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Characteristics of Soil Chemical Properties Associated with Inceptisols in Various Land Use in Jasinga, Bogor

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ABSTRACT

Inceptisols are soils with low to moderate fertility and have not experienced further development. This study aims to characterize the chemical properties of inclusions and base exchange fractionation of P of soil on Inceptisol soil map units of forest land, dry land, and paddy fields in Jasinga. Soil samples were taken at three horizons (Ao or Ap, AB/B1, and B/Bt) on forest soil profiles and dry land, while on paddy fields, they were taken at a depth of 0-20 cm, 20-40 cm, and 40-60 cm from the surface land. The chemical properties of the soil analyzed were soil pH, C-organic, soil bases, P-total, CEC, base saturation, and P fractionation. The results showed that the chemical properties of inclusions in the Inceptisol Jasinga soil map unit included high CEC and BS and low Mn-dd. The dominant soil inclusions are in paddy fields, followed by forests, and the lowest is in dry land. The chemical properties findings did not significantly differentiate the available inorganic P, Al-P, (Fe, Mn)-P, and (Ca, Mg)-P fractions. The inclusion of chemical characteristics did not result in a reversal of the correlation with the inorganic P fraction.

Keywords: Alfisols, inceptisols, inclusion chemistry, land use

INTRODUCTION

Inceptisol soil has low to moderate fertility and has not experienced further development (Hardjowigeno, 1993). Indonesia has an Inceptisol soil type covering an area of 70.52 million ha (37.5%) of Indonesia's plain area (Muyassir et al. 2012). Low fertility levels in Inceptisol soil are limiting factors for plant growth, including low soil pH and low P levels, so it is necessary to carry out appropriate agricultural practices to improve Inceptisol soil quality, one of which is by knowing the characteristics of Inceptisol.

According to Hardjowigeno (1993), Inceptisol is an immature soil whose profile development is weaker than mature soil and still resembles many properties of its parent material. The physical and chemical properties of soil depend on its parent material (alluvium, sedimentary material, or volcanic material), have ocric and albic epi pedons such as Entisol soil, and can also have some other characteristic properties such as cambic horizon but do not yet qualify for other soil orders. Soil Survey Staff (2014) states that the central concept of Inceptisol is soiled from cold or very hot, humid, sub-humid regions and those with cambic horizons and ocric epipedons.

Inceptisol in Jasinga, precisely in Curug Village, is Inceptisol derived from calcareous clay parent material, included in the type of Typic Eutrudepts soil with characteristics, namely good drainage, slightly fine texture, slightly acidic soil pH, medium cation exchange capacity (CEC) with high alkaline saturation (BS) (BBSDLP, 2017). The results of soil mineralogical analysis in the laboratory showed that the minerals contained in the study site consisted of vermiculite, halloysite, and gutite.

Assessment of the characteristics of the inorganic P fraction is vital for applying sustainable agriculture to different land uses, such as forests, dry lands, and rice fields in acidic soil locations such as Inceptisol. The low availability of P in the soil due to high P fixation is a significant problem encountered in acidic soils. Fractionation aims to determine the forms of the tiniest fractions of P related to Al, Fe, and Mn ions that play a specific role in the availability of P fractions in the soil so that it can be easier to handle precisely and efficiently. This study aims to characterize the chemical properties of inclusions: alkaline swapped fractionation P soil on Inceptisol soil map units of forest land, dry land, and rice fields in Jasinga. Based on the Serang Sheet Geological Map (1991), Jasinga District is included in the Bojongmanik (TMb) formation with the constituent material of the parent rock (geological formation) derived from the material of interspersing sandstone with klei, napal and limestone interspers. Differences in parent rocks certainly lead to differences in the characteristics of the soil formed.

MATERIALS AND METHODS

The study was conducted on three types of land use, namely forest at coordinate position 6°30’9.336"LS-106°25’4.68" BT, dry land at 6°30’10.12"LS-106°25’3.033" BT, rice field 6°30’11.249"LS-106°25’4.395" BT in Curug Village, Jasinga District, Bogor Regency, West Java. Soil analysis was conducted at the Laboratory of Soil Chemistry and Fertility, Department of Soil Science and Land Resources, Faculty of Agriculture, Bogor Agricultural University (IPB).

The research consists of four activities: determination of soil sampling points, soil sampling, soil sampling analysis, and data analysis. Determining soil sampling points is based on overlay procedures from soil type maps and land use maps (Figure 1). Soil samples were taken in forest, dryland, and rice field use types.

