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THE STATUS OF SOIL PHOSPHORUS AT DIFFERENT CROPPING SYSTEM IN PANGALENGAN, SOUTH BANDUNG

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ABSTRACT

The fixation of P in soils is dynamic in nature and the behavior of P-fraction may change with time and cropping system. Application of organic matter to soil under upland soil have been reported to decrease P-sorption and increase P-desorpion. Pangalengan, South Bandung in west Java is one of the wet humid area of Indonesia that has high rain fall, covered mainly by tropical humid forest, volcanic area with fertile volcanic soil. The objective of this study were to describe and compare some chemical characteristic and behavior of P-fraction as a function of crops and slope of the land in the farming system in Pangalengan, South Bandung, West Java, Indonesia. Soil samples from the surface soil (0-20 cm) were collected from 15 locations based on different planted crops (Tea, Vegetables, Forest, and Intercropping crops), and level of slope of the land areas of Cihawuk village, District Kertasari, Kecamatan Pangalengan. The result of the study showed that C-organic content of soil samples from 15 location of planted crops was slightly high (3.04-4.92 %) but total Nitrogen was low (0.22-0.45 %), wih soil reaction (pH H_2O) was slightly acids (5.60-6.30) and pH (KCl) was lower than pH(H_2O) (4.60-5.70). The available-P was low (3.50 – 7.10 ppm), but the HCl 25 % P from tea and vegetables location was higher than from forest and intercropping crops. Majority of P fraction from tea and vegetable location was Al-P fraction, but from Forest and intercropping crops was Ca-P fraction. The order of P fraction were Al-P > Ca-P> reductant soluble-P>Fe-P in tea and vegetables locations, but in the forest and intercropping were Ca-P> reductant-P > Al-P > Fe-P. However, The data showed that the total P (P-organic + P-inorganic) from tea and vegetables crop location was higher, and was dominated by inorganic form, than from forest and intercropping location was dominated by organic form. However, the slope did not affect the pattern of P-fractions and the sources of organic matter added or accumulated in those location formerly affected the amount and the pattern of P-fractions.

Keyword: Amorphous compound/allophane, organic mater, P-fractions, slope.

INTRODUCTION

In Indonesia, the Andisol soil occurs extensively in the upland foot slopes of volcanoes or former volcanoes in Sumatra, Java, Sulawesi, and Papua. It is one the important soil groups that contributes to Indonesia's economic growth. This soil is suitable for industrial and horticultural crops (e.g. rubber, tea, oil palm, and vegetables). However, the soil fertility problem of these volcanic ash soils are related to their being dominated by amorphous hydrated oxide especially allophane. Allophane is an amorphous compound, and it has high fixing capacity for phosphorus (P). Of all components in acid or neutral soils, amorphous Al hydroxides and Fe oxide (that is hydroxy polymers of Al and Fe) are very highly adsorptive for P, and reaction is rapid. Iyamuremye *et al*. (1996a) also stated that phosphorus (P) is relatively unavailable for plant uptake in highly weathered soil (Ultisol and Oxisol) and in volcanic soil with high amount of amorphous compound. Soluble P may be strongly adsorbed on the surface of Fe and Al oxides or precipitated as Al and Fe phosphate minerals

Pangalengan, South Bandung in west Java is one of the wet humid area of Indonesia that has high rain fall, covered mainly by tropical humid forest, volcanic area with fertile volcanic soil. However, in humid tropical areas, this volcanic ash soils are often associated within chronosequences where different soil types may coexist over short distances, following the weathering sequences: primary minerals-allophane-halloysite-kaolinite (Parfitt *et al*. 1983). The sequential diversity of these soils lead to striking differences in physic-chemical characteristics that are important for their fertility management, e.g. their charge and ion retention properties which chiefly govern.

Deforestation in the tropical regions has long been considered to lead to the degradation of the soil properties determining soil fertility. Steiner (1996) stated that bio-physical and socio-economic are one of the problems that causes of soil degradation. The main reasons for soil erosion and chemical soil degradation are agricultural mismanagement, overgrazing, and deforestation. Chemical characteristics of the soil, particularly, soil phosphorus (P), is one of the important soil properties determining soil fertility that is considered might be greatly affected by forest clearing and its conversion to other land uses.

