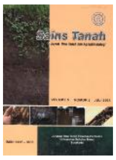
SAINS TANAH – Journal of Soil Science and Agroclimatology, 17(2), 2020, 115-121

SAINS TANAH – Journal of Soil Science and Agroclimatology

Journal homepage: http://jurnal.uns.ac.id/tanah



Characteristics of Inceptisols derived from basaltic andesite from several locations in volcanic landform

Rufaidah Qonita Muslim*, Pronika Kricella, Mira Media Pratamaningsih, Setiyo Purwanto, Erna Suryani, Sofyan Ritung

Indonesian Center for Agricultural Land Resources Research and Development, Bogor, Indonesia

ARTICLE INFO

Keywords:
Basaltic andesite
Inceptisols
Parent materials

Article history
Submitted: 2019-12-20
Accepted: 2020-12-04
Available online: 2020-12-30

* *Corresponding Author*
Email address:
rufaidah@pertanian.go.id

ABSTRACT

The widespread of Inceptisols in Indonesia especially in volcanic landform has the characteristics potentially to be used as agricultural land. This study aimed to identify the characteristics of Inceptisols found in volcanic landform developed from basaltic andesite parent materials. Soil samples were collected in 6 locations. A total of 23 samples were taken from each horizon from 6 pedons for physical, chemical, and mineral analysis. The results showed that Inceptisols had different colors depending on land use and mineral content, but were dominated by yellowish brown to dark brown with hue 7.5YR to 10YR, color value varied from 2.5 to 4, and croma varied from 1 to 6. Base saturation varied from low to very high, cation exchange capacity varied from low to high. Soil textures were dominated by clay, clay loam, and sandy loam. Three pedons in Purwakarta, Bandung Barat, and Jember Regency, Java Island were dominated by weatherable minerals, while the others obtained in Seluma, Rejang Lebong, and Ogan Komering Ulu Selatan Regency, Sumatera Island were dominated by resistant minerals such as opaque and quartz. Physical, chemical, and mineral content can be used as a reference in soil management and recommendation for balanced fertilization.

How to Cite: Muslim, R. Q., Kricella, P., Pratamaningsih, M. M., Purwanto, S., Suryani, E., and Ritung, S. (2020). Characteristics of Inceptisols derived from basaltic andesite from several locations in volcanic landform. Sains Tanah Journal of Soil Science and Agroclimatology, 17(2): 115-121 (doi: 10.20961/stjssa.v17i2.38221)

1. Introduction

Inceptisols are relatively young soils characterized by the presence of a cambic horizon. Horizons are formed as a result of the process of physical change. The cambic horizon is characterized by the development of structure or color, chemical transformation, material transfer, or a combination of two or more of these processes (Soil Survey Staff, 2014). Inceptisols can be found in a very diverse environment. It can be formed from cold climates to very warm and humid to subhumid, from arctic to tropical (Palmer, 2005). According to FAO (2015), the total area of Inceptisols reaches 1,500 million hectares, while Subagyo et al. (2000) stated that the area of Inceptisols in Indonesia reaches 70 million hectares. The largest distribution is on Sumatera Island with an area of 17.6 million hectares.

Soil characteristics can be categorized into various soil types even though they came from the same parent material. The formation of soils was not only influenced by parent material, but also by other factors, such as climate, topography, organisms, and time (Jenny, 1994). In this study, Inceptisols observed were derived from basaltic andesite in volcanic landform. Inceptisols that develop from volcanic materials have characteristics consisting of clay content ≥40% and has a homogeneous matrix color, deep soil cross section, base saturation <50% in some parts of the B horizon, has a characteristic horizon A ochric, umbric, or B cambic, has no plintit, and vertic properties (Subardja et al., 2016). According to Hardjowigeno (1993), soil developed from volcanic rocks (andesite) would have a clay loam to clay texture. There are also Inceptisols that developed from volcanic materials dominated by basalt. According to Shamshuddin & Kapok (2010), basalt-based soils have relatively better fertility since they have a pH close to neutral because basalt has the ability to increase soil pH as well as lime. The nature of Inceptisols from limestone varies greatly depending on weathering, topography, and rainfall (Khresat, 2005).