Based on the land map of Figure 1, forests, dry land, and rice fields are included in the Typic Eutrudepts land map unit. Each type of land use created three soil profiles with a distance between the 5-10 m profiles, and the number of these profiles was repeated. Each soil profile has Three disturbed soil samples according to the horizon or layer. For forest and dry land, soil samples were taken from horizons A/Ap, AB/B1, and B/Bt, while soil in rice fields soil samples were taken at 0-20 cm, 20-40 cm, and 40-60 cm. Thus, the number of disturbed soil samples taken was 27, consisting of three types of land use, three profiles, and three soil layers. The analysis of soil chemical properties performed was pH (H_2O extract), C-organic (Walkley and Black), exchangeable bases and CEC (NH_4OAc 1 N pH 7), and P-total (HCl extract 25%), P fractionation

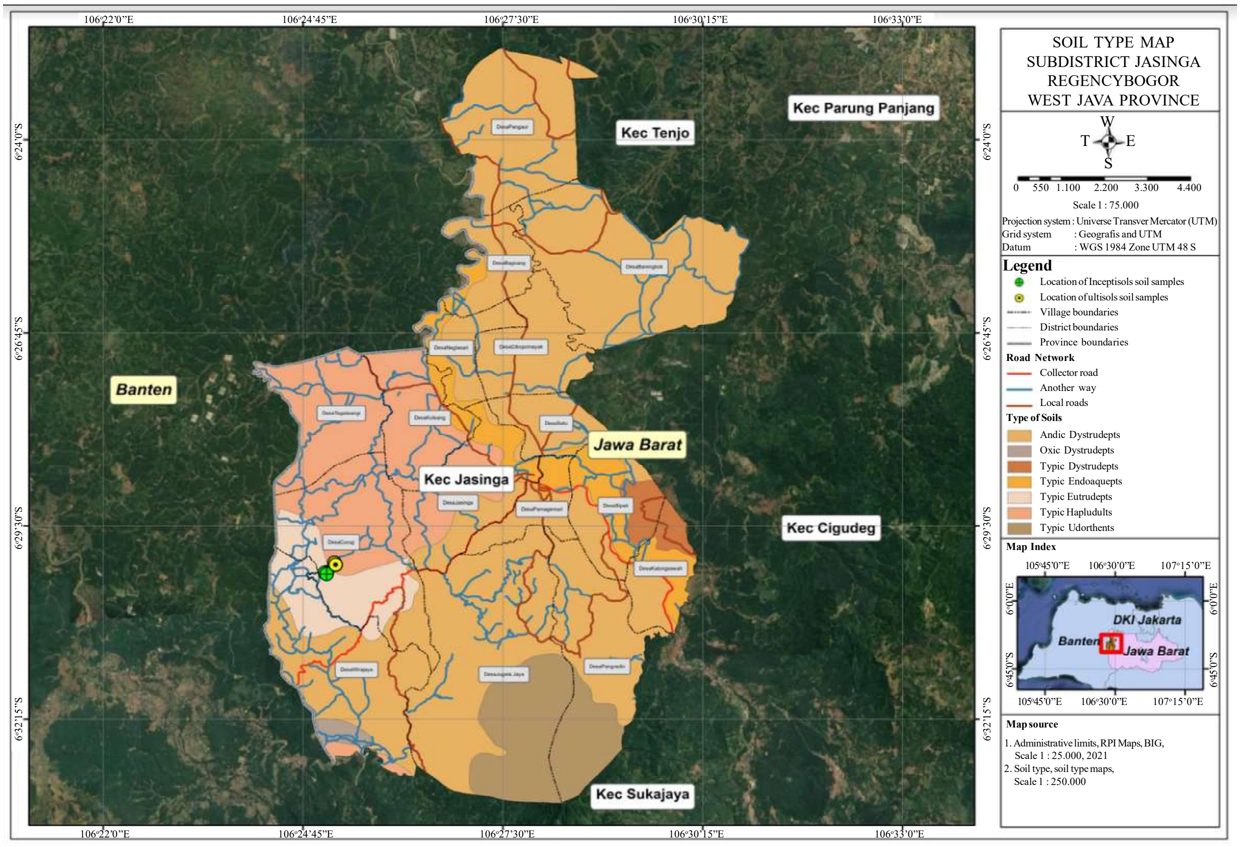

Figure 1. Location of soil sampling in Curug Village, Jasinga.

