nature of the Philippine lowland soils, total chemical, mineralogical, and physico-chemical analyses were performed. The Philippine lowland soils examined were characterized by relatively low SiO_2 and K_2O contents, but relatively high Al_2O_3, Fe_2O_3, MnO_2, CaO and MgO contents, compared with the other tropical Asian lowland soils. However, some regional differences were noted: in Bicol, total Fe_2O_3 and MnO_2 contents were relatively low, probably due to the reducing condition induced by ground water, and total base content was also low, due to leaching under the humid climatic conditions. In the soils analyzed, mean heavy mineral content in the fine sand fraction was about 10 % and the heavy fraction was dominated by pyroxenes. Clay fraction was characterized by the predominance of 14 Å minerals, which is peculiar to the Philippine lowland soils compared with the other tropical Asian lowland soils. Thus, the Philippine lowland areas were considered to be strongly influenced by basic volcanic materials. Moreover, the Philippine lowland soils showed a high organic matter status, high base status, high available SiO_2 content, and high clay content, compared with the other tropical Asian lowland soils, which should be related to the basic nature of the soil materials. Regional differences in the soil characters

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associated with the organic matter status were observed, reflecting differences in the climatic conditions: organic C and total N contents were highest in Bicol, while lowest in Central Luzon; the pH (H_2O) was lowest in Bicol, with the highest value being recorded in Central Luzon. The saturated permeability was observed to be very low in most of the soils examined, owing to their clayey nature. The bulk density generally varied with the amount of organic matter: it was lowest in the surface samples within the profile and was relatively low in the Bicol soil samples among the regions with a relatively high organic matter content.

Additional key words: chemical and physical properties, primary and clay mineral composition, rainfall conditions, regional differences, total chemical composition

Introduction

In the Philippines, it is essential to increase rice production by increasing yield to match the rapid population increase which occurred in recent years[3]. Thus, it is high time to investigate the Philippine lowland soils to understand their characteristics compared with those in the other tropical Asian lowland soils and to determine their actual potential for rice production.

The material characteristics and fertility evaluation of Philippine lowland soils were already reported in a series of studies conducted by Kawaguchi and Kyuma[4, 5, 6, 7, 8, 9]. According to Kyuma[10], the lowland soils in general are derived from the most recent geological sediments and have a very immature profile morphology. Therefore, their characteristics are very much dependent on the nature of the parent sediments, which is determined by the local geology and by the degree of weathering in the catchment area or the milieu of sedimentation, or both. In addition, in the case of the Philippines where the rainfall regime varies considerably over the country[2], significant soil variation across the country is observed.

Against this background, the current study was conducted to characterize the Philippine lowland soils from the pedogenetic viewpoint in reference to factors such as parent materials and climatic conditions. In the present paper, total chemical and mineralogical compositions are dealt with to reevaluate the nature of the soil materials in the Philippine lowland areas, and chemical and physical properties relevant to soil fertility are identified.

Materials and Methods

1) Study area and samples

The soil samples used in this study consisted of thirty two lowland soils selected from six lowland rice areas in the Philippines (Table 1). The geographical distribution of these six lowland rice areas is shown in Fig. 1. As for the local geology in the catchment area, intermediate to basic igneous rocks such as andesite, basalt, and gabbro chiefly occur in mountain ranges, while in rolling to hilly areas around the mountains sedimentary rocks such as shale, sandstone, conglomerate, and limestone are found.

An attempt was made to select the typical lowland rice soils which cover large areas in a region. At each of the site, the soil profile was described and soil samples were taken from each horizon for laboratory analyses.

2) Analytical methods

The total contents of the ten major elemental oxides, i.e., SiO_2, Al_2O_3, Fe_2O_3, TiO_2, MnO_2, CaO, MgO, K_2O, Na_2O, and P_2O_5, were analyzed by X-ray fluorescence spectrometry using samples pressed

Table 1. Location and cropping pattern of the sites studied and classification of the soils

