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Classification of andisol soil on robusta coffee plantation in Silima Pungga - Pungga District

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Abstract. The survey study aims to classify the Inceptisol soil on Robusta coffee plantation in Silima Pugga-Pungga District, from Order level to Sub Group level. The study was conducted on location of sample soil profiles which were determined based on Soil Map Unit (SMU) with the main Andisol Order, i.e. SMU 12, SMU 15 and SMU 17 of 18 existing SMU. The soil profiles were described to determine the morphological characteristics of the soil, while the physical and chemical properties were done by laboratory analysis. The soil samples were taken from each horizon in each profile and analyzed in the laboratory in the form of soil texture, bulk density, pH H_2O, pH KCl, pH NaF, C-organic, exchangeable bases (Ca^{2+}, Mg^{2+}, K^+, Na^+), ZPC (*zero point charge*), base saturation, cation exchange capasity (CEC), P-retention, Al-Oxalate (Al-O) and Si-Oxalate (Si-O). The results showed that the classification of Andisol soil based on Soil Taxonomy only has one Sub Group namely *Typic Hapludand.* It is expected that the results of this study can provide information for more appropriate land management in order to increase the production of Robusta coffee plant in Silima Pungga-Pungga Sub district.

1. Introduction

Andisol soil is one of orders from eleven orders of soil in soil taxonomy. In this world, there are around 100 million hectare or 0.76% of the total land in the world [1]. There are 6.4 million hectare of Andisol soils in Indonesia and 200 thousand hectare in North Sumatera Province which is spread in wet and dry climate which has various characteristic.

The order of this Andisol soil is the newest order, formerly this soil is called Andosol or Andept. The change in the classification of Andept sub-order into Andisol order because some irregularities were found in the definition of sub-order in the soil taxonomy.

According to Soil Research Center [2] and Center for Agricultural Land Resources Research and Development Agency for Agricultural Research and Development [3] define Andosol soil as a soil that has a molic horizon, or A umbrik horizon and may be above the B kambik horizon; or A okhrik and B kambik horizon that have one or both of the following conditions: (a) bulk density (on water content of 1/3 bar and fine earth (< 2mm)) less than 0.85 g /cm^3 and the exchange complexes are dominated by amorphous materials, (b) 60% or more are vitric ash, or pyroclastic materials in the fraction of dust, sand, and gravel.

According to Soil Survey System [4] in soil survey system, the soil which is known as Andosol above is equivalent to Andisol order, land that has Andik soil properties ≥ 60% of soil thickness. Physically, the soil has a low bulk density (< 0.90 g/cm^3), high water content, water availability for plants form medium to low, high water holding capacity and high total porosity.

Regional shape or topography is one of the factors that form the soil that greatly affect the process of land formation and its management. Seen from the shape of its land area Andisol spread in choppy, bumpy, hilly, and mountainous areas. However, most of the land lies in hilly to mountainous areas.

In North Sumatra Province there are several districts that have coffee, one of which is Dairi Regency for Robusta coffee. Silima Pungga Pungga District is the region with highest production and productivity of Robusta coffee in Dairi Regency: 467 ton and 610.46 ton / hectare / year, but this level of productivity is still low. The low productivity of Robusta coffee is caused by improper land management.

Proper land management based on its characteristics and potential will provide optimal productivity. One effort that can be done is to know the nature and specific characteristics of a soil type, commonly called the soil classification [3]. The classification of soil in this study, as did also by Marbun [5] in this study refers to the land classification system which was developed by the USDA in 1975, known as Soil Taxonomy. Until now the classification system has grown until 2014 with many additional contents in the granting of land nomenclature categories.

This study aims to determine the soil classification of Andisol to sub group based on Keys To Soil Taxonomy 2014 [4]. It is expected that the results of this study will be able to provide more appropriate land management information in order to increase the production of Robusta coffee in Silima Pungga Pungga District.

2. Material and methods

This research was conducted on Robusta coffee plantation in District of Silima Pungga-Pungga, Dairi Regency ($2^0$80' - $2^0$88' NL and $98^0$04' – $98^0$17' EL), with a height of 400 to > 800 meters above sea level. Soil analysis was conducted at the Faculty of Agriculture's Research & Technology laboratory, University of Sumatera Utara.