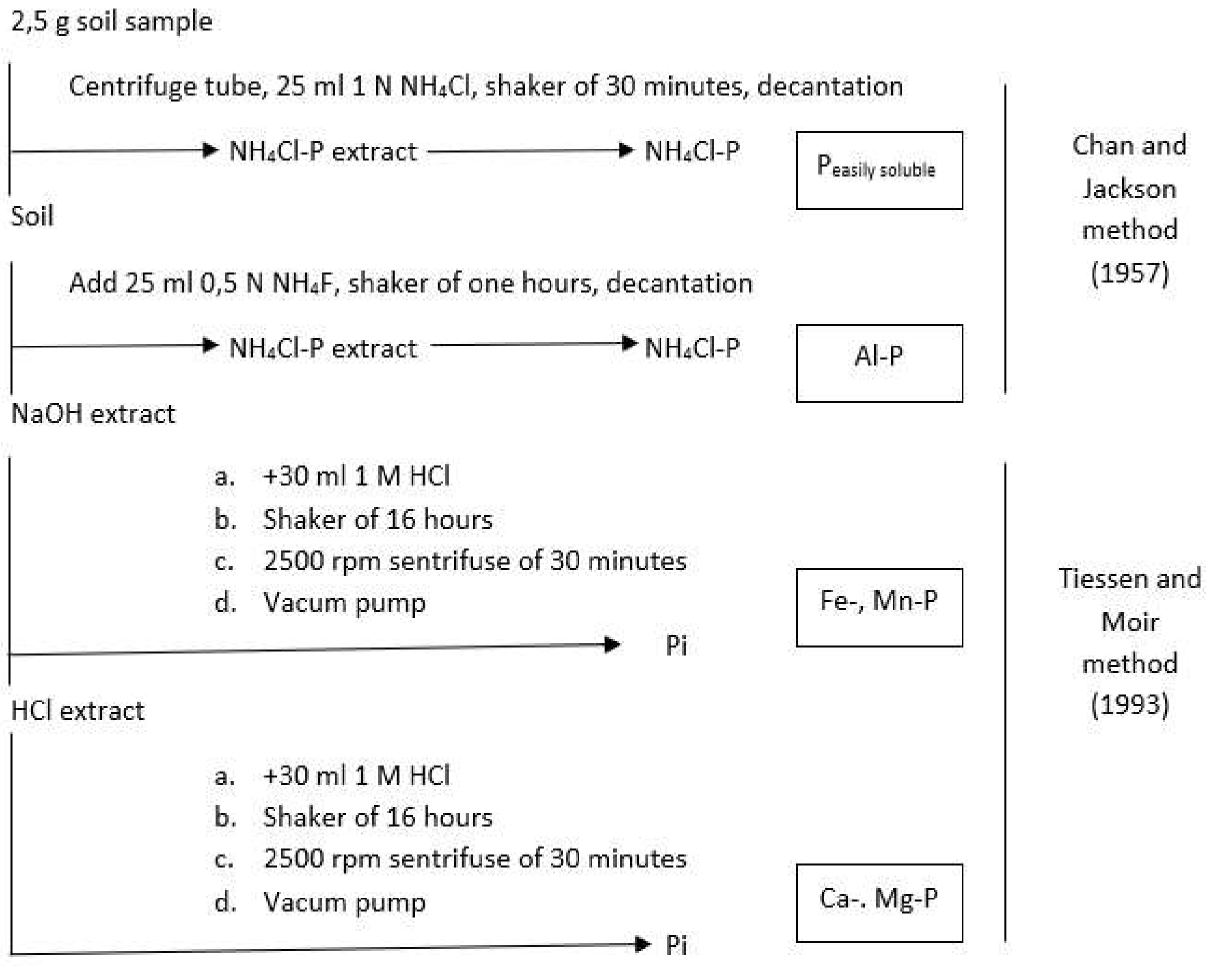

Figure 2. The combined method P fractionation procedure (Chang and Jackson 1957 with Tiessen and Moir 1993).

(combination of Chang and Jackson 1957 with Tiessen and Moir, 1993) (Figure 2). The soil chemistry data obtained were then analyzed descriptively in Tables and Graphs, and P fractions were correlated with selected soil chemical properties with Pearson correlation using SPSS 22.

RESULTS AND DISCUSSION

Soil Texture and Soil Chemistry Properties of Inceptisol from Jasinga

Based on preliminary clues of soil types at the study site, including the Typic Eutrudepts subgroup of the Inceptisol soil map unit, the results of soil classification in the field found the existence of the Typic Hapludalfts subgroup of the Alfisol soil order in the Inceptisol soil map unit, namely in forest land use so that the research location has two soil orders, namely forests including the Typic Hapludalfs subgroup (Alfisol), dry land and rice fields including the Typic Eutrudepts (Inceptisol) subgroup.