Soil	Location	Cropping pattern	Classification[a)]
1. Cagayan Valley			
IS1	Echague, Isabela	double cropping of rice	Typic Epiaquult
IS2	Cabatuan, Isabela	double cropping of rice	Typic Epiaqualf
CA1	Solana, Cagayan	triple cropping of rice	Vertic Tropaquept
2. Central Luzon			
NE1	Munoz, Nueva Ecija	fallow	Oxyaquic Ustropept
NE2	Talavera, Nueva Ecija	rotation of rice and tomato	Fluvaquentic Epiaquoll
NE3	Munoz, Nueva Ecija	double cropping of rice	Ustic Epiaquert
NE4	Llanera, Nueva Ecija	double cropping of rice	Choromic Vertic Epiaqualf
NE5	Jaen, Nueva Ecija	mango field	Typic Ustropept
NE6	Zaragoza, Nueva Ecija	double cropping of rice	Typic Epiaqualf
NE7	San Leonardo, Nueva Ecija	double cropping of rice	Vertic Tropaquept
NE8	San Leonardo, Nueva Ecija	double cropping of rice	Vertic Tropaquept
NE9	San Leonardo, Nueva Ecija	double cropping of rice	Ustic Epiaquert
BU1	San Miguel, Bulacan	double cropping of rice	Vertic Tropaquept
PA1	Villasis, Pangasinan	rotation of rice and vegetables	Fluventic Ustropept
TA1	San Manuel, Tarlac	rotation of rice and tobacco	Aeric Tropaquept
TA2	La Paz, Tarlac	single cropping of rice	Vertic Tropaquept
TA3	La Paz, Tarlac	rotation of rice and vegetables	Oxyaquic Ustropept
3. Laguna			
LA1	Santa Rosa, Laguna	double cropping of rice	Vertic Tropaquept
LA2	Bay, Laguna	double cropping of rice	Aeric Vertic Epiaqualf
LA3	Santa Cruz, Laguna	double cropping of rice	Fluvaquentic Endoaquoll
4. Bicol			
CS1	Milaor, Camarines Sur	double cropping of rice	Vertic Fluvaquent
CS2	Minalabac, Camarines Sur	triple cropping of rice	Vertic Tropaquept
CS3	Canaman, Camarines Sur	double cropping of rice	Vertic Fluvaquent
CS4	Minalabac, Camarines Sur	triple cropping of rice	Vertic Fluvaquent
CS5	Minalabac, Camarines Sur	triple cropping of rice	Vertic Fluvaquent
AL1	Polangui, Albay	double cropping of rice	Typic Tropaquept
SO1	Casiguran, Sorsogon	double cropping of rice	Vertic Fluvaquent
5. Iloilo			
IL1	Sara, Iloilo	double cropping of rice	Vertic Tropaquept
IL2	San Miguel, Iloilo	double cropping of rice	Vertic Tropaquept
6. Cotabato			
CO1	Cotabato, Maguindanao	single cropping of rice	Vertic Fluvaquent
CO2	Tacurong, Sultan Kudarat	double cropping of rice	Vertic Tropaquept
CO3	Kabacan, North Cotabato	double cropping of rice	Typic Tropaquept

[a)]Based on the system of Soil Taxonomy[12)].

at 20 tons/cm^2 for 1 min. after grinding of air-dried fine earth samples.

The fine sand (0.2 to 0.05 mm) and clay (<2 μm) fractions collected from the residues of the particle-size analysis indicated below, were used for the primary and clay mineralogical analysis, respectively. For the preparation of microscopic specimens of fine sand, separation of the heavy fraction from the light fraction with tetrabromoethane (s.g. 2.96) and mounting on a glass slide, were performed. Both the heavy and light mineral specimens obtained were examined to analyze the primary mineral composition under a petrographic microscope. For the preparation of oriented clay specimens, saturation with Mg and K was made. Employing the Cu Kα-radiation, X-ray diffraction patterns were obtained. The relative amount of 7, 10, and 14 Å minerals in the clay fraction was semiquantitatively determined on the basis of the relative intensities of the diffraction peaks of the Mg-clay.

For the soil chemical analysis, the air-dried

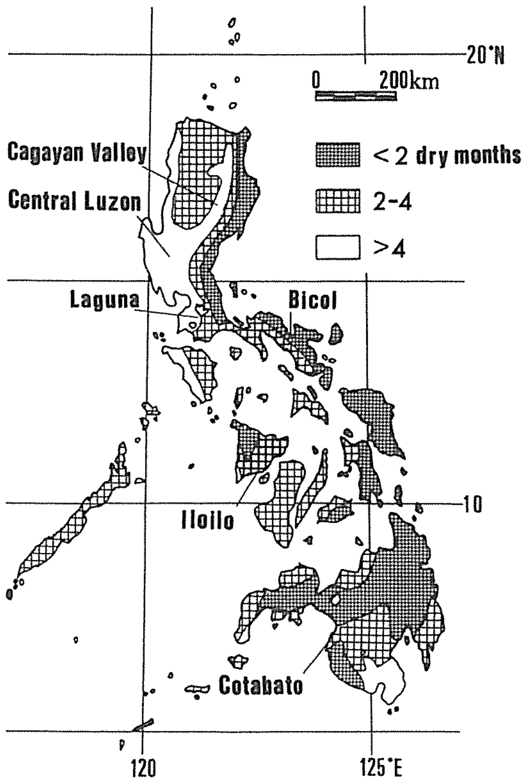

Fig. 1. Location of the lowland areas studied and climatic classification of the Philippines based on the number of dry months

