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Changes in Soil Chemical and Physical Properties of Andisols under Oil Palm Small holder in the West Pasaman District of West Sumatra

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Abstract. Monitoring the productivity and sustainability of oil palm plantations is very important to anticipate the possibly land degradation occurs. The objective of this research was to comprehend the influence of oil palm plant age on the change on soil chemical and physical properties in small oil palm plantation in West Pasaman district of West Sumatra. Field research was conducted from May to July 2016 by using survey method under 3 different plant ages (5-10, 10-15, and >15 years old) in 3 areas (Kinali, Pasaman, and Koto Balingka sub-district). The variables of this study consisted of soil chemical properties: SOM, CEC, pH, total N, available-P, exchangeable base cations (K, Ca, Mg and Na-exch.); physical properties: bulk density, plant available water and water content at pF 2.54 and pF 4.2. Soil quality value calculations obtained with least squares linear regression for three different ages of oil palm plants, did not show significant effect on soil quality of Andisols under small oil palm plantation in West Pasaman district. Our findings suggested that there was no effect of oil palm ages on soil quality of Andisols, however other researches in soil biology and biochemical properties are still needed to obtain a comprehensive result.

1. Introduction

Oil palm plantations have expanded rapidly over the last decades in Indonesia. According to Directorate General of Plantation in Indonesia [1], the structure of ownership in oil palm plantations consisted of that 51% of the area was owned by smallholders and 49% was by large-scale enterprises (both state and private). This large-scale land-use change had caused great impacts on both the areas converted to oil palm and their surroundings. Oil palm plantations generally reduced ecosystem compared to forests [2] and tended to reduce the initial fertility and N-availability [3]. Vijay et al [4] noted that oil palm gave an impact on biodiversity loss. Ref. [3] and Ref. [5] found that there was a tendency of a decrease in soil N levels in line with the age of the plant. The most serious impact occurs when land is cleared to establish new plantations, and immediately afterwards. In West-Pasaman District, it pushes oil palm farmers (entrepreneurs and society) to convert forest into oil palm plantation in order to fulfil the market need of palm oil. The total area of oil palm plantation either for the big company or for individual society in West Pasaman reached 159,965 ha.. The plantation area was derived from functioning natural forest occupied by Andisols [6]. Soil derived from volcanic ash or Andisols is one of fertile and the most productive soil among the soil orders. Therefore, the area with Andisols has a high capability for human life [7]. In Sumatra, Andisols were found from lower to higher altitude, from 20 to 1,800 m above sea level (a. In lower altitude, Andisol was found at foot part of Mount Pasaman and Talamau, West Sumatra [8,9].

According to Sukarman et al. [7] , bulk density (BD) of Andisols in Indonesia was highly various, that was 0.37-0.90 g/cm^3. This low BD of Andisols much depends on amorphous mineral dominated this soil. Since Andisol was dominated by amorphous mineral, this soil has many micro pores, either found intra or inter-aggregates of the allophane. Organic carbon content of Andisols varies from 1.24-22.46%, and the highest content was found on the A horizon. In Indonesia, organic-C content on A horizon of Andisols was 2- 8%. It was found that there was a depletion in organic-C of Andisols as they were used for plantation or horticulture land. As reported by Yasin [10] that fertility (physical, chemical, and biological fertility) of soil under oil palm plantation decreased after 20 years if it was compared to cacao plantation and annual crop farming. This was due to the fact that the source of soil organic matter (SOM) in the oil palm plantation was only derived from the leaves after being cut. Dechert et al [5]) found in Central Sulawesi that soil organic matter stock was affected by t land use and length of cultivation. Soil organic matter stocks were found to be the highest in natural forest, and then followed by forest fallow, and the lowest in maize and agroforestry sites. In maize field, SOM decreased by continuous cultivation, whereas in agroforestry it was stable or had the tendency to increase by time. According to van Straaten et al.[11], the key factor that could predict soil organic carbon (SOC) change across plantations was the amount of SOC present in the forest before conversion. The higher the initial SOC, the higher it was loss. Allen et al [12] found that decreasing in SOC stocks was most pronounced in the topsoil, although older plantations showed considerable SOC losses below 1-m depth. Forest conversion to agriculture can decrease soil nutrient stocks overtime. However, inherent spatial variability in soil biochemical properties in converted landscapes could be high, and may supersede the effects of land-use change on soil nutrient changes.

