PROFILE CHARACTERIZATION OF SOME ALFISOLS AND ULTISOLS IN THAILAND

SURAPHOL RATANASOPHON

FEBRUARY, 1981

PROFILE CHARACTERIZATION OF SOME ALFISOLS AND ULTISOLS IN THAILAND

SURAPHOL RATANASOPHON

SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
UNIVERSITY OF THE PHILIPPINES AT LOS BAÑOS
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE
DEGREE OF

DOCTOR OF PHILOSOPHY
(Soil Science)

February, 1981

ABSTRACT

SURAPHOL RATANASOPHON, University of the Philippines at Los Baños, February, 1981. Profile Characterization of Some Alfisols and Ultisols in Thailand.

Major Professor: Dr. Lupe A. Montecillo

Some physical, chemical, mineralogical and surface charge characteristics of four Alfisols and four Ultisols profiles from different areas in Nakhon Ratchasima province, Thailand, were studied in an attempt to understand more the distinguishing characteristics of Alfisols and Ultisols and to determine the role of a number of these properties in soil classification.

Ultisols showed finer texture and higher water retentions but less available water holding capacity and bulk density than Alfisols. The increase in percent clay with depth that met criterion for argillic horizons indicated their fairly well developed profiled. The application of the Pidgeon equation worked out better on Ultisols than on Alfisols in estima-

ting soil moisture content at field capacity and at permanent wilting point based on percent silt, clay and organic matter.

There were more organic matter, available phosphorous and potassium, free iron, exchangeable aluminum and percent aluminum saturation in Ultisols than in Alfisols. The electrical conductivity values of all soil samples were lower than 4 m mho/cm, indicating no adverse salinity effect on plants in these soils. Ultisols were generally more acidic than Alfisols.

Aluminum saturation of 30% in subsoils within the critical pH range of 5.4 to 5.1 was proposed as the tentative new criterion for the maximum limit of Alfisols and minimum limit of Ultisols to differentiate one from the other.

Using effective cation exchange capacity (ECEC) as a more realistic cation exchange capacity (CEC) measurement for routine analysis was confirmed. Direct measurement of apparent cation exchange capacity (ACEC) of clay was also recommended. Base saturation (BS) of 50% of CEC obtained by ammonium acetate method and 65% BS of ECEC were suggested as the alternating criteria

instead of 35% BS of CEC obtained by sum of exchangeable cations in the present classification of Alfisols and Ultisols.

Clay weathering index as an indicator of the soil order categories worked better in Ultisols than in Alfisols. The higher degree of pedogenic development with more predominating pH-dependent (PDC) of Ultisols than Alfisols was indicated by the greater values of zero point of charge (ZPC), PDC and the ratios of PDC to the permanent charge (PC).

With increasing pedogenic development the ZPC approached the pH measured in N KCl of the soils. This was also shown by some decreases in the relative differences of PC, ECEC/SCEC ratios and net permanent negative charges (σi) between Alfisols and Ultisols. All soil samples exhibited net permanent negative charges as indicated by the negative values of ΔpH (pH measured in N KCl-pH measured in water) and σi. The overall results showed that ZPC, PDC/PC ratio and σi may be used as the surface charge parameters for soil classification according to Soil Taxonomy (1975).

TABLE OF CONTENTS

	PAGE
INTRODUCTION	1
REVIEW OF LITERATURE	6
General Characteristics of Alfisols and Ultisols in Thailand	6
Classification Aspects of Alfisols and Ultisols	7
Physical Properties	8
Chemical Properties	14
Cation exchange capacity levels	14
Cation exchange cpacity measurements of soils	15
Exchangeable acidity and base saturation	20
Application of a cation exchange factor as a weathering index	22
Exchangeable aluminum and aluminum saturation percentage	25
Surface Charge Characterization	29
Surface charge parameters	33
Charge characteristics of oxides, crystalline and soil systems	36