The fixation of P in soils is dynamic in nature and the system may change with time. Since all phases of P fixation are due to the attraction between phosphate and Al (or Fe), the difference in reaction rate can be attributed to the difference in readiness of Al or Fe available for reaction. Moreover, soil minerals may be decomposed during aging and provide more reactive Al and Fe to the system, thereby fixing more P. Most of the available mineral P came from Al sites. Aluminum phosphate, being more soluble, are gradually transformed into Fe-P. In Allophanic families, fixation is primarily in the form of Al-P because of the high content of Al oxide and the low content of Fe oxides in acid Andepts.

Soil organic matter has been suggested as the most important indicator of soil quality and productivity (Doran and Parkins, 1996). The changes of soil organic matter are usually assessed by comparing site subjected to specific agricultural practices with reference site, such as a native forest or grassland. Although soil organic matter is recognized as a critical component of soil quality, comparing of the masses of organic C and N may not provide an adequate assessment of the important changes that occur in the soil organic matter (Wander *et al.* , 1994). Nevertheless, soil organic matter content can be used as a coarse measure of soil quality, because high level usually show good correlations with other desirable attribute of soil, such as high level of microbial biomass, available plant nutrients, and good soil structure. Related with P availability, organic and/or inorganic anion can compete with orthophosphate for the adsorbing sites, the presence in the soil, in turn, increase P availability (Appelt *et al.,* 1975; Deb and Datta, 1967).

Phosphorus dynamic in soils are also complex. Both organic and inorganic are important, and the exchange between these pools is affected by chemical, physical, and biological factors (Back and Sanchez, 1994). Chang and Jackson (1957) developed a fractionation method, which separate inorganic P pools into aluminum (Al)-, iron (Fe)-, and calcium (Ca)-bound P, respectively. Then, Petersen and Corey (1966) modified their method and fractionated/ separated the inorganic fraction as Aluminum phosphate (Al-P), Iron phosphate (Fe-P), reductant soluble phosphate, and calcium phosphate (Ca-P). Duffera and Robarge (1999) studied that soils from the highland plateau region of Ethiopia under different management practices have different capacities to retain P and therefore require different levels of P fertilization. Djuniwati (1992) studied on the Podzolic and Andisol soil of Lampung, South Sumatra Indonesia, and showed that the majority of the P-fraction in both soils was in the form of Fe-P. The order of P-fraction were Fe-P > Ca-P > Al-P in Podzolic and Fe-P > Al-P > Ca-P in Andisol. However, Not only inorganic P, but also organic P may be fixed in soils by formation of insoluble Al and Fe complexes (Gunjigake and Wada, 1981), and Andisol usually contain large amounts of organic P, as much as 80% of the total P content in the organic form in some cases (Kosaka and Abe, 1957).

Since soil formed in Pangalengan, South Bandung is dominated by Andisol and the area covered by tropical humid forest, secondary forest and agricultural land (vegetables crops), therefore, P supply is might be one of the factors limiting crop production. The objective of this study were to describe and compare some chemical characteristic and status of P-fraction as a function of crops and slope of the land in the farming system in Pangalengan, South Bandung.

MATERIAL AND METHODS

This study was conducted from Januari-Mei 2006**.** Soil samples from the surface soil (0-20 cm) compositely were collected from 15 locations based on different planted crops and level of slope of the land areas of Cihawuk village, District Kertasari, Kecamatan Pangalengan, South Bandung, West Java, Indonesia. Analysis of some chemical characteristic and P-fractions of soil samples were conducted in the Laboratory of Soil Chemistry and Fertility, Department of Soil Science and Land Resource, Faculty of Agriculture, Bogor Agriculture University, Indonesia on February - March 2006, and in Laboratory of College of Bio-resource Sciences, Nihon University, Japan on April 21 to Mei 20, 2006.