fine earth samples were ground to pass through a 0.5 mm sieve. The amount of organic C was determined by wet combustion with a mixture of $K_2Cr_2O_7$ and H_2SO_4 (Walkley-Black procedure). Total N content was determined by digestion with H_2SO_4, distillation, and titration (Kjeldahl procedure). The pH of the soil samples was determined in a 1:2.5 soil/distilled water mixture using a glass electrode pH meter. The exchangeable bases were extracted with 1 M NH_4OAc (pH 7.0) by percolation. The amounts of exchangeable Ca and Mg were determined by atomic absorption spectrophotometry, and those of exchangeable K and Na by flame emission spectrophotometry. After replacement of exchangeable bases with NH_4OAc, washing with ethanol and replacement of NH_4^+ with 100 gL^{-1} KCl were successively performed by leaching. To measure the CEC of the sample, NH_4-N content was determined by distillation and titration. Available P_2O_5 was extracted with an acidic ammonium fluoride and the content was determined by spectrophotometry (Bray & Kurz No. 2 procedure). Available SiO_2 was extracted with an acetate buffer solution (pH 4) and the content was determined by spectrophotometry.

For the particle size distribution, the silt (2 to 20 μm) and clay (<2 μm) fractions were analyzed by a pipette method, after removal of organic matter with H_2O_2 and free Fe oxides by the DCB method, and dispersion with NaOH. The sand fraction was separated into coarse sand (0.2 to 2 mm) and fine sand (0.02 to 0.2 mm) fractions by wet sieving. The fine sand fraction obtained was separated through a 0.05 mm sieve into 0.05 to 0.2 mm and 0.02 to 0.05 mm fractions following the USDA system of grain size limits. The textural class was reported according to the ISSS system and the USDA system.

The saturated hydraulic conductivity and bulk density were measured using undisturbed 100 cc core samples.

Results and Discussion

1) Soil material characteristics

(1) Peculiarity of the Philippine lowland soils

Mean total chemical composition for the Philippine lowland soils is shown in Fig. 2, along with those for the tropical Asian lowland soils reported by Kawaguchi and Kyuma[5]. For both the surface and subsurface samples, the Philippine lowland soils showed relatively low SiO_2 and K_2O contents, but relatively high Al_2O_3, Fe_2O_3, MnO_2, CaO, and MgO contents, as compared with the overall mean for the surface samples of tropical Asian lowland soils. Such data reflect more the basic nature of the Philippine soils, compared with the other tropical Asian lowland soils.

The mean primary mineral composition of the Philippine lowland soils examined is given in Table 2. The heavy mineral content of the fine sand fraction was often as high as 10% or more for both the surface and subsurface samples, reflecting the presence of basic volcanic materials. In general, pyroxenes dominated the heavy fraction, while

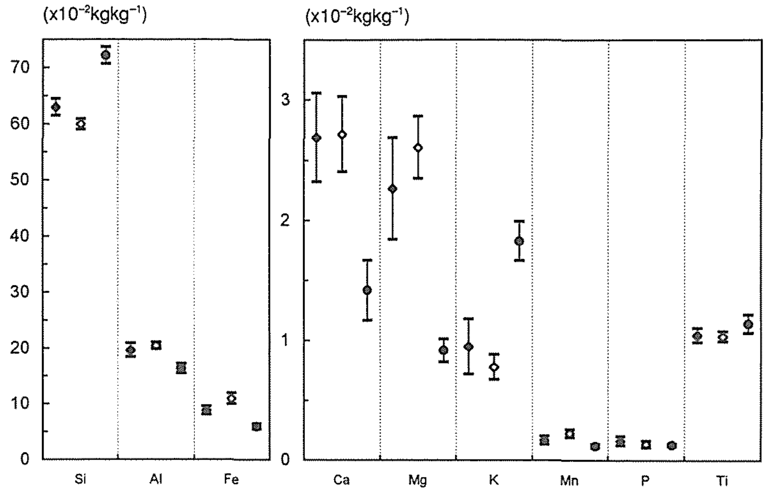

Fig. 2. Means of total chemical composition for the Philippine and tropical Asian lowland soils (all expressed as oxides)
◆, surface samples of Philippine lowland soils; ◇, subsurface samples of Philippine lowland soils; ●, surface samples of tropical Asian lowland soils; vertical bars show the confidence interval at 99%.