There are not many studies on Inceptisols derived from basaltic andesite, so the research on it will be able to fill the lack of knowledge. This study aimed to find the characteristics of Inceptisols derived from basalt-andesite material. Several tests were carried out to evaluate the nature of the soil, i.e. physical-morphological, chemical properties, and mineral composition. The results of this study are expected to enrich the information about the properties of Inceptisols derived from andesite basalt material in Indonesia, as well as its potency for agricultural development.

2. Materials and Method

The materials used in the study were six pedons taken from several locations with the same parent material, basaltic andesite. All pedons were found in the volcanic landform group, i.e. old volcanic plains, volcanic hills, volcanic foot, and volcanic slopes. Detailed information about pedons was presented in Table 1.

A total of 23 soil samples were taken from each horizon on the six pedons for physical, chemical, and mineral analysis. The physical and chemical analysis included texture, organic carbon, pH (H_2O), potential P and K, cation exchange capacity (CEC), and base saturation. Soil color was determined by the Munsell soil color chart. Soil pH was measured in supernatant suspension of a 1:5 soil:liquid (H_2O) after 30 minutes of equilibration (Eviati & Sulaeman, 2012; Van Reeuwijk, 1993). Organic carbon was obtained by using Walkley & Black methods (Horwitz, 2010). The total P_2O_5 and K_2O content were measured in HCl 25% extract. Exchangeable cations (Ca, Mg, K, Na) were extracted by NH4-Acetat 1N pH 7 and measured using atomic absorption spectrophotometry (AAS) for Ca, Mg and flame photometer for K, Na using a standard series as a comparison. The CEC was measured in NH_4-Acetat 1N (buffered at pH 7.0) (Eviati & Sulaeman, 2012). The composition of the sand fraction mineral was determined by line counting method, which is counting up to 100 grains of mineral using a polarization microscope (Balittanah, 2005).

3. Results

3.1. Morphological and physical attribute

The depth, color, and texture of each pedon can be seen in Table 2. All pedons observed had deep solum (74-140 cm). The A horizon was 15 to 23 cm thick, while B horizon was >55 cm thick (Table 2). Cambic horizons (Bw) was found in the P1, P2, P3, P4, and P6 with high clay content. Bg horizon on P5 showed strong gleization indicated that the soil condition was in inundation or water saturation state for a long time. Land use of P5 was rice fields so that the soil was in the water saturated conditions.

Table 1. Information of pedons observed

Pedon	Parent material/ rock type	*Soil Classification*	*Landform*	Location	Coordinate
P1	Basaltic Andesite (rock)	Typic Eutrudepts	Old volcanic plain	Seluma Regency, Bengkulu Province	102°24'59.1'' E 04°01'07.4'' S
P2	Basaltic Andesite (tuff)	Typic Dystrudepts	Foot of a mountain	Rejang Lebong Regency, Bengkulu Province	102°30'19.5'' E 03°23'55.8'' S
P3	Basaltic Andesite (tuff)	Typic Dystrudepts	Lower volcanic slope	Purwakarta Regency, West Java Province	107°32'25.7'' E 06°39'26.0'' S
P4	Basaltic Andesite (rock)	Eutric Humudepts	Volcanic hills	Bandung Barat Regency, West Java Province	107°21'26.8'' E 06°56'09.5'' S
P5	Basaltic Andesite (tuff)	Aquic Dystrudepts	Lower volcanic slope	Jember Regency, East Java Province	113°52'06.1'' E 08°11'55.5'' S
P6	Basaltic Andesite (rock)	Typic Epiaquepts	Old volcanic plain	Ogan Komering Ulu Selatan Regency, South Sumatera Province	103°52'46.0'' E 04°27'45.8'' S