PAGE

Factors effecting the zero point of charge 39

Zero point of charge and soil development 40

pH-dependent charge and permanent charge of soils 42

MATERIALS AND METHODS 47

Field Procedures 47

Laboratory Procedures 48

Preparation of soil samples 48

Physical analysis 49

Chemical analysis 51

X-ray diffraction analysis of silt and clay fractions 57

Zero point of charge determination 60

Permanent charge determination 62

pH-dependent charge determination 62

Charge ratio 62

RESULTS AND DISCUSSION 63

Soil Morphology 63

Physical Properties 67

Chemical Properties 85

PAGE

Organic matter 85

Available phosphorous and potassium 86

Electrical conductivity 87

Free iron 87

pH in water, pH in N KCl and Δ pH 88

Exchangeable aluminum and aluminum saturation percentage 90

Cation exchange capacity 96

Exchangeable acidity and base saturation 104

Mineralogical Properties 107

Surface Charge Characteristics 122

Zero point of charge 122

Permanent and net permanent negative charge 127

pH-dependent charge and charge ratio 130

CONCLUSION 133

LITERATURE CITED 149

APPENDICES 159

LIST OF TABLES

TABLE NO.		PAGE
1	Ranges and means of selected physical properties of Alfisols and Ultisols	69
2	Distribution of non-clay and clay fractions in the soil profiles in percent	71
3	Correlation coefficients of water retention at 1/3 and 15 bars with some other properties of Alfisols and Ultisols	81
4	Correlations among % silt, % clay and the CECs of soil and clay of Alfisols and Ultisols	84
5	Ranges and means of soil pH measured in water and in N KCl and ΔpH for the surface and subsoils of Alfisols and Ultisols	89
6	Ranges and means of exchangeable aluminum and percent aluminum saturation with some ranges of pH of Alfisols and Ultisols	92
7	Linear regression equations and correlation coefficients among soil pH, exchangeable aluminum and percent aluminum saturation for the subsoils of Alfisols and Ultisols	95

TABLE NO.		PAGE
8	Means with the standard deviations, minimum and maximum values of soil and clay CECs of the different methods for Alfisols and Ultisols	97
9	Matrix correlation coefficients among the soil CECs of the different four procedures for Alfisols and Ultisols	100
10	Matrix correlation coefficients among clay CECs of different procedures for Alfisols and Ultisols	102
11	Relative amounts of silt fraction minerals occurrence in the horizons of the eight soil profiles	108
12	Relative amounts of the clay minerals occurrence in the horizons of the eight soil profiles	112
13	Surface charge characteristics of Alfisols	123
14	Surface charge characteristics of Ultisols	124

LIST OF FIGURES

FIGURE NO.		PAGE
1	Distribution of clay with depth of Alfisols	74
2	Distribution of clay with depth of Ultisols	75
3	Available water ranges of Alfisols	78
4	Available water ranges of Ultisols	79

LIST OF APPENDICES

APPENDICES NO.			PAGE
A	Table 1.	Distribution of Alfisols and Ultisols in Thailand	159
B	Table 2.	Particle size distribution and bulk density of the soils	160
	Table 3.	Water retention, available water capacity (AWC), predicted field capacity, permanent wilting percentage and AWC of the soils	163
	Table 4.	Chemical properties of the eight soil profiles	166
C	Figures 1-8	X-ray diffractograms of the silt fraction of Alfisols	176
	Figures 9-16	X-ray diffractograms of the clay fraction of Ultisols	184
D	Profile descriptions of the eight soil series		196

INTRODUCTION

Studies on the physical, chemical, mineralogical and charge characteristics of Alfisols and Ultisols are important because of the relationships of these properties to soil fertility management and classification. In Thailand, soils classified as Alfisols and Ultisols in the order category are the most extensive. These soils occupy approximately 27,622,300 hectares or 53.7% of the country's total land area (about 51,398,200 hectares). Of these two orders Ultisols is the most common soil, occurring under different climatic conditions, landforms, parent materials and vegetation. They occupy approximately 22,112,560 hectares or 43.03% of the country's total land area. The Alfisols are less extensive and their most common occurrences are restricted to the basic parent materials. The distribution of Alfisols and Ultisols in Thailand is shown in Appendix Table 1.