The results of soil texture analysis (Table 1) show that, generally, soil texture classes in all land uses are classified as klei textured. Based on the soil map of the study location (Figure 1), the three land uses included in the subgroups Typic Halpludalfs and Typic Eutrudepts are characterized by a smooth and relatively smooth texture with good drainage (BBSDLP, 2017). The Klei separation data in Table 1 show that the distribution of Klei particles increases at soil depth in forest and dry land use but is not patterned the same in rice fields. The increase in klei separation in forest land use and dryland gardens is thought to be due to the leaching and accumulation of klei on the subsurface horizon in forests and dry lands that occur naturally due to relatively unintensive soil management. A different thing happened in rice fields, which did not consistently show increased klei separation with soil depth. The process of tillage as a rice field, namely silt, affects the distribution of klei separation in the profile of the rice field, plus the location of the rice field located at the bottom of

Table 1. Forest soil texture, dry land, and paddy fields.

Land	Horizon	Sand		Silt	Clay
		… Texture Class (%) ...			
	A1	4.89	31.55	55.8	
Forestry 1	Bt1	8.04	36.16	63.52	Clay
	Bt2	3.61	27.6	68.79	
	A	4.53	32.02	56.99	
Forestry 2	Bt1	7.99	35.02	63.45	Clay
	Bt2	3.59	27.8	68.61	
	A	5.01	34.98	55.94	
Forestry 3	Bt1	7.97	36.09	60.01	Clay
	Bt2	3.68	26.9	69.42	
	A	8.84	29.14	55.08	
Dry Land 1	AB	9.95	34.97	62.02	Clay
	B	9.11	27.22	63.67	
	A	8.89	30.02	56.58	
Dry Land 2	AB	9.45	33.97	61.09	Clay
	B	9.09	29.06	61.85	
	A	8.83	29.19	55.07	
Dry Land 3	AB	9.92	35.01	61.09	Clay
	B	9.13	29.01	61.86	
	Ap	5.4	29.39	65.21	
Paddy Fields 1	A1	3.91	35.22	60.87	Clay
	B2	3.91	33.56	62.53	
	Ap	5.5	30.01	64.49	
Paddy Fields 2	A1	3.93	35.89	60.18	Clay
	B2	3.91	34.01	62.08	
	Ap	5.39	29.5	65.11	
Paddy Fields 3	A1	3.96	35.15	60.89	Clay
	B2	3.96	33.7	62.34	

the area, which has the opportunity to accommodate the eroded klei from the land above. Following the above soil grouping into the Inceptisol order, the development of soil profiles that appear from the increase in klei separation is still relatively weak, as Rachim and Suwardi (1999) stated.

Soil chemical properties at the study site include pH, C-organic, cation exchange capacity (CEC), base saturation (BS), Ca-dd, and Mg-dd, presented in Table 2. The general soil pH value in rice field use ranges from 4.4-6.4, including very acidic to slightly acidic; dry land and forests have a pH range of 5.0-5.8 and 5.0-56, classified as acidic to slightly acidic. The difference in pH range between rice fields and non-paddy land use can be attributed to the weaving process. The increase in pH in acidic soils due to inundation is controlled by the Fe^{2+}-$Fe(OH)_3$ system where H^+ consumption occurs. This picture is especially seen in the soil layer of rice fields at a depth of 0-20 cm, which undergoes intensive treatment in the washing process.

Soil C-organic levels generally decrease with soil depth with a range of values of 0.6-2.5% on forest land, classified as very low-medium, 0.8-2.3% on dry land, classified as very low-low and 0.2-1.2% on rice fields classified as very low to low. The level of land management affects organic matter, so generally, the sequence level of C-organic levels is rice fields < dry land < forest land. C-organic levels in forests are thought to be due to higher levels of vegetation diversity and density compared to dry land and rice fields, so they have a higher supply of organic matter from the ground cover. Dryland gets organic matter donations from crop residues and organic fertilizer. In contrast, in rice fields, the source of organic matter comes from root biomass residues, straw buried in rice field maps, and organic fertilizer application by farmers.

Table 2. The chemical properties of the selected soils on the profile of forest land, dry land, and paddy fields.