Tabel 2. The morphological and physical attribute of pedons observed

Pedon	Horizon	Depth (cm)	Matrix color	Texture, consistency
P1	A	0-19	db (7.5YR 3/4)	CL
	Bw1	19-46	dyb (10YR 4/4)	CL
	Bw2	46-74	yb (10YR 5/4)	SL
	C	74-120	o (5Y 5/3)	LS
P2	A	0-19	dyb (10YR 3/4)	SiC, ss sp
	Bw1	19-42	dyb (10YR 3/6)	C, s p
	Bw2	42-90	b (7.5YR 4/4)	C, s p
	Bw3	90-120	sb (7.5YR 4/6)	C, s p
P3	A	0–15	db (7.5YR 3/2)	C, s p
	Bw1	15–50	db (7.5YR 3/4)	CL, ss sp
	Bw2	50–80	b (7.5YR 4/4)	C, s p
	Bw3	80–120	b (7.5YR 4/4)	C, s p
P4	A	0-19	db (7.5YR 3/2)	C, s p
	Bw1	19-47	db (7.5YR 3/3)	C, s p
	Bw2	47-77	drb (2.5YR 3/4)	C, s p
	Bw3	77-140	r (2.5YR 4/6)	C, s p
P5	A	0-15	vdg (7.5YR 3/1)	SL, so po
	Bg	15-45	db (7.5YR 3/2)	SL, ss sp
	Bw	45-80	db (7.5YR 3/3)	SL, so po
	BC	80-120	db (7.5YR 3/4)	L, ss sp
P6	A	0-23	vdg (2.5Y 3/1)	C, s p
	Bw1	23-53	db (7.5YR 3/3)	C, s p
	Bw2	53-120	db (7.5YR 3/4)	CL, s p

Remarks: Matrix color = db (dark brown), dyb (dark yellowish brown), yb (yellowish brown), o (olive), b (brown), sb (strong brown), drb (dark reddish brown), r (red), vdb (very dark brown), vdg (very dark gray); Texture = CL (clay loam), SiC (Silty Clay), C (clay), SiL (Silt Loam), SL (Sandy Loam); Consistency = ss (slightly sticky), s (sticky), so (non-sticky), sp (slightly plastic), p (plastic), po (non-plastic).

The colors of all profiles were 7.5YR and 10YR hue, except the topsoil in P6 (2.5Y hue) and the subsoils in P4 (2.5YR hue) (Table 2). The values ranged from 3 to 5 and chroma ranged from 1 to 6. All pedons observed had a darker topsoil color than the subsoils. The color of topsoil of P3, P4, P5, P6 were darker than P1 and P2 indicated that topsoil of P1 and P2 have poor organic matter. It can be caused by the low supply of plant nutrients. According to Wiesmeier et al. (2019), soil organic matter was influenced by vegetation type and decomposition of carbon. All pedons had dark brown matrix color, in the form of dark brown, dark yellowish brown, strong brown, or very dark brown, except the top layers of P5 and P6 that had very dark gray color because of its land use. Other than that, P4 had dark reddish brown and red in subsoils.

The texture of the soil was dominated by clay (clay content of 40% to 77%), but in certain pedons (P1, P2, and P5) the textures were clay loam, silty clay, silty loam, and sandy loam (Table 2). Clay texture has sticky and plastic consistency, silty clay and sandy loam texture have slightly sticky and slightly plastic consistency, and silty loam texture has non-sticky and non-plastic consistency.

3.2. Chemical properties

Soil reaction (pH H_2O) of all pedons varied, i.e. strongly acidic (pH <4.5), acidic (pH 4.5-5.5), and slightly acidic (5.5-6.5) as can be seen in Table 3. The low pH value was caused by leaching bases due to high rainfall intensity. Whereas the high pH value was caused by lower rainfall intensity, such as P5 located in East Java which has a drier climate than other locations. Based on climate-data.org, the rainfall in Jember Regency is 1,593-2,834 mm year^{-1}. Otherwise, rainfall in Seluma Regency is 3,240-3,433 mm year^{-1}, rainfall in Rejang Lebong Regency is 3,131-3,381 mm year^{-1}, rainfall in Purwakarta Regency is 2,141 mm year^{-1}, rainfall in Bandung Barat Regency is 2,049 mm year^{-1}, and rainfall in Ogan Komering Ulu Selatan Regency is 2,693-2,808 mm year^{-1}.