Table 2. Means and standard deviations of primary mineral composition for the Philippine lowland soils examined.

Samples		H.F. (%)[a]	Heavy fraction (%)[b]				Light fraction(%)[c]				
			Py	Am	Ma	Al	Qu	Pl	Vg	Po	Al
Surface (N=52)	Mean	12	53	7	9	31	41	14	2	3	40
	S.D.	6	22	8	9	22	21	12	11	5	21
Subsurface (N=128)	Mean	10	47	9	11	33	30	11	2	1	55
	S.D.	7	24	13	12	26	19	10	11	2	24

[a] Weight % of the heavy (s.g. >2.96) fraction in the fine sand (0.05 to 0.2mm) fraction.
[b] Grain % in the heavy fraction: Py, pyroxenes; Am, amphiboles; Ma, magnetite; Al, alterite; olivine and zircon with <0.2% are not shown.
[c] Grain % in the light fraction; Qu, quarts, Pl, plagioclase, Vg, volcanic glass; Po, plant opal; Al, alterite.

alterite which could not be identified under the microscope together with quartz and plagioclase, often predominated in the light fraction. Quartz may have originated from sedimentary rocks such as sandstone and conglomerate[1]. However, the siliceous material may be a minor component in most soils examined, considering the clayey nature presented below.

Based on the clay mineralogical data obtained (Table 3), 10 Å minerals were not detected in the soils examined, supporting the basic nature of the soil materials. Thus, the clay fraction of the Philippine lowland soils was characterized by the combination of 14 and 7 Å minerals. Compared with the contents of 14, 10, 7 Å minerals of the representative tropical Asian lowland soils, the present study indicated that in the Philippine lowland soils the mean value of 14 Å minerals was much higher and the mean value of 7 Å minerals was much lower in both the surface and subsurface samples. Since the CEC/clay ratio was higher in the Philippine lowland soils, it is assumed that the clay activity may be much higher. Based on the classification of the clay mineral composition proposed by Kawaguchi and Kyuma[5], most samples taken from Philippine lowland soils belonged to the "14-dominant" type.

The results obtained indicated that the soil materials of the Philippine loeland areas have similar characteristics to those weathered from basic volcanic rocks. The present results are comparable to those obtained by Kawaguchi and Kyuma[5], suggesting that the soil samples used in this study roughly represent the lowland soils in the Philippines.

(2) Regional differences within the country

The lowland soils from three regions, i.e., Central Luzon, Laguna, and Bicol in Luzon Island were selected for the discussion that follows. Cagayan Valley soils including the weathered soil on the river terrace and the soils taken from Iloilo and Cotabato islands were omitted due to the absence of an adequate number of samples. These three regions in Luzon Island are under different rainfall conditions. Number of dry months (<100 mm of rainfall) is as follows: Central Luzon >4 dry months, Laguna 2 to 4 dry months, and Bicol <2 dry months per year[11], as shown in Fig. 1.

Since there were no distinct regional differences in the primary and clay mineral composition, regional differences in the total chemical composition of the surface samples were assessed and presented below (Table 4). Surface and subsurface samples showed a similar trend

Table 3. Means and standard deviations of relative contents of 14, 10, and 7 Å minerals for the Philippine and tropical Asian lowland soils

	Philippines				Tropical Asia[a)]	
(No. of samples)	Surface (52)		Subsurface (128)		Surface (529)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
14Å minerals (%)	85.6	12.3	85.0	14.6	38.7	22.9
10Å minerals (%)	0	–	0	–	16.8	15.1
7Å minerals (%)	14.4	12.3	15.0	14.6	43.7	20.8
CEC/clay (cmol(+)kg^{-1})	72.8	17.4	80.9	23.3	46.4	–

a)Source:Kyuma[10].