The landform of the study area is dominated by undulating to hilly landform. The area of the villages surrounding the forest and are located ranging between 1400 to 1600 m above mean sea level (AMSL), and the level of slope in the range of 3 to 31^0. For every crop of planted at every location, the soil was sampled compositely at the depth of 0 – 20 cm (top soil), after taking off the litter layer. Fifteen (15) soils sampling collected from different planted crops were consisted of :

1) Tea, foot slope, 14^0 and 1150 m above mean sea level (AMSL)
2) Tea, middle slope, 22^0 and 1400 m AMSL
3) Carrot, foot slope
4) Grasses, foot slope
5) Cabbage, top slope, 26^0 and 1410 m AMSL
6) Cabbage, middle slope, 0 – 3^0 and 1420 AMSL
7) Carrot, top slope, 0 – 3^0 and 1420 AMSL
8) Tea, top slope, 0 – 3^0 and 1420 m AMSL
9) Carrot, middle slope of 26^0 and 1410 m AMSL
10) Forest (Rasamala)
11) Intercropping, foot slope, 0 – 3^0 and 1530 m AMSL
12) Intercropping, middle slope, 28^0 and 1580 m AMSL
13) Intercropping, top slope, 31^0 and 1600 m AMSL
14) Secondary forest, foot slope, 28^0 and 1580 m AMSL
15) Secondary forests, middle slope, 30^0 and 1600 m AMSL

Analyses of some soil chemistry characteristics and P-fractions. The soil samples were air dried and ground to pass a 2 mm sieve. The soil characteristic was analyzed were pH was determined in water (soil : water 1: 2) and in 1 N KCl, Carbon content by Walkey and Black, total N (Kjeldahl), total P (1 N HCl), available-P (Bray 1). Inorganic P-fraction was analyzed by the method Peterson and Corey (1966). In this method P fraction are separated P by continues extractant i.e. easily soluble P (soluble in 1 N NH_4Cl), aluminum phosphate (Al-P) (soluble in 0.5 N NH_4F, pH 8.2), iron phosphate (Fe-P) (soluble in 0.1 N NaOH), reductant soluble P (soluble in 0.3 M $Na_3C_6H_5O_7$. 2 H_2O and $Na_2S_2O_4$), and calcium phosphate (Ca-P) (soluble in 0.5 N H_2SO_4).

Phosphorus-organic and inorganic fraction were determined by Tan (1996) method. The organic P content was determined by extraction before and after ignition. Inorganic P was extracted from samples before ignition and total P was extracted from ignited samples. The difference between total P (ignited) and inorganic P (non-ignited) was organic P.

RESULT AND DISCUSSION

Table 1. showed some chemical characteristics of soil samples from 15 location of planted crops. The content of C-organic of soil samples from 15 location of planted crops fluctuated but the amount was slightly high (3.04 - 4.92 %), and the soil reaction (pH H_2O) mostly is weekly acid and in the range of 5.60 to 6.30, and the pH KCl is in the range of 4.60 to 5.70. The lower the pH KCl than pH H_2O indicated that the soil carries a net negative charges (Sanchez, 1976). The content of available-P of soil samples are mostly low (3.50-7.10 ppm), its may be due to high P fixation capacity of this soil. Iyamuremye *et al.* (1996c) explained that chemical fixation of P in soil is due to the ability of some soil compound, such as allophanic material, clay minerals, and Al and Fe oxides and hydrous oxides. Nevertheless, there was no relation between available-P content in soil samples and any pH. However, total P (HCl) as inorganic P of soil samples from tea and vegetables crops (cabbage and carrot) was higher than from forest and intercropping location. Possibly due to continuously additional of organic matter (manure and/or animal waste) by the farmer before planting of vegetables or due to accumulation of organic residue of plants on the soil surfaces during long term plant growth, its released ion P in soil solution and P was rapidly fixed by Al and Fe oxide/hydroxide. The high of organic matter was indicated by the carbon organic of soil samples was in the range of slightly high, but total N of 15 soil samples was low because nitrogen is the highest amount of nutrient uptake by plants and is easily leached in soils.

Table 1. Some chemical characteristics of 15 soil sample from the areas of different planted crops and slope of the land on the cropping system in Cihawuk, Pangalengan, south Bandung.