Soil Type	Land	Horizon	pH	C-org	CEC	BS	Ca-dd	Mg-dd
				%	me 100 g^{-1}	%	me 100 g^{-1}	
Alfisol (*Typic Hapludalfts*)	Forest 1	A1	5.2 A	1.1 L	73.9 VH	80.3 VH	5.1 R	53.6 VH
		Bt1	5.4 A	0.8 VL	53.7 VH	71.1 H	3.8 R	34.1 VH
		BH2	5.3 A	0.6 VL	43.5 VH	92.8 VH	4.3 R	35.7 VH
	ForesH 2	A1	5.1 A	2.5 L	54.9 VH	104.6 VH	6.5 M	50.2 VH
		BH1	5.6 MA	1.4 L	55.7 VH	105 VH	5.5 M	52.1 VH
		BH2	5.7 MA	0.8 VL	43.9 VH	102 VH	4.4 R	39.2 VH
	ForesH 3	A	5.0 A	1.1 L	49.0 VH	84.2 VH	7.7 M	32.5 VH
		BH1	5.2 A	0.7 VL	62.8 VH	92.3 VH	9.3 M	47.5 VH
		BH2	5.5 A	0.7 VL	58.1 VH	103.4 VH	8.8 M	50.2 VH
IncepHisol (*Hypic EuHrudepHs*)	Dry Land 1	A	5.3 A	1.0 VL	62.8 VH	43.3 M	15.7 H	11.1 VH
		AB	5.6 MA	1.4 L	40.1 VH	70.1 H	18.5 H	9.3 VH
		B	5.7 MA	0.8 VL	41.5 VH	73.5 H	17.3 H	12.6 VH
	Dry Land 2	A	5.0 A	2.3 M	51.4 VH	84.4 VH	18.4 H	24.2 VH
		AB	5.2 MA	0.9 VL	62.0 VH	105.9 VH	29.2 H	35.8 VH
		B	5.6 A	0.2 VL	62.8 VH	104.2 VH	39.6 H	25.2 VH
	Dry Land 3	A	5.2 MA	2.0 L	50.6 VH	101.5 VH	9.8 R	40.7 VH
		AB	5.8 MA	1.6 L	50.4 VH	103.1 VH	10.4 M	40.6 VH
		B	5.6 MA	0.9 VL	56.1 VH	108.9 VH	11.7 H	47.7 VH
IncepHisol (*Hypic EuHrudepHs*)	Paddy Land 1	Ap	6.1 MA	1.2 L	41.5 VH	109.2 VH	21.9 VH	22.8 VH
		A1	6.2 MA	0.2 VL	47.8 VH	121.1 VH	26.3 VH	30.9 VH
		B2	6.4 MA	0.5 VL	61.6 VH	97.0 VH	26.6 VH	32.4 VH
	Paddy Land 2	Ap	5.4 A	1.2 L	41.1 VH	50.7 M	10.1 M	22.0 VH
		A1	4.6 A	0.5 VL	60.0 VH	42.8 M	9.9 M	14.8 VH
		B2	4.4 A	0.6 VL	54.9 VH	51.3 M	11.2 H	16.3 VH
	Paddy Land 3	Ap	5.8 SA	1.2 L	51.0 VH	102.9 VH	27.6 VH	23.7 VH
		A1	5.7SA	0.4 VL	48.2 VH	101.1 VH	24.3 VH	23.4 VH
		B2	4.7A	0.5 VL	49.4 VH	86.6 VH	19.2 H	22.7 VH

Description: VL=very low, L=low, M=medium, H=high, VH=very high, VA=very acid, SA = slightly acid, A = acid

The value of soil CEC in all land uses is classified as very high criteria in the order; namely, forests ranging from 43.5 me 100 g^{-1} - 73.9 me 100 g^{-1}, dry land with a range of 40.1 me 100 g^{-1} - 62.8 me 100 g^{-1} and rice fields with a range of 41.1 me 100 g^{-1} - 61.6 me 100 g^{-1}. High soil CEC values are rarely found in general Inceptisol at this study site. The highest soil CEC yields are found in forest land use. According to Muklhlis et al., (2011), the main determinants of CEC value are soil texture, organic matter, and type of klei minerals. Of these three factors, the texture factor supports the chance of high CEC values; however, organic matter levels are not, so it is suspected that high CEC values are more related to the type of clay minerals found at the study site.

The alkaline saturation value (BS) of the soil at the study site is classified as medium - very high criteria. KB values of paddy field, dry land, and forest use were 42.8-121.1%, 43.3-108.9%, and 71.1-105%, respectively. It is generally known that when the KB value is very high, even above 100%, many soil cations form compounds with carbonate anions or other anions outside the soil exchange complex. The value of soil BS also differs from the general characteristics of soils around the study site.

Chemical Characteristics of Inclusions of Interchangeable Cations Inceptisol from Jasinga

The cation-cation levels can be exchanged in Table 2, showing that in general, soil Ca-dd levels

Table 3. Distribution of concentrations and percentages of inorganic P in forest use profile, dry land, and paddy fields.