Soil organic carbon was generally high at the depth of 0-30 cm and decreased at the depth of >30 cm (Table 3). In P5, the content of organic carbon was very low (<1%) in each layer as compared to other pedons. Besides, the organic carbon content in P5 at the depth of 80-120 cm was higher than the topsoil.

The total P_2O_5 content was generally high (41-60 mg 100 g^{-1}) to very high (>60 mg 100 g^{-1}) in each layer in P1, P3 and P5. P2 and P6 had moderate content of total P_2O_5 (21-40 mg 100 g^{-1}), while P4 had a low content of total P_2O_5 (<20 mg 100 g^{-1}). The high content of P_2O_5 was likely caused by fertilization. The total K_2O content was generally very low (<10 mg 100 g^{-1}), except P5 which had a low content of total K_2O (10-20 mg 100 g^{-1}) in the subsoil and moderate content of total K_2O (29 mg 100 g^{-1}) in the topsoil (Table 3).

The cations exchangeable content (Ca, Mg, K, Na) were generally low in all pedons, except P4 (Table 3). Ca^{2+} content was generally low (2-5 cmol kg^{-1}) in P2 and P3, moderate (6-10 cmol kg^{-1}) in P1, P5, P6, and very high in P4 (7.9-12 cmol kg^{-1}). Mg^{2+} content was generally low to moderate (0.3-2 cmol kg^{-1}), but found to be high (2.1-8 cmol kg^{-1}) in P1 and very high in P4 (>8 cmol kg^{-1}). K^+ content was low (0.1-0.3 cmol kg^{-1}) and very low (<0.1 cmol kg^{-1}), as in P1 and P4. Na^+ content was generally very low (<0.1 cmol kg^{-1}) and low (0.1-0.3 cmol kg^{-1}).