Table 4. Comparison of total chemical composition for the surface soil samples among the three regions in the Philippines

Region (No. of samples)		Central Luzon (21)		Laguna (7)		Bicol (11)		Difference among regions[a)]
		Mean	S.D.	Mean	S.D.	Mean	S.D.	
SiO_2	($10^{-2}kgkg^{-1}$)	61.97	4.01	63.77	1.56	61.86	1.55	ns
Al_2O_3	($10^{-2}kgkg^{-1}$)	18.84	2.80	18.47	0.46	24.25	2.20	**
Fe_2O_3	($10^{-2}kgkg^{-1}$)	9.41	1.91	10.79	2.19	7.51	1.10	**
TiO_2	($10^{-2}kgkg^{-1}$)	1.00	0.13	1.23	0.14	1.13	0.14	**
MnO_2	($10^{-2}kgkg^{-1}$)	0.21	0.09	0.18	0.12	0.06	0.03	**
CaO	($10^{-2}kgkg^{-1}$)	3.10	0.97	2.50	0.79	2.24	1.27	ns
MgO	($10^{-2}kgkg^{-1}$)	2.95	1.22	1.14	0.11	1.47	0.34	**
K_2O	($10^{-2}kgkg^{-1}$)	0.76	0.32	0.71	0.04	0.52	0.27	ns
P_2O_5	($10^{-2}kgkg^{-1}$)	0.15	0.09	0.14	0.05	0.19	0.17	ns
Na_2O	($10^{-2}kgkg^{-1}$)	1.63	0.67	1.05	0.48	0.78	0.52	**
Total base[b)]	($10^{-2}kgkg^{-1}$)	8.43	2.84	5.40	1.17	5.01	2.09	**

a)By analysis of variance: ns=not significant; **=significant at the 1% level.
b)Total base corresponds to the sum of CaO, MgO, K_2O, and Na_2O.

(data not shown).

Bicol soils showed the lowest mean Fe_2O_3 and MnO_2 contents among the soils of the three regions. Since most of the Bicol soils are ground water aquic in this study, continuous saturation and reduction, associated with the humid climatic conditions as well as double or triple cropping of rice, may have led to a high mobility for Fe^{2+} and Mn^{2+} that can be easily transported by water as they move through the soil. Thus, the leaching of Fe^{2+} and Mn^{2+} may account for the decrease of the Fe_2O_3 and MnO_2 contents in the Bicol soils. Furthermore, the lowest mean total base ($CaO+MgO+K_2O+Na_2O$) content in Bicol soils is also assumed to be due to leaching under the humid climatic conditions. On the other hand, the highest mean Al_2O_3 content found in Bicol soils, might be attributed to the relative resistance of Al_2O_3 to leaching.

2) Soil chemical characteristics

(1) Peculiarity of the Philippine lowland soils

The mean values of chemical properties and clay content for both the surface and subsurface samples of the Philippine lowland soils and for the surface samples of all tropical Asian lowland soils[4, 5],