Soil type	Land	Horizon	P readily available	P slowly available			P Not available		P Total	
			$P_{easily\ available}$	Al-P	(Fe. An)-P	(Ca. Ag)-P	P Residual			
			ppm					%	ppm	%
		A1	0.09	0.7	0.44	0.83	252.87	99.19	254.9	100
	Forest 1	BH1	0.08	0.66	0.52	0.75	209.78	99.05	211.8	100
		BH2	0.1	0.61	0.56	0.74	325.48	99.34	327.6	100
		A1	0.13	0.59	0.25	0.38	269.61	99.32	271.5	100
Alfisol (*Hypic HapludalfHs*)	Forest 2	BH1	0.13	0.36	0.21	0.32	231.09	99.23	232.9	100
		BH2	0.14	0.51	0.23	0.21	233.22	99.15	235.2	100
		A	0.15	0.23	0.31	0.72	272.65	99.26	274.7	100
	Forest 3	BH1	0.15	0.7	0.47	0.67	212.21	99.07	214.2	100
		BH2	0.12	0.7	0.44	0.63	209.25	99.07	211.2	100
		A	0.12	0.77	0.28	0.93	112.85	98.34	114.8	100
	Dry Land 1	AB	0.13	0.76	0.34	0.62	104.8	98.26	106.7	100
		B	0.14	0.79	0.36	0.79	99.84	97.95	101.9	100
		A	0.13	0.59	0.53	0.87	105.68	97.93	107.9	100
IncepHisol (*Hypic EuHrudepHs*)	Dry Land 2	AB	0.13	0.66	0.55	0.76	978.9	99.79	980.9	100
		B	0.14	0.71	0.52	0.83	948.18	99.77	950.4	100
		A	0.14	0.61	0.42	0.88	106.79	98.11	108.8	100
	Dry Land 3	AB	0.13	0.7	0.46	0.80	178.12	98.85	180.2	100
		B	0.16	0.71	0.49	0.87	198.58	98.89	200.8	100
		Ap	0.12	0.32	0.99	1.16	105.06	97.59	107.7	100
	Paddy Land 1	A1	0.17	0.35	0.65	0.72	191.98	99.02	193.9	100
		B2	0.21	0.39	0.87	1.00	242.89	98.99	245.4	100
		Ap	0.11	0.79	0.46	0.97	238.21	99.17	240.2	100
IncepHisol (Hypic EuHrudepHs)	Paddy Land 2	A1	0.17	0.46	0.5	0.37	210.82	99.29	212.3	100
		B2	0.34	0.44	0.67	0.24	221.49	99.24	223.2	100
		Ap	0.18	0.44	0.76	1.19	212.21	98.8	214.8	100
	Paddy Land 3	A1	0.2	0.44	0.85	1.2	107.97	97.57	110.7	100
		B2	0.36	0.46	0.91	1.11	121.82	97.73	124.7	100

from high to low are sequentially rice fields with a range of 9.9-27.6 me 100 g^{-1} (medium-very high), dryland with a range of 9.8-39.6 me100 g^{-1} (low-high) and forests with a range of 3.8-9.3 me 100 g^{-1} (low-medium). Soil Mg-dd levels sequentially from high to low are forest land use with a value range of 32.5-53.6 me 100 g^{-1}, dry land with a range of 9.3-47.7 me 100 g^{-1}, and rice fields with a range of 14.8-32.4 me 100 g^{-1} which are respectively classified as high and very high.

The analysis results of alkaline cations can be exchanged, showing uniqueness at the study site where soil Mg-dd levels are higher than soil Ca-dd levels. High levels of soil Mg-dd, according to Gao et al., (2015) and Gransee and Fuhrs et al., (2013), are influenced by the type of parent material, fixation, erosion, leaching Mg, soil pH, soil moisture, high NPK fertilizer use, and other management activities. The high levels of Mg-dd at the research site came from ultra basalt parent material, which contains a lot of Mg which is thought to come from dolomite limestone; the process of the existence of the parent material is thought to come from the process of parent rock intrusion (breakthrough rock) at the research site (Sukarman July 14, 2022, personal communication).

High levels of Ca-dd Mg-dd at the study site showed a tendency to the characteristics of Alfisol at the study site. Hardjowigeno (1993) suggests that Alfisol soil is generally reasonably fertile, indicated by high soil Ca-dd, Mg-dd, and CEC values. The results of Campbell and Edmonds' (1984) research