Table 3. Result of chemical analysis

Pedon	Depth cm	pH H_2O	Organic carbon	HCl 25%		Cations Exchangeable (NH_4-Acetat 1N, pH 7)						KCl 1N		Saturation	
				P_2O_5	K_2O	Ca	Mg	K	Na	CEC of soil	Effective CEC	Al^{3+}	H^+	Base	Al
			%	mg 100 g^{-1}				cmol$_c$ kg^{-1}				cmol$_c$ kg^{-1}		%	
P1	0-19	5.4	1.65	61	5	6.82	5.57	0.09	0.24	23.18	13.33	0.61	0.17	54.87	4.58
	19-46	5.5	0.55	50	4	6.84	6.17	0.07	0.30	23.32	13.47	0.09	0.17	57.38	0.67
	46-74	6.0	0.36	78	2	3.95	2.33	0.03	0.08	8.70	-	-	0.06	73.45	-
	74-120	6.2	0.18	79	3	3.85	2.22	0.04	0.05	7.49	-	-	0.04	82.24	-
P2	0-19	4.7	2.66	28	10	3.18	1.06	0.20	0.11	17.93	7.31	2.76	0.37	25.38	37.76
	19-42	4.5	1.22	20	7	2.44	1.58	0.13	0.05	15.75	7.58	3.38	0.33	26.67	44.59
	42-90	4.7	0.57	15	10	2.16	1.42	0.19	0.08	15.29	7.48	3.63	0.36	25.18	48.53
	90-120	4.6	0.51	19	6	2.82	1.32	0.11	0.05	15.88	7.97	3.67	0.45	27.08	46.05
P3	0–15	4.4	2.45	226	7	2.04	0.57	0.13	0.03	19.22	4.17	1.40	0.18	14.41	33.58
	15–50	4.5	1.74	135	5	1.85	0.43	0.10	0.10	16.61	3.57	1.09	0.20	14.93	30.48
	50–80	5.1	1.41	117	7	2.36	0.67	0.14	0.06	17.84	3.61	0.38	0.17	18.11	10.65
	80–120	5.3	1.07	97	10	3.20	0.75	0.19	0.07	17.61	4.39	0.18	0.18	23.91	4.13
P4	0–19	6.1	1.65	16	3	12.00	17.13	0.06	0.03	31.33	29.00	-	0.14	93.00	-
	19-47	6.2	1.37	19	3	11.96	17.55	0.06	0.09	29.91	30.00	-	0.11	99.00	-
	47-77	6.5	0.99	18	3	10.17	17.34	0.06	0.10	28.29	28.00	-	0.07	98.00	-
	77-140	5.9	0.43	22	3	7.90	14.15	0.04	0.28	28.21	22.00	-	0.11	79.00	-
P5	0-15	6.0	0.65	146	29	7.03	1.36	0.58	0.19	16.71	-	-	-	55.42	-
	15-45	5.9	0.42	161	9	4.21	1.78	0.18	0.07	9.70	-	-	-	44.23	-
	45-80	5.8	0.18	123	15	3.15	1.51	0.29	0.10	10.37	-	-	-	39.63	-
	80-120	5.7	0.92	170	18	4.23	1.90	0.35	0.06	11.03	-	-	-	51.13	-
P6	0-23	5.2	1.64	42	5	5.30	1.31	0.09	0.18	17.03	6.93	0.05	0.05	40.40	0.72
	23-53	5.3	0.78	25	8	6.75	2.70	0.14	0.26	16.25	9.89	0.04	0.09	60.62	0.40
	53-120	5.1	0.38	19	14	3.86	1.29	0.26	0.29	13.78	6.10	0.40	0.17	41.36	6.56

The low content of cations exchangeable influenced base saturation content to also be low (20-40%) to very low (<20%) in P2 and P3. P1, P5, P6 had moderate base saturation content (41-60%) and P4 had very high base saturation content (79-99%). Cation exchange capacity (CEC) of all pedon was low to moderate (7.49-23.32 cmol kg^{-1}), except P4 which had high CEC (28.21-31.33 cmol kg^{-1}). The CEC value was generally decreased in the lower layer, as in the underlying layer of P1 and P5 had low CEC (7.49-9.70 cmol kg^{-1}) (Table 3).

Aluminum cation dominance in the soil as indicated by aluminum saturation content. Aluminum saturation content in P2 and P3 were moderate (30-40%), while P1 and P6 were very low (<5%). Aluminum saturation in the topsoil of pedon P1 and P3 were higher than the subsoil (Table 3). On the contrary, the subsoil of P2 and P6 had higher aluminum saturation than the topsoil.

3.3 Mineral sand fraction

Six pedons with total of 18 samples had been analyzed to find out the composition of the mineralogy of sand fraction. Three pedons (P3, P4, and P5) were dominated by weatherable minerals, such as augite, hypersthene, labradorite, rock fragment, and volcanic glass (Figure 1). The amount of augite found in the samples ranged from 1-23%, hypersthene ranged from 1-16%, labradorite ranged from 1-21% and found sporadic (sp) in P3 (subsoil) and P6 (topsoil), rock fragment ranged from 2-24%, volcanic glass ranged from 1-8% and found sporadic (sp) in P1 (subsoil) and P3. The remaining three pedons (P1, P2, and P6) were dominated by resistant weathered minerals, such as opaque and quartz (Figure 1). The amount of opaque found in the samples ranged from 7-53% while quartz (clear and turbid) ranged from 1-39% and found sporadic (sp) in P5.

Besides countable minerals, there were minerals found sporadic, such as zircon in P3, P4 and P5, iron concretion in P1, P2, and P4, hydragilite in P1, P2, P4, P5 and P6, bytownite in P2 and P3, anorthite in P3, orthoclase in P2, P3, P4, P5, and P6, sanidine in P3, biotite in P4 and P6, brown hornblende in P5, andalusite in P1 and P4. The mineral composition of the sand fraction was presented in Figure 1.