No	Planted Crops	pH		C-org (%)	N-total (%)	P ….. ppm ….	
		H_2O	KCl			BrayI	HCl 25%
1	Tea, foot slope 14^0	5.60	4.60	3.62	0.27	5.40	627,20
2	Tea, midlle slope 22^0	6.20	5.00	4.05	0.33	6.30	528.70
3	Carrot, foot slope 26^0	6.30	5.10	3.70	0.22	4.00	476.20
4	Grasses, foot slope 26^0	6.30	5.40	3.09	0.45	4.10	556.60
5	Cabbage, midlle slope of 26^0	5.90	5.10	3.27	0.25	7.10	607.50
6	Cabbage, upper slope $0\text{-}3^0$	6.00	5.00	3.60	0.30	3.60	901.40
7	Carrot, upper slope $0\text{-}3^0$	5.80	4.90	3.96	0.32	3.80	740.50
8	Tea, upper slope $0\text{-}3^0$	5.70	4.60	4.30	0.29	4.10	960.60
9	Carrote, midle slope 26^0	6.20	5.00	3.73	0.30	5.70	689.60
10	Forest, Rasamala,	5.90	5.00	3.04	0.22	3.60	239.70
11	Intercropping, lower slope $0\text{-}3^0$	5.80	5.70	3.77	0.25	3.80	303.80
12	Intercropping middle slope 28^0	5.90	5.00	4.28	0.30	4.70	229.90
13	Intercropping, upper slope	6.20	4.90	4.46	0.31	4.00	208.50
14	Secondary forest	6.00	4.70	4.92	0.36	3.50	259.40
15	Secondary forest	6.30	5.20	4.09	0.27	3.60	229.90

Table 2 showed that the phosphorus fraction in the 9 soil samples i.e. from location of tea and vegetables plants (cabbage and carrot) was dominated by Al-P and are followed by Ca-P, reductant soluble P, and Fe-P, respectively. The other 6 soil samples from location were planted by forest and intercropping plants were dominated by Ca-P, and followed by reductant soluble P, Al-P, and Fe-P, respectively. Generally, however, the amount of P-fractions (Ca-P, Fe-P, and Al-P) from location of forest and intercropping are lower than from tea and vegetables locations. Its related and indicated by the higher the total P (HCl) and/or by total P (P-organic + P-inorganic) in location of tea and vegetables plants.

The higher of the Al-P, Fe-P, and mostly reductant soluble-P and Ca-P fraction related with the higher of the total P (HCl) or P-inorganic of the soil samples from location of tea and vegetables plants, presumably due to organic matter in those location have been highly decomposed, therefore the release of P from organic matter or solubility of P due to organic acids from soil-P was rapidly fixed to form inorganic P. Organic acids, such as citric acid effectively increase the availability of previously bound P (Kafkafi *et al*. 1988). Furthermore, Deb and Datta (1967) explained that complexion of solution Fe or Al may occur by ionic bonding to organic ligands, resulting in reduced P-fixation. However, if a concentration of organic ligands insufficient for complexion reactions exists in the solution, amorphous precipitates, such as $Al(OH)_2H_2PO_4$ can be formed. Otherwise, in forest and intercropping location, the source of organic matter mostly from plants residue, the rate of decomposition and mineralization of organic residue might be slower than manure or animal waste, then P that was released also in slower and lower concentration, therefore P in those soil still be held as organic P. Its indicated by the value of C-organic and P-organic of soil samples from forest and intercropping mostly higher than from tea and vegetables crops. The forest and intercropping location, therefore, was dominated by Ca-P due to high C-content in those areas.

Table 2. Phosphorus fraction of 15 soil sample from the areas of different planted crops and slope of the land on the cropping system in Cihawuk, Pangalengan, south Bandung.

No	**Planted crops**	**Easily soluble P**	**Al-P**	**Fe-P**	**Reductant soluble P**	**Ca-P**	**P-Organic**	**P-Inorganic**
		………. … …..…………………………			ppm	….……………………………………..		
1	Tea, lower slope 14^0	5.90	610.46	100.95	239.27	223.43	294.39	1128.11
2	Tea, middle slope 22^0	1.60	462.62	101.02	288.70	258.85	240.03	965.48
3	Carrot, lower slope 26^0	1.09	476.35	75.63	227.00	422.35	354.21	866.89
4	Grasses, lower slope 26^0	0.67	597.90	75.25	300.77	433.25	240.14	992.14
5	Cabbage, midlle slope 26^0	2.24	595.78	65.61	258.20	340.60	71.15	1287.68
6	Cabbage, upper slope $0\text{-}3^0$	1.57	859.10	77.16	294.63	468.68	384.66	1584.97
7	Carrote, upper slope $0\text{-}3^0$	2.07	782.35	62.24	287.77	381.48	250.75	1200.38
8	Tea, upper slope $0\text{-}3^0$	1.50	823.95	62.64	296.60	356.95	1078.9	1039.79
9	Carrote, middle slope 26^0	0.72	640.07	78.21	312.48	384.20	346.10	1239.92
10	Forest, Rasamala,	0.69	98.71	85.51	256.01	321.53	573.09	327.90
11	Intercropping, lower slope $0\text{-}3^0$	1.20	272.39	53.86	272.45	337.88	792.74	455.66
12	Intercropping middle slope 28^0	1.57	205.91	49.46	212.00	267.03	612.06	341.59
13	Intercropping, upper slope	4.06	179.81	43.60	193.16	237.05	517.94	266.38
14	Secondary forest	3.61	190.97	32.94	218.50	299.73	529.77	586.77
15	Secondary forest	2.13	213.41	35.28	199.93	283.38	625.07	338.37