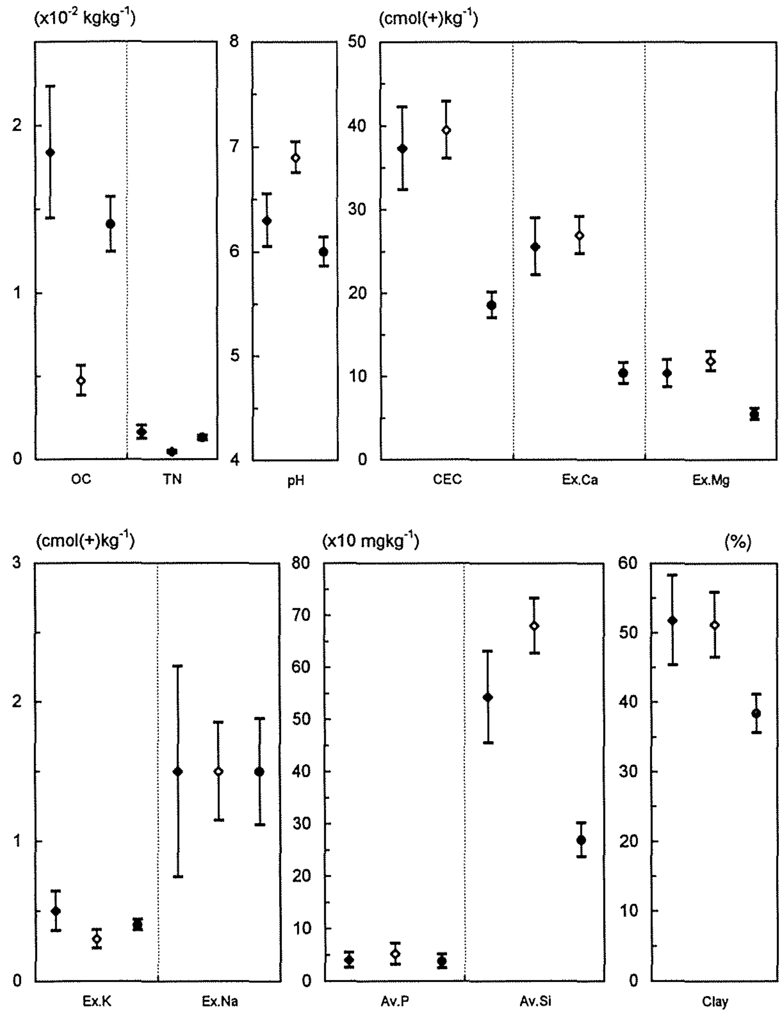

Fig. 3. Means of chemical properties and clay content for the Philippine and tropical Asian lowland soils
◆, surface samples of Philippine lowland soils; ◇, subsurface samples of Philippine lowland soils; ●, surface samples of tropical Asian lowland soils; vartical bars show the confidence interval at 99%.

are shown in Fig. 3.

The surface soil samples of the Philippine lowland soils showed relatively high means of organic C and total N contents, compared with the mean values for all tropical Asian lowland soils. The higher mean value of pH (H_2O) was also recorded in the Philippine soils, reflecting the higher base status. In addition, mean values for CEC, exchangeable Ca, and exchangeable Mg, which are controlled by the amount and nature of clay, were also high in the Philippine soils. The mean available SiO_2 content was much higher in the Philippine soils than in all tropical Asian soils. The mean available P_2O_5 content, however, was not appreciably different from the overall mean for the tropical Asian soils. The Philippine subsurface samples had similar characteristics when compared with the surface samples except for the organic C and total N contents.

The mean clay content was as high as more than 50 % in both the surface and subsurface samples of the Philippine lowland soils, a value much higher than that of the surface samples of all tropical Asian lowland soils, presumably due to the basic nature of the parent sediments that can readily undergo weathering to clay without leaving sand-size grains behind.

According to Kawaguchi and Kyuma[8], the Philippine lowland soils displayed a high organic matter-nitrogen status and high inherent potential determined primarily by the nature and amount of clay and by the base status. The present results are in agreement with those obtained by the latter authors, again suggesting that the soil samples in this study roughly represent the Philippine lowland soils.

(2) Regional differences within the country

The soil samples from Central Luzon, Laguna, and Bicol in Luzon Island were again selected for the following discussion. Some regional differences were noted in the characteristics of the surface and subsurface samples taken from these three areas.

As for the regional differences in the surface soil samples (Table 5), the highest means for organic C and total N were observed in Bicol, while the lowest in Central Luzon. The highest organic matter status in Bicol soils may be attributed to the relatively wet soil moisture conditions under a more uniformly humid climate. Bicol soils showed the lowest mean pH (H_2O) value, presumably due to the dissociation of acidic functional groups in the

Table 5. Comparison of chemical properties and clay content for the surface soil samples among the three regions in the Philippines

Region (No. of samples)		Central Luzon (21)		Laguna (7)		Bicol (11)		Difference among regions[a]
		Mean	S.D.	Mean	S.D.	Mean	S.D.	
Oragnic C	($10^{-2}kgkg^{-1}$)	1.17	0.6	1.88	0.72	3.05	1.06	**
Total N	($10^{-2}kgkg^{-1}$)	0.10	0.06	0.15	0.06	0.30	0.11	**
pH (H_2O)		6.6	0.6	6.5	0.4	6.0	0.4	*
CEC (pH7)	($cmol(+)kg^{-1}$)	30.7	9.8	38.0	9.1	44.7	11.4	**
Ex. Ca	($cmol(+)kg^{-1}$)	22.1	6.5	26.4	8.2	31.5	9.6	**
Ex. Mg	($cmol(+)kg^{-1}$)	9.1	5.3	12.5	2.3	11.7	3.8	ns
Ex. K	($cmol(+)kg^{-1}$)	0.3	0.2	1.1	0.5	0.4	0.3	**
Ex. Na	($cmol(+)kg^{-1}$)	0.8	0.5	1.3	0.3	3.1	4.2	*
CEC/clay	($cmol(+)kg^{-1}$)	72.8	14.1	81.3	7.0	63.3	9.0	*
Av. P_2O_5	($10mgkg^{-1}$)	3.4	3.2	4.9	3.5	2.2	2.3	ns
Av. SiO_2	($10mgkg^{-1}$)	46.0	19.8	87.0	27.4	59.3	16.5	**
Clay	(%)	43.6	18.2	47.4	13.5	70.2	14.0	**