4. Discussion

Characteristics of Inceptisols derived from basaltic andesite had morphological properties that tend to be the same in all pedons. Still, there were differences in color due to their landuse and mineral contents. The different morphological properties in P5 (color and texture) and P6 (color) were influenced by land use. All pedons had dark brown matrix color (dark brown, yellowish dark brown, very dark brown), except for P4, P5, and P6. In A horizon, P5 and P6 had gray matrix color (very dark gray) (Table 2). Paddy and sugarcane were planted alternately in P5 so that the soil in the location was alternately wetting and drying, while P6 was planted by paddy continuously so that the soil was in the water saturated conditions frequently. During this condition, the chemical nature of iron is transformed from ferric (Fe^{3+}) to ferrous (Fe^{2+}) because some groups of microbes use Fe^{3+} for respiration. Because the aerobic iron (Fe^{3+}) is characterized by a reddish color while anaerobic iron produced grey-colored horizons, the color of soil horizons changed from red to grey (Ashman & Puri, 2013). The subsoil in P4 had dark reddish brown and red color. Red color in P4 was caused by the movement of iron from top layer which changed its color from brown to red (Ashman & Puri, 2013). In addition, the high content of iron in subsoil was influenced by minerals containing iron, such as hypersthene, augite, and hornblende (Figure 1). All pedons had Bw horizon containing clay (clay, clay loam, and silty clay texture), except P5 (Table 2). This fine to slightly fine texture showed one of the cambic characteristics of Inceptisols (Soil Survey Staff, 2014). Bg horizon was only found in P5. The soil texture of P5 was sandy loam. Based on geological maps, P5 contained sandy fraction which derived from weathered breccias and tuff (Sapei et al., 1992).