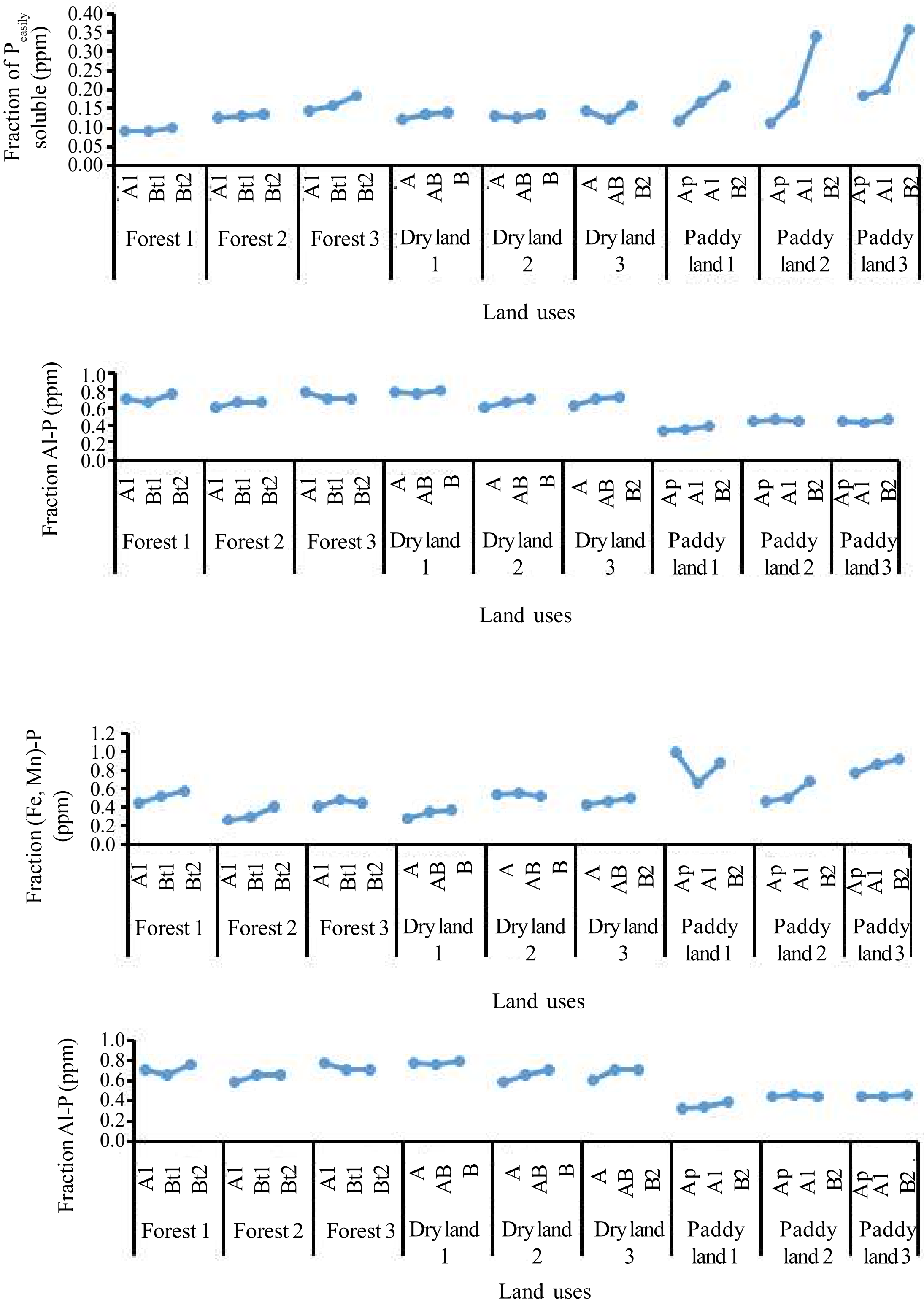

Figure 3. Concentration of the inorganic P fraction in forest and land use profiles dry and paddy.

showed the diversity of soils formed from the Roman formations at nine sites; four locations had the order Entisol, while the other locations found Ultisol, Inceptisol, and Alfisol only within a distance of only seven meters, found a high pedological diversity at very short distances.

Inorganic P Fraction of Forest, Dry Land, and Rice Fields in Inceptisol of Jasinga

The concentration of inorganic P fraction in forest, dryland, and rice field use is shown in Figure 3. The distribution of concentration and percentage of inorganic P in forest, dryland, and paddy use is described in Table 3. The soil P grouping in this study is based on several fractions, namely the soluble Peasily fraction (NH_4Cl extract) is a form of a rapidly available fraction, Al-P fraction (NH4F extract), fraction (Fe, Mn)-P (NaOH extract) and fraction (Ca, Mg)-P (HCl extract) is a form of slow fraction available. The total fractions Al-P and (Fe, Mn)-P in Table 4 characterize very acidic soils, while the (Ca, Mg)-P fractions characterize slightly alkaline to alkaline soils. The residual-P fraction is obtained from a 25% reduction in HCl-extracted P with the number of fast P fractions and slow P available.