The variation of soil physical and chemical properties is most likely to be due to its soil forming processes, and the variation of soil chemical properties tend due to soil management practices [13]. In many cases it is found that soil fertility under plantation crops is lower than that under forest. However, the rate of decline under plantation is often much lower than that under annual cropping because of the higher rates inputs as well as the lower losses of the nutrients [14]. Soil management practices in smallholder are generally less intensive than the industrial oil palm plantations (state and private companies). Smallholders plantation usually apply less fertilizer than oil palm companies and the dose of fertilizer may not be determined based on the leaf diagnosis or soil analysis due to economic considerations and/or lack of knowledge [15].

2. Materials and Methods

The research was conducted in an oil palm plantation located at S.00°00′29.6″-E.99°59′22,8″ (Kinali Sub-district); N.00°07′40,2″-E.99°55′23,6″ (Pasaman sub-district) and N.00°23′40,2″- E.99°33′48,9″ (Koto Balingka sub-district). The rainfall has a bimodal distribution characteristic with peaks occurring in September to December and a period of lower precipitation mostly in July to August. The region has a wet and humid climate. The annual rainfall was between 3000-3500 mm and the mean annual temperature was 31.8 - 32°C. The area is characterized by tall trees and oil palm trees. Based on climate data, Oldeman et al [24] the areas were classified into A type climate, having wet month for 9-11 months and dry month for 1-2 months each year.

Field study was conducted from May to July 2016 in Kinali, Pasaman, and Koto Balingka sub district of West Pasaman District, West Sumatra Province. The areas were located between 279-387 m (Table 1). In this study, an area of > 15% slope as well as 5 - >15 years old oil palm plantation were selected for the purpose of evaluating the impact of different plant ages on soil physical and chemical properties in oil palm plantation. Soil samples were taken from top soil (0-20 cm) and subsurface soil (20-40 cm) under 3 different plant ages: 5-10; 10-15, and> 15 years old in Kinali, Pasaman, and Koto Balingka sub-districts. Soil samples were collected from three randomly selected points within each plot using a soil auger. The three samples for each quadrant were mixed thoroughly together to obtain a composite sample. Undisturbed samples for soil physical properties studies were taken by using ring samples. Total soil samples for undisturbed and composite were 75 samples.

Soil analysis was conducted at soil laboratory, Agriculture Faculty Andalas University and at laboratory of soil physics, Soil Research Institute [6]. Soil chemical properties analyzed were soil acidity (pH) using electrometric method, organic carbon (Walkley and Black), total N (Kjeldhal method),

available P (Bray-2 method), K-exchangeable, Ca-exchangeable, Mg-exchangeable, Na-exchangeable and cation exchange capacity (CEC) using NH_4OAc buffered at pH 7 (Ammonium Acetate at pH-7). Soil physical properties analyzed were soil water content (gravimetri method), bulk density (core method), water content pF 2.54 (pressure plate apparatus) and pF 4.2 (pressure membrane apparatus [6]. Data resulted from laboratory analysis were analyzed by least squares linear regression. Description of the research site was performed in Table 1.

Table 1. Description of sample site in Kinali, Pasaman and Koto Balingka sub-district, West Pasaman District

Oil palm area (Sub-district)	Sampling Location	Elevation (m asl)	Soil Types (Soil Taxonomy, 1995)	Age of oil palm (years)
Kinali	S.00°00^{1}29.6^{11} E.99°59^{1}22,8^{11}	279	Andisols	5-10
	S.00°00^{1}25,3^{11} E.99°59^{1}16,1^{11}	286	Andisols	10-15
	S.00°00^{1}30,6^{11} E.99°59^{1}20,7^{11}	279	Andisols	>15
Pasaman	N.00°07^{1}40,2^{11} E.99°55^{1}23,6^{11}	387	Andisols	5-10
	N.00°07^{1}45,1^{11} E.99°55^{1}16,9^{11}	325	Andisols	10-15
	N.00°07^{1}43,8^{11} E.99°55^{1}17,8^{11}	337	Andisols	>15
Koto Balingka	N.00°23^{1}40,2^{11} E.99°33^{1}47,7^{11}	302	Andisols	5-10
	N.00°23^{1}49,0^{11} E.99°33^{1}48,9^{11}	311	Andisols	10-15
	N.00°23^{1}38,2^{11} E.99°33^{1}48,5^{11}	292	Andisols	>15

3. Results and Discussion

3.1. Soil Chemical Properties

General description of soil chemical properties under small oil palm plantation in Kinali, Pasaman, and Koto Balingka sub district was presented in Table 2a and 2b.