[a]By analysis of variance: ns=not significant; *=significant at the 5% level; **=significant at the 1% level.

organic fraction, induced by the large amount of organic matter in Bicol. However, even in the Bicol soils, the mean pH (H_2O) value was still as high as 6.0 and the sum of exchangeable bases was higher than the CEC value, indicating a high base status. Relatively high means of CEC and exchangeable Ca seen in Bicol soils may be attributed to the high clay content.

The highest mean of clay content in Bicol was contributed by the five soils from Camarines Sur Province which contained >60 % clay. Such a high clay content may be due to the physiographic location, i.e., on or near the back swamp of the lower reaches of the Bicol River as well as the basic nature of the parent sediments.

Mean values for available SiO_2 and exchangeable K were highest in Laguna, for unknown reasons.

3) Soil physical characteristics

For paddy soils, soil physical properties or tilth may be of minor importance, because paddy rice management requires water logging and puddling. Some of the physical properties are briefly described below.

As stated above, the Philippine lowland soils showed a high mean clay content of >50 % for both the surface and subsurface soil samples. Consequently, 77 % of the surface and subsurface samples were classified as clayey with a clay content of >35 %. According to the USDA system, 50 % of the surface samples and 45 % of the subsurface samples belonged to the C (clay) textural class. Based on the ISSS system, 56 % of the surface samples and 58 % of the subsurface samples were assigned to the HC (heavy clay) textural class (Fig. 4). As for the Philippine lowland soils studied by Kawaguchi and Kyuma[5], 48 % of them belonged to the HC class with a mean clay content of about 42 %.

In the case of saturated permeability, more than 80 % of the surface and subsurface samples showed a very low saturated hydraulic conductivity of 10^{-5} to 10^{-8} cm/sec (Fig. 5). The mean saturated hydraulic conductivity was 10^{-6} for both the surface and subsurface samples. This trend seems to indicate that the hydraulic conductivity decreases as the clay content increases (r=-0.380, significant at the 0.1 % level). However, some surface samples from Bicol with a relatively high organic carbon content showed a relatively high hydraulic conductivity of 10^{-4} to 10^{-3} cm/sec against their very high clay content of >65 %. These findings may be related to the low correlation between the hydraulic conductivity and clay content, as a whole.

The bulk density ranged from 0.53 to 1.66 Mgm^{-3} in the sample soils. More than 50 % of the surface and subsurface samples displayed a bulk density of 1.1 to 1.5 Mgm^{-3} (Fig. 6). In general, samples with a larger amount of organic carbon

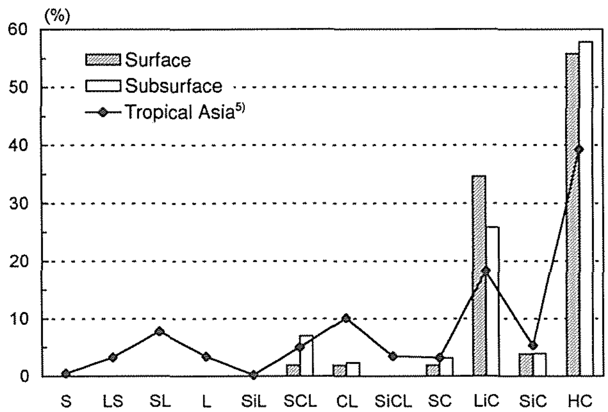

Fig. 4. Percentage distribution of textural class according to the ISSS system for the Philippine and tropical Asian lowland soils

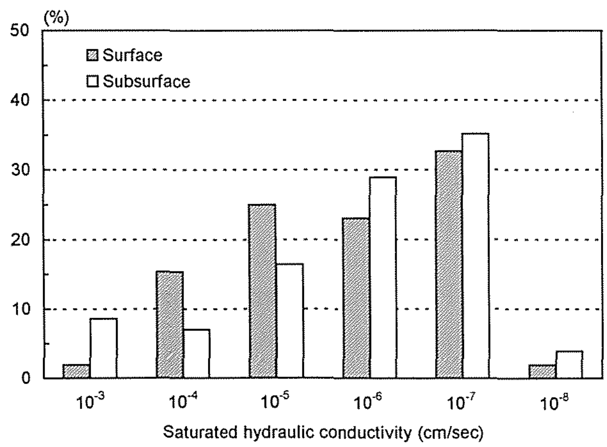

Fig. 5. Percentage distribution of saturated hydraulic conductivity fot the Philippine lowland soils