Tools and materials which was used in this research are; administration map, soil types map, land slope map and land altitude map with scale of 1 : 25,000 for each map, rainfall data and air temperature data. Soil samples taken from each horizon on each soil profile are made in each SMU. Tools which are used are GPS (Global Positioning System), earth drill, tape measure, ring sample, Munsell Soil Colour Chart book, plastic bag, labels, cleaver, knife, camera, marker, etc.

This research used survey method to determine the morphology and characteristics of the soil, in order to classify the soil from Order to Sub-group level according to Keys to Soil Taxonomy. The procedures of this research were devided into five stages, namely: secondary data collection, field observation, soil sampling, soil analysis and report compilation.

Determination of coordinate points and location of the profile is determined based on secondary data on SMU 12, 15 and 17. Preparation of the profile begins with the drilling at several points representing each SMU, after considered representative then soil profile point which want to be observed can be determined.

Field observations were carried out on soil profiles of 1 m x 1 m x 1.5 m and depicted according to soil horizons for soil characterization which shows soil morphological properties and characteristics to be observed include: soil horizon limit, soil color, soil texture, soil structure, soil consistency and effective depth.

Soil samplings, undisturb soil and disturbed soil, were performed on each soil horizon for analysis in the laboratory. At the time of sampling the soil is also recorded data from the study area, including vegetation, physiography, drainage, altitude, slope, geographical location and land use. The soil properties analyzed and the method of analysis are presented in Table 1.

Data of field research and laboratory are then used for land classification based on "Keys To Soil Taxonomy 2014" [5]. The stages of classification of land are as follows: (1) Determination of the main horizon symbol and sub horizon, (2) Determination of the horizon of the identifiers, (3) Determination of the horizon under the identifiers, (4) Determination of other identifiers, (5) Determination of the Land Order, (6) Determination of Sub Order, (7) Determination of Great Group and (8) Determination of Sub Group.

Table 1. Observed variable factors and analysis methods

No.	Component Analysis	Method/Tool
	I. Environmental factors	
1.	Climate	Secondary data (meteorology climatolog and geophysics agency)
2.	Vegetation	Field Observation
3.	Physiography	See the form of environment
4.	External Drainage	Predicted from the slopes
5.	Internal Drainage	Characteristic shown by rust/gley
6.	Surface Rock	Observation of rock distribution
	II. Physical Properties in the Laboratory	
1.	Texture 3 fractions	Pipette
2.	Content weight	Ring Sample
3.	Water Content	Gravimetry
	III. Chemical Properties in the Laboratory:	
1.	pH H_2O, pH KCL and pH NaF	pH meter
2.	C- Organik	Walkey dan Black
3.	Cation Exchange Capacity (CEC)	Extract of NH_4Oac 1 N pH 7
4.	Bases exchangeable (K,Ca,Mg,Na)	Extract of NH_4Oac 1 N pH 7
5.	N-total (%)	Kjedhal
6.	P-available (ppm)	Bray II
7.	P-total	Extract of HCL
8.	K-total	Extract of HCL
9.	EC	Platina Elektroda
10.	P-retention	Blackmore
11.	Al-amorf	NH_4Oksalat
12.	Fe- amorf	NH_4Oksalat

3. Result and discussion

The Andisol land order is found in SMU 12, 15 and 17 of 18 (eighteen) SMU in District of Silima Pungga-Pungga. Order of land, altitude, slope, villages' name and area of each SMU can be seen in Table 2 below.

Table 2. Order of land, altitude, slope, villages' name and area SMU 12, SMU 15 and SMU 17

SMU	Soil	Altitude (m asl)	Slope (%)	Village's Name	Area (ha)
SMU 12	Andisol	400 - 500	0 – 4	Polding Anak – anak	605.92
SMU 15	Andisol	500 - 600	0 – 4	Bakal Gajah	916.42
SMU 17	Andisol	500 - 600	8 - 16	Bakal Gajah	720.89

Based on the observation in the field, there are similarities in these three soil profiles so that only one of the three soil profiles are discussed namely SMU 12 because its profile represents the SMU 15 and SMU 17 profiles.