3.2. Nitrogen (N) and Phosphor (P)

Nitrogen availability in soil becomes a limiting factor for plant production within some natural and agricultural land. This is due to the fact that N is one of element functioning to compound amino acid, amide, nucleic acid, nucleotide, protein, enzyme, co-enzyme, and hexamine. While main role of phosphorous (P) relates to ATP functioning for composing sugar phosphate, nucleic acid, nucleotide, co-enzyme, phospholipids, and phytic acid [25]. Result on Table 2 described the distribution of N and P-availability on surface (0-20 cm) and subsurface (20-40 cm) soil layer in Kinali, Pasaman, and Koto Balingka sub-district. It can be explained that the mean of the N total was around 0.27 % (0.03-0.55 %) and available-P was about 34.31 ppm (21.51-55.92 ppm). Total-N content of Andisols in Kinali sub-district was considered low to high, in Pasaman sub-district was very low to medium, and in Koto

Balingka sub-district was low to medium. Table 2 showed that available-P content of Andisols was considered medium to high (22.44-55.92 ppm) in Kinali sub-district, medium (21.51-29.97 ppm) in Pasaman sub-district, and low to high (23.56-54.71 ppm) in Koto Balingka sub-district. Based on linear regression, the effect of oil palm age in Kinali, Pasaman, and Koto Balingka sub-districon total N, available P, were not significant (Table 3).

Table 2a. Soil chemical characteristics under three different ages of small oil palm plantation in West Pasaman District

Sub-District	Age of plant (year)	pH		SOM (%)		N-total (%)		P-available (ppm)		Al-exch (cmol/kg)	
	Depth	0-20 cm	20-40cm	0-20 cm	20-40cm	0-20 cm	20-40cm	0-20 cm	20-40cm	0-20 cm	20-40cm
Kinali	5-10	5.90	5.92	5.61	4.24	0.31	0.16	50.2	33.4	0.0	0.0
	10-15	6.27	6.11	7.54	5.18	0.48	0.55	55.1	50.0	0.08	0.0
	>15	6.17	5.89	6.91	4.93	0.36	0.27	63.9	55.9	0.0	0.0
	Mean	6.11	6.67	6.69	4.78	0.38	0.33	56.4	46.4	0.03	0.0
Pasaman	5-10	5.98	5.71	7.75	5.38	0.45	0.38	41.2	21.5	0.0	0.0
	10-15	6.00	6.50	6.89	5.29	0.36	0.18	38.4	25.2	0.0	0.0
	>15	6.19	5.90	5.37	6.55	0.09	0.05	28.2	22.7	0.30	0.0
	Mean	6.06	6.04	6.67	5.74	0.30	0.20	35.9	23.1	0.10	0.00
Koto Balingka	5-10	6.17	6.25	5.45	5.03	0.28	0.19	33.7	38.3	0.0	0.0
	10-15	6.08	5.97	5.23	4.62	0.27	0.21	41.9	36.4	0.0	0.0
	>15	6.06	6.25	5.21	4.31	0.27	0.18	34.3	43.2	0.0	0.0
	Mean	6.10	6.16	5.30	4.65	0.27	0.19	36.6	39.3	0.0	0.0
	Forest	6.29		9.26	7.72	0.60	0.43	75.3	75.7	0.0	0.0

3.3. Cation Exchange Capacity (CEC)

Based on laboratory analyses, the CEC values of Andisols were classified as medium to high (20.60-29.88 cmol/kg) in Kinali sub-district and (21.60-28.31 cmol/kg) in Pasaman sub-district, and then high (17.28-28.65 cmol/kg) in Koto Balingka sub-district. The overall mean CEC values of the Andisols at those three sites were 22.99 cmol/kg (17.28-29.8 cmol/kg). High CEC values of the soil at all research location was due to the allophane (the clay mineral dominant in the soil) and high soil organic -C (5.21-9.26 % C). Statistical analysis by linear regression indicated that there was no significant effect of oil palm age on CEC of soil in Kinali, Pasaman and Koto Balingka sub-district (Table 3).

One of soil chemical properties that highly affects nutrient availability and as an indicator of soil fertility is soil cation exchange capacity (CEC). The CEC value of a soil is the amount of cations exchangeable on colloid surface having negative charges. The unit of CEC is milli equivalence per 100 g soil (me/100g) but now is centimolecule/kg (cmol/kg) soil. Variation in CEC values in soils was determined by the clay and the organic-C content of the soil [9].