Table 3 shows that, in general, the total P concentration in soil is very high in all land uses in order of forest land use with values of 211.21-327.64 ppm, rice fields 0.66-245.37 ppm, and dry land 9.36-200.81ppm. The total P distribution pattern generally varies with soil depth. The highest generally highest P fraction of unavailable soil (P residual) is shown in the use of dry land 99.84-948.18 ppm, forests with values of 209.25-325.48 ppm, and rice fields with values ranging from 105.06-242.89 ppm. The distribution pattern of the P fraction not available varies with soil depth in all land uses. In general, the concentration of the rapidly available (easily soluble) P fraction of soil is very low compared to the slowly available fraction (Al-P, (Fe, Mn)-P and (Ca, Mg)-P) and the residual-P fraction in all land uses.

Generally, the fast P fraction available in all land uses is very low in rice fields in the range of 0.12-0.36 ppm, forest land of 0.09-0.18 ppm, and dry land of 0.12-0.16 ppm. Figure 4 shows the distribution pattern of the generally soluble P fraction increasing at soil depth in all land uses. The high concentration of soluble Pmudah in rice fields is thought to be influenced by the content of organic matter, and the high pH value (Table 2), as well as the distribution pattern of the soluble Pmudah fraction, is also in line with the distribution of soil pH increases with soil depth. Wierzbowska et al., (2020) added that the concentration of soluble Pmudah fraction positively correlates with soil CEC and soil P-total.

A slow P fraction of Al-P, (Fe, Mn)-P, and (Ca, Mg)-P fractions are available. Generally, the highest Al-P fraction is found in forest and dry land with a range between 0.59-0.79 ppm and rice fields ranging from 0.32-0.46 ppm. The high concentration of Al-P fraction in the forest profile is thought to be due to the binding of P elements by Al. In general, the concentration of Al-P fraction in forest and dryland land use is higher than in paddy fields, and forest distribution patterns vary, while dryland and rice fields tend to increase with depth (Figure 3). It shows that different land management, namely natural land (forest), less intensive management (dry land, and intensive land management (rice fields), affect the concentration and distribution pattern of P fraction in the soil at the study site.

The highest concentrations of fractions (Fe, Mn)-P were found in rice fields with a value range of 0.46-0.99 ppm, forest lands ranging from 0.25-0.26, and dry lands with a range of 0.28-0.55 ppm (Figure 3). The distribution pattern of fractions (Fe, Mn)-P generally increases with soil depth. The transformation of P by pedogenesis begins with the Ca-P fraction as the dominant main mineral. The P released during the weathering process turns into rapidly available P, including soil organic matter, and then into slowly available P bound to Al and Fe hydrous oxides so that the Al-P and Fe-P fractions become the primary forms in soils that have undergone advanced weathering commonly found in the tropics (Nishigaki et al., 2018).

Rice fields have the highest fraction value (Ca, Mg)-P with a range of 0.24-1.19 ppm, dry land ranges from 0.62-0.97 ppm, and forests range from 0.63-0.88 ppm. The general distribution pattern of fractions (Ca, Mg)-P varies with soil depth in all forms of land use (Figure 4). The high concentration of fractions (Ca, Mg)-P in rice fields can be attributed to the accumulation of Ca in rice fields due to leaching Ca from surrounding fields and the weaving process. (Table 3). Figure 3 shows that the pattern of fraction distribution (Ca, Mg)-P varies with soil depth; in all land uses, there is a high buildup of (Ca, Mg)-P fractions on the upper ground horizon.

In general, based on Table 3, the concentration of slow P fractions available is dominated by fractions (Ca, Mg)-P > Al-P > (Fe, Mn)-P. This result is supported by high pH, KTK, KB, and Mg-dd values in rice fields and forest land use (Table 2). The high slow P fraction available in fractions (Ca, Mg)-P indicates that P in soil solution is rapidly bound by Ca and large amounts of Mg form (Ca, Mg)-P. According to Nishigaki et al., (2018), the fraction (Ca, Mg)-P in the soil is characteristic of young soil where the primary P source comes directly from the parent material, mineral apatite. The higher concentration of fractions (Ca, Mg)-P compared to other P fractions at the study site strengthened the assumption of finding soil inclusion chemistry at the study site.

CONCLUSIONS

The chemical characteristics of inclusions in the Inceptisol Jasinga soil map unit include high CEC and KB, higher Mg-dd than low Ca-dd. Inclusion is dominant in rice fields, followed by forests, and lowest in dry land. These chemical inclusion characteristics do not provide significant differences in the inorganic fractions of soluble Peasily, Al-P, (Fe, Mn)-P, and (Ca, Mg)-P. Inclusions of chemical characteristics do not result in the reversal of their correlation with inorganic P fractions.

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