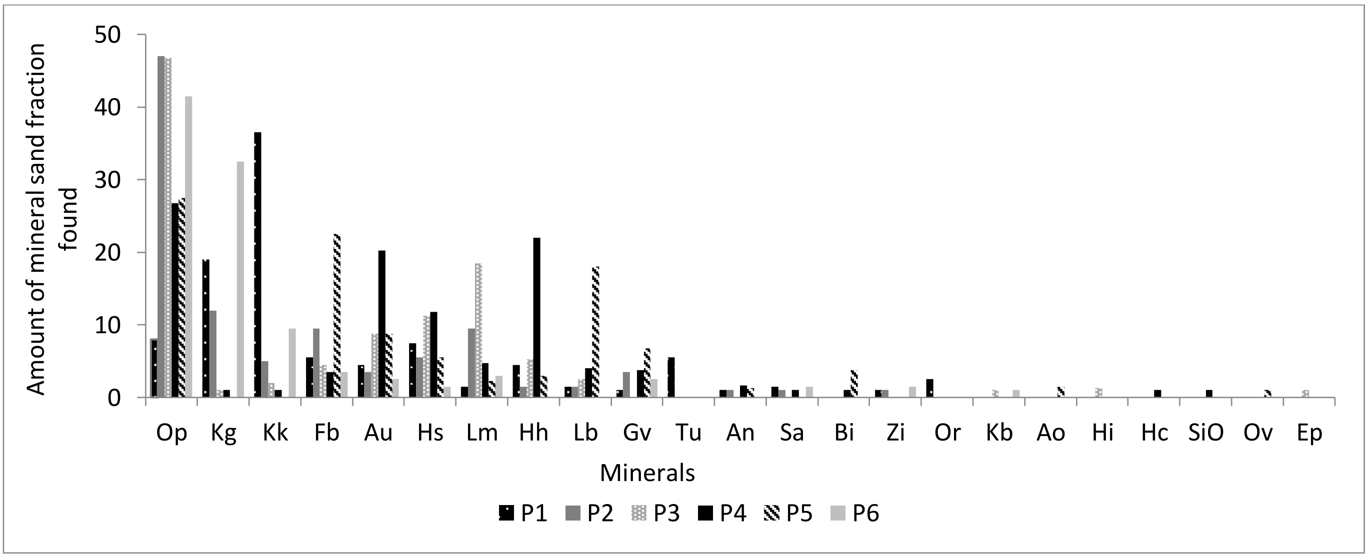


Figure 1. Composition of sand fraction mineral

Remarks: Op=Opaque, Kg=Clear quartz, Kk=Turbid quartz, Fb=Rock fragment, Au=Augite, Hs=Hyperstene, Lm=Weathered mineral, Hh=Green horblende, Lb=labradorite, Gv=Volcanic glass, Tu=Tourmaline, An=Andesine, Sa=Sanidine, Bi=Bytownite, Zi=Zircon, Or=Orthoclase, Kb=Iron concretion, Ao=Anorthite, Hi=Hidragillite, Hc=Brown hornblende, SiO=Organic SiO2, Ov=Olivine, Ep=Epidote.

Soils derived from basaltic andesite reacted acidly, ranged from strongly acidic, acidic, to slightly acidic (pH 4.4-6.5) (Table 3). Anda et al. (2012) reported that soils derived from basaltic andesite reacted acidly with pH values of 5.2-5.5. Soil acidity with pH value <5 in P2 and P3 caused high content of Al saturation. According to Đalović et al. (2012), aluminium solubility in the soil can be estimated by soil acidity. Acidic soils are associated with low base content (Suratman et al., 2018). This low base content was indicated by the low base saturation in P2 and P3. Whereas P1, P5, and P6 had moderate base saturation (39.63%-82.24%) (Table 3) because they reacted slightly acidic (pH >5). Strong leaching conditions associated with very high precipitation was presumed to be the cause of very low base saturation (Wu & Chen, 2005). P4 had high base saturation (79-99%) because it reacted slightly acidic (pH 5.9-6.5) which was also associated with high level of Ca and Mg cations in the soil.

Organic carbon in all pedons was generally low (1-2%). The content of organic carbon in subsoil is caused by high soil temperatures which lead to increase microbial decomposition that can reduce organic carbon in topsoil (Clara et al., 2017). Land use of P5 which had very low organic carbon (<1%) was rice field. Lack of organic matter availability caused poor organic carbon content in paddy soils. Soil organic carbon enhancement can be done by providing straw after harvesting. P1, P4, and P6 have low organic carbon (1-2%). The high content of organic carbon in P2 and P3 was caused by their land use, namely mixed plantations and nutmeg plantations, respectively.

P4 had high content of Ca and Mg exchangeable because it contained high levels of hornblende and augite which are source of Ca and hypersthene and hornblende which are source of Mg (Soepardi, 1983). Besides, the content of cations exchangeable was influenced by the intensity of land management. P1, P5, and P6 had higher cations exchangeable (Ca, Mg, Na) content than P2 and P3. It showed that the tillage of P1, P5, and P6 was more intensive than other pedons.

The highest CEC values were at P4 and P1 (A horizon), followed by P3, P2, P5, and P6 (Table 3). Soils with moderate to high organic matter have higher CEC than soil with low organic matter (Sufardi et al., 2013; Suriadikarta et al., 2002). The organic carbon in the pedon represents a relationship with CEC values which explain the contribution of organic matter to the CEC of soil (Karuma et al., 2014). Therefore the low CEC value in the subsoil was because the content of organic matter decreased along with the depth of the soil. Based on Fooladmand (2008), the CEC value depends on soil texture: increasing large particles such as sand will decrease soil CEC. Conversely increasing fine particles such as clay will increase soil CEC. The soil CEC of subsoil of P1 and P5 were lower than the others due to their soil texture were sandy loam, loamy sand, and loam. In addition, the soil CEC in P4 was higher than others because the clay content was very high.