3.1. Soil morphology

The soil color in the SMU 12 profile ranges from grayish black (2.5 Y 3/2) to faded yellow (2.5 Y 6/6). The more down the soil colors become brighter because of the reduced of organic material content in the lower horizon. Soil organic material affects various chemical and physical properties and increases soil biological activity as well as crop productivity. The dark color of humus on the

surface horizon (black or dark brown) with crumb structure, loose consistency, high organic matter content as well as smeary is one of the most decisive properties in Andisol soil.

The soil structure on the surface horizon is generally glob. According to Prasetyo [6] Andisol land has a soil structure that reflects the high level of soil material in the form of non-crystalline minerals and soil organic material. These ground-level horizons generally have grain structures and lumpy structures. Agricultural cultivation tends to cause grain structure changes to become globules.

The consistency of the soil in the field is examined in moist and wet conditions. In general the consistency of the soil is generally loose, while in wet conditions are generally somewhat adhesive. As is known Andisol soil contains many non-crystalline mineral materials that affect consistency. Soil consistency is usually less adhesive and less plastic, but a low C-organic content with increased clay content results in consistency of being sticky and plastic.

Soil texture on SMU 12 varies greatly, but the horizon on this profile generally has a sandy clay loam texture (Table 2). Andisol soil has a very varied texture from sandy loam to sandy clay, it depends on the type and size of particles released during eruption.

3.2. Physical properties of soil

Physical properties of soil observed in the field include color, structure and consistency, while the soil physical properties analyzed in the laboratory are soil texture and bulk density. The physical properties of soil SMU 12 can be seen in Table 3 below.

Table 3. Morphology and analyses soil physical properties at SMU 12, SMU 15 and SMU 17 profile

Soil Profile	Horizon	Depth (cm)	Color	Structure	Consistency		Particle Size Distribution (%)			Texture	Bulk Density (g/cm^3)
					Moist	Wet	Sand	Silt	Clay		
	A	0 - 14	2,5 Y 3/2	sab	friable	ss	47.84	19.28	32.88	scl	0,85
SMU 12	Bw_1	14 - 35	2,5 Y 4/4	sab	friable	ss	54.56	18.56	26.88	sl	0,70
	Bw_2	35 - 150	2,5 Y 6/6	sab	friable	ss	48.56	16.56	34.88	scl	0,75
	Ap	0 - 45	2,5 Y 3/2	sab	friable	s	49.84	23.28	26.88	sl	0,60
SMU 15	Bw_1	45 - 90	2,5 Y 4/4	sab	friable	s	54.56	20.56	24.88	scl	0,75
	Bw_2	90 - 150	2,5 Y 6/6	ab	firm	vs	36.56	15.84	47.60	sl	0,84
	Ap	0 - 40	2,5 Y 3/2	cr	friable	ss	49.84	31.28	18.88	l	0,80
SMU 17	A	40 - 75	2,5 Y 4/4	cr	friable	ss	54.56	26.56	18.88	sl	0,76
	Bw	75 - 150	2,5 Y 3/2	b	firm	s	34.56	17.84	47.60	c	0,87

Notes: structure: ab = angular blocky; sab = sub angular blocky; cr = crumb
consistency: ss = slightly sticky; s = sticky; vs = very sticky
texture: scl = sandy clay loam; sl = sandy loam ; l = loam; c = clay

3.3. Chemical properties of soil

Chemical Properties of Soil observed in the laboratory are: pH of H_2O, pH of KCl, pH NaF, Bases exchange (Ca, Mg, K and Na), Cation Exchange Capacity (CEC), Base saturation, C-organic, Al-O, and Fe-O can be seen in Table 4 below.