Organic matter contains metal such as Ca and/or Mg which may be mineralized from organic amendments and Ca may form soluble complexes with P in the soil solution, thus preventing P from being fixed by Al or Fe (Iyamuremye *et al.*, 1996 a). Iron-P (Fe-P) is the lowest amount in all soil samples, there are some possible mechanisms that Fe-P is lower: 1) Fe reacting with organic compounds mineralized from organic matter, and 2) dissolution of mineral P phases (Iyamuremye *et al.*, 1996b), or 3) the content of Fe oxide in this soil is actually low. In Allophanic families, fixation is primarily in the form of Al-P because of the high content of Al oxide and the low content of Fe oxides in acid Andepts.

Apparently, P-fraction among the slope was no significantly different, and the pattern of P-fraction among the slope at the same crop also did not show differences. It might be due to phosphorus is one the elements that is immobile in the soil, therefore phosphorus tend un- leached in the soil. However, the sources and the amount of organic matter that have been added or accumulated formerly showed differences in the amount and pattern of P-fraction

Iyamuremye *at al.* (1996a) found that crop residue from alfalfa and wheat straw had the same C-content. they have different effect on P sorption. Conversely, soils amended with manure or alfalfa, which had different C content but similar P content, decrease P sorption similarly. Phosphorus immobilization in decomposing residues is believed to be responsible for as much as 70% increase in the amount of P in agricultural residues (Schombergh and Steiner, 1999), and from 20 to 200% increase in tree leaves (Conn and Dighton, 2000). Furthemore, some report suggested that immobilization of P in residues could significantly decrease P availability from added plant residues (Schombergh and Steiner, 1999; Mofongoya *et al.*, 2000), however, availability of P from plant residues is affected by initial release of P from the residues and microbial transformations occurring during decomposition of plant residues (Blair and Boland, 1978; Salas *et al.*, 2003).

CONCLUSIONS

The chemical characteristic of the soil samples studied revealed the following:

The C-organic content of soil samples from 15 location of planted crops was fluctuated and the amount was slightly high (3.04-4.92 %) but total Nitrogen was low (0.22-0.45 %), then the soil reaction (pH H_2O) was weekly acids (5.60-6.30) and pH (KCl) was lower (4.60-5.70) than pH(H2O), it indicated that the soil contains net negative charges. The content of available-P was low (3.50 – 7.10 ppm), but the total P (HCl) from tea and vegetables location was higher than from forest and intercropping crops.

Among the inorganic P-fractions, Fe-P was the lowest P-fraction. The majority of P fraction of soil samples from tea and vegetable location was in the form of Al-P fraction, but from Forest and intercropping was in the form of Ca-P. The order was follows: Al-P > Ca-P> reductant soluble-P>Fe-P in tea and vegetables locations, and Ca-P> reductant-P > Al-P > Fe-P in the forest and intercropping. However, The P-fraction (Al-P, Fe-P, and mostly reductant-P and Ca-P) of soil samples from tea and vegetables location was higher than from forest and intercropping locations.

Generally, the majority of P form of soil samples from tea and vegetables location was in the form of inorganic P, but from forest and intercropping location was in the form of organic P. Thereafter, the total P (P-organic + P-inorganic) from tea and vegetables crop location was higher than from forest and intercropping location.

Generally, the slope was not affect the pattern of P-fraction. However, the sources of organic matter that have been added or accumulated in those location formerly affected the amount and the pattern of P-fractions.

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