The composition of sand fraction minerals of soils derived from basaltic andesite was dominated by augite, hypersthene, amphibole, andesine, labradorite, and volcanic glass (Mohr et al., 1972; Wibisono et al., 2016). The results of sand fraction mineral analysis in the six pedons showed the same thing as the study (Figure 1).

Three pedons (P3, P4, and P5) were dominated by weatherable minerals (Figure 1). Several groups of weatherable minerals were feldspar (alkali feldspar and plagioclase feldspar), pyroxene, and amphibole (Prasetyo et al., 2004). The alkali feldspar groups found in the soil samples were sanidine and orthoclase. Sanidine was found in five pedons (P1, P2, P3, P4, and P6) ranged from 1-2% and found sporadic in P2 (subsoil), P3 (all layers), and P4 (topsoil and third layer) (Figure 1). The highest amount of sanidine was found in P1 and P6. Orthoclase was found in P1 (3% in topsoil and 2% in subsoil) and was found sporadic in P2, P3, P4, P5, and P6. The highest amount of orthoclase was found in P1 (Figure 1). The alkali feldspars are source of K and Na elements (Parsons & Lee, 2000).

The plagioclase feldspar groups found in the soil samples were labradorite, bytownite, andesine, and anorthite. Labradorite was found in all pedons (Figure 1). Bytownite was found in four pedons (P2, P3, P4, and P5). Andesine was found in five pedons (P1, P2, P3, P4, and P5). Anorthite was found in two pedons (P3 and P5). The plagioclase feldspar groups are rich in Ca and Na. The highest amount of labradorite, bytownite, andesine, and anorthite were found in P5 that had exchangeable Ca content ranged from 3.15-7.03 cmol kg^{-1}.

Included in the pyroxene group are augite, hypersthene, and enstatite. Augite and hypersthene were found in all pedons, yet the highest amount of augite and hypersthene was found in P4 (Figure 1). Augite is rich in Mg, Fe, and Ca while hypersthene is generally rich in Mg and Fe (Anda et al., 2012; Landeweert et al., 2001). P4 had higher Mg and Ca content than others. Their presence in the soil can be used as a source of these elements for plant growth.

Sand fraction mineral that belongs to the amphibole group is hornblende. Green hornblende was found in five pedons (P1, P2, P3, P4, and P5), yet the highest amount was found in P4. Brown hornblende was found sporadic in P4 and P5 (Figure 1). Hornblende, according to its chemical structure, is rich in elements of Ca, Na, Mg, Fe, and Al. It can be seen that Ca content in P4 and P5 were higher than others. The presence of these minerals in large quantities will have positive impact on plant growth.

The remaining three pedons contained few easily weathered minerals and were dominated by hard weathered minerals, such as opaque and quartz. It showed P1, P2, P6 already experienced the weathering process (Figure 1). Hard weathered minerals, such as opaque and quartz, cannot provide nutrient reserves for plant growth (Pramuji, 2009).

5. Conclusion

Inceptisols derived from basaltic andesite had A to Bw horizons with average thickness >120 cm. The soil color was dominated by dark brown and yellowish dark brown. Some Inceptisols contained resistant minerals such as opaque and quartz, some contained weatherable minerals such as hornblende, augite, hypersthene, and labradorite. The soil texture was clay, clay loam, and sandy loam with acidic to slightly acidic soil reactions. Generally, the topsoil had higher organic carbon than subsoil. Cation exchange capacity (CEC) of the soils was low to high. Based on the soil characteristics, the soil studied can be used for agricultural, both seasonal and annual crops. The seasonal crops in the existing land use were paddy fields and vegetable, while annual crops in the existing land use were palm oil, coffee, durian, nutmeg, cloves, and sugarcane.

Acknowledgments

This work was supported by Indonesian Centre for Agricultural Land Resource Research Development (ICALRD). We would like to thank all the soil survey team for their helpful information and fieldwork support.

Declaration of Competing Interest

The authors declare no competing financial or personal interests that may appear and influence the work reported in this paper.

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