Table 4. The chemical properties of soil data analysis result in soil profile of SMU 12, SMU 15 and SMU 17 robusta coffee's field in sub district silima pungga pungga

Soil Profile	Horizon	Depth (cm)	pH			CEC (me/100g)	BS (%)	Ca-exch	Mg-exch	K-exch	Na-exch	C-org (%)	Ret-P (%)	AlO (%)	Fe0 (%)	Al + ½ Fe (%)
			H_2O	KCl	NaF			(me/100g)								
	A	0 – 14	4.97	3.50	9.81	10.21	27.11	1.406	0.923	0.210	0.229	1.10	90.89	1.67	3.43	3.38
SMU 12	Bw_1	14 – 35	4.72	3.61	9.62	12.10	29.88	1.058	1.386	0.258	0.913	1.07	87.89	1.63	4.41	3.83
	Bw_2	35 – 150	4.58	3.61	10.21	21.09	17.69	0.659	0.735	0.079	0.182	0.63	88.89	1.28	3.38	2.97
	Ap	0 – 45	4.76	3.62	9.46	13.88	13.61	0.675	0.798	0.170	0.246	1.14	87.74	3.16	1.07	3.69
SMU 15	Bw1	45 – 90	4.88	3.74	9.47	12.10	13.74	0.578	0.796	0.056	0.232	0.99	90.80	6.49	0.66	6.82
	Bw2	90 – 150	4.87	3.58	9.85	9.39	25.43	0.577	1.526	0.148	0.137	0.74	85.46	8.04	1.95	8.51
	Ap	0 – 40	4.99	4.16	9.21	14.43	26.66	0.973	2.237	0.432	0.205	1.77	90.67	0.70	3.45	2.42
SMU 17	A	40 – 75	4.76	3.85	9.70	13.10	8.71	0.574	0.295	0.041	0.231	1.58	93.33	1.30	3.41	3.00
	Bw	75 – 150	5.01	3.61	9.72	11.96	25.21	0.595	2.073	0.231	0.116	0.33	95.56	2.15	4.55	4.42

3.4. Soil classification

Based on data obtained from both climate data, field observation and soil sample data from the laboratory, soil classification by using Keys Soil Taxonomy 2014 [4] is done. The first step is to determine the surface horizon identifiers (epipedon), the sub surface horizon identifiers as well as the other identifiers. In addition, the determination of orders, sub-orders, great groups and sub groups.

3.5. Determination of surface horizon identifier/epipedon

Epipedon soil identifier on soil surface for SMU 12, SMU 15 and SMU 17 is epipedon umbrik. Terms for epipedon umbrik are the position located above the soil, has a color value and chroma of 3 or less (humid), base saturation < 50% and moist soil in a state of more than 3 months.

3.6. Determination of sub surface horizon identifier

Kambik horizon is found in SMU 12, SMU 15 and SMU 17, because it has a very fine sand texture called sandy loam, horizon tickness is more than 15 cm, the absence of clay illuviasi process and is not part of the Ap horizon, also did not experience the aquatic condition.

3.7. Determination of other identifier

SMU 12, SMU 15 and SMU 17 have a moisture regime udik, because the soil never dries within 90 days (cumulative), more than 90 days or from the data obtained by the average rainfall in the wet season range from 7 - 10 months per year or 210 days to 300 days (cumulative), and has soil temperature regime isohipertermik, because the hottest and coldest is smaller than 6^0C, it is 1.71^0 dan average annual soil temperature bigger than 22^0C, it is 22.5^0C. This soil is also have the characteristic of Andik because it has Phosfat retention which is bigger than 85%, bulk density is smaller than 0.90 g/cm3 and Al+1/2Fe (extract of ammonium oxalate) is bigger than or same as 2%.

3.8. Order determination

SMU 12, SMU 15 and SMU 17 belong to *Andisol* order because they have the characterictics of Andik soil, bigger than or same as 60% of the tickness.

3.9. Sub order determination

SMU 12, SMU 15 and SMU 17 belong to *Udand* because they have soil moisture regime udik.

3.10. Great group determination

SMU 12, SMU 15 and SMU 17 belong to great group *Hapludand* because they have udand with the other characterictics.

3.11. Sub group determination
SMU 12, SMU 15 and SMU 17 belong to *Typic Hapludand* sub group because they have another characteristic of hapludand.

4. Conclusion
Classification soil of SMU 12, SMU 15 and SMU 17 are order: *Andisol*, sub order: *Udand*, great group; *Hapludand* and sub group: *Typic Hapludand*.

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