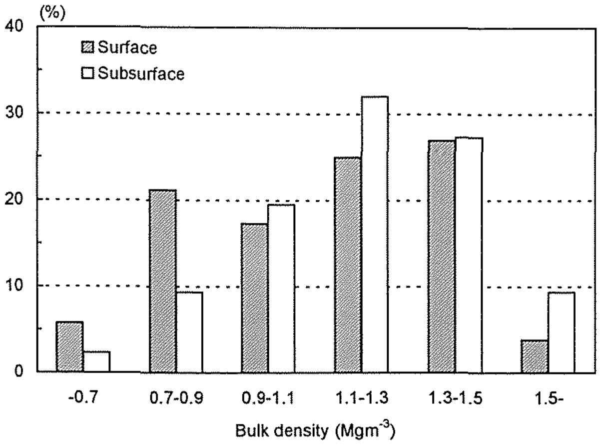

Fig. 6. Percentage distribution of bulk density for the Philippine lowland soils

showed a lower bulk density (r=-0.552, significant at the 0.1 % level). Obviously, the surface samples showed a lower mean of 1.10 than the subsurface samples of 1.20 Mgm^{-3}. These findings may account for the observation that in general the surface samples of Bicol soils with a high organic carbon content, showed a relatively low bulk density with a mean of 0.79 Mgm^{-3}.

Conclusion

The findings of this study indicate that the characteristics of the Philippine lowland soils are essentially controlled by the basic nature of the parent materials. Therefore, it is considered that the Philippine lowland soils have a relatively high inherent potential for rice production among the tropical Asian lowland soils. However, the differences in the soil characters related to the organic matter status among regions are induced by the local rainfall conditions. To reveal the distribution patterns of two aquic soil groups in terms of the effect of irrigation water or ground water in the Philippines, controlled by the climatic and topographic conditions, further analysis is required.

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フィリピンにおける低地土壌の特性とそれに対する母材と気候条件の関与

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摘 要

フィリピンは人口急増が著しく，需要に見合った米の安定生産が最大の課題である。そこで，生産基盤である低地土壌の肥沃度的特徴を科学的に把握することが必要である。この研究では，フィリピンの主要な低地土壌を対象として，全化学組成，鉱物性および理化学性について分析を行い，土壌特性に及ぼす母材と気候条件の関与について検討した。全化学組成については，フィリピン低地土壌は他の熱帯アジア諸国の低地土壌と比較して，ケイ酸とカリウム含量が低いが，アルミニウム，鉄，マンガン，カルシウムおよびマグネシウム含量が高いという特徴が見出された。しかし，ルソン島内で明瞭な地域間差が見られ，ルソン島東南部のビコール地域では，鉄とマンガン含量，塩基含量が他の地域より低く，これは湿潤な気候条件を反映したものと考えられた。鉱物組成については，細砂中の重鉱物含量が平均10％に達し，重鉱物画分は輝石類が主体であった。粘土画分は，14Å鉱物が卓越し，熱帯アジア諸国の低地土壌の中では，特異的であった。しかし，鉱物性については明瞭な地域間差は認められなかった。こうした鉱物的な特徴から，フィリピン低地は塩基性火山噴出物の影響を強く受けているものと考えられた。さらに，フィリピン低地土壌は熱帯アジア諸国の低地土壌のうちでは，有機物および塩素状態，有効態ケイ酸および粘土含量が高いことが示され，これは塩素性土壌材料に基づくものと考えられた。しかし，有機物状態は気候条件の影響をよく反映し，ルソン島内のより湿潤な地域で有機態炭素と全窒素含量が高かった。また，飽和透水性については，供試土壌の多くで非常に低く，主として粘土含量の高さに依存していた。仮比重は有機態炭素含量に規定され，断面内では表層部，地域別にはビコールで比較的低かった。

以上より，フィリピン低地土壌は塩基性母材の影響を強く受けており，熱帯アジア低地土壌の中では，自然肥沃度は概して高い部類に属する。しかしながら，有機物状態は降雨条件の影響を強く受け，有機物に強く関わる土壌特性値の地域間差を発現していた。

キーワード：化学的および物理的性質，一次および粘土鉱物組成，降雨条件，地域間差，全化学組成

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