Table 2b. Soil chemical characteristics under three different ages of small oil palm plantation in West Pasaman District

Sub-District	Age of plant (year)	Ca-exch (cmol/kg)		Mg-exch (cmol/kg)		K-exch (cmol/kg)		Na-exch (cmol/kg)		CEC (cmol/kg)	
	Depth	0-20 cm	20-40cm	0-20 cm	20-40cm	0-20 cm	20-40cm	0-20 Cm	20-40 cm	0-20 cm	20-40 cm
Kinali	5-10	0.58	0.68	1.08	1.14	0.23	0.26	0.49	0.60	27.17	28.40
	10-15	0.77	0.71	1.09	0.88	0.25	0.20	0.57	0.44	24.92	20.60
	>15	0.64	0.71	0.92	0.84	0.21	0.19	0.60	0.37	25.31	22.22
	Mean	0.66	0.66	1.03	0.95	0.23	0.22	0.56	0.47	25.80	23.74
Pasaman	5-10	0.67	0.59	1.14	1.16	0.26	0.27	0.70	0.34	27.07	24.93
	10-15	0.67	0.53	1.25	0.92	0.29	0.21	0.48	0.43	22.82	21.60
	>15	0.65	0.88	1.16	1.97	0.27	0.45	0.50	0.48	24.92	21.68
	Mean	0.66	0.67	1.18	1.35	0.27	0.31	0.56	0.42	24.94	22.74
Koto Balingka	5-10	0.55	0.57	1.08	1.08	0.25	0.25	0.41	0.49	24.57	17.76
	10-15	0.61	0.63	1.20	1.28	0.28	0.29	0.41	0.28	19.83	17.28
	>15	0.54	0.42	1.06	1.05	0.24	0.24	0.40	0.38	21.54	17.28
	Mean	0.57	0.54	1.11	1.14	0.26	0.26	0.41	0.38	21.98	17.44
	Forest	1.08	0.94	1.60	1.60	0.37	0.37	0.59	0.46	26.56	25.56

The criteria in evaluating chemical degradation of a soil was depletion of CEC values (%/y) in the soil, but for advanced weathered soils such as Ultisols and Oxisols, the criteria was included the amount of basic cations leached due to high annual rainfall. Degree of soil chemical degradation in terms of soil CEC depletion as affected by oil palm age is very low (<2.5%) each year for soil having high CEC values. A high CEC value of soils in research location was mainly determined by the content of allophane clay mineral. Allophanes are very reactive component of Andisols. They have high specific surface area and strongly retain phosphate and organic matter [16]. According Tan [8], type of soil colloids was type of the charges determining soil retention capacity and fertility. Especially in nutrient adsorption, the colloids adsorb nutrients in forms of cations that can be available and exchangeable. Allophane, a type of non crystalline clay mineral, has 100-1000 m2/g outer surface area, and then high soil organic matter content, therefore, the soil has high soil CEC values.

3.4. Cations Exchangeable

Based on basic cation (Ca, Mg, Na, and K) analyses in laboratory, the mean values of Ca-, Mg-, K-, and Na-exchangeable were 0.69, 1.04, 0.24, and 0.51 (in Kinali sub-district), 0.65, 1.27, 0.29, and 0.47 (in Pasaman sub-district), and 0.55, 1.14, 0.26, and 0,38 (in Koto Balingka sub-district), respectively.

Concentration of Ca-exchangeable of Andisols in Kinali sub-district was considered very low -(0.57-0.79 cmol/kg), and Na-exchangeable was low to medium (0.34-0.66 cmol/kg).

Andisols in Koto Balingka sub-district had very low Ca-exchangeable (0.42-0.64 cmol/kg), low to medium Mg-exchangeable (0.93-1.28 cmol/kg), low K-exchangeable (0.21-0.29 cmol/kg), and low to medium Na-exchangeable (0.26-0.49 cmol/kg). Based on Table 2, it can be explained that oil palm plantation under all age levels (5-10, 10-15, and >15 years) did not significantly decrease the Ca-, Mg-, K-, and Na-exchangeable of Andisols compared to the forest soil. The basic cations of forest soil was considered very low for Ca (0.94-1.23 cmol/kg), medium for Mg (1.60 cmol/kg), medium for K- (0.37 cmol/kg), and medium for Na-exchangeable (0.46-0.72 cmol/kg). Based on linear regression analyses, the effect of oil palm age in Kinali, Pasaman and Koto Balingka sub-district on Ca exchangeable, Mg exchangeable, K exchangeable, Na exchangeable was not significant (Table 3). Low basic cations (Ca^{2}+, Mg^{2}+, K+, dan Na+) of Andisols in research location were caused by leaching process due to high annual rainfall (3000-3500 mm). This leaching process was accelerated by the condition of the Andisols in Pasaman sub-district having high infiltration rate as affected by low bulk density and high total pore percentage.

Plant nutrients are in form of ions, plant nutrients are classified into macro such as Ca, Mg, and K. Calcium is a nutrient functioning to form lamella cell wall. Magnesium (Mg) is needed by enzymes functioning to transfer phosphate and to form chlorophyll molecules. Then, K is needed as co-factor for other 40 enzymes and as a main cation to keep cell turgor and electronetrality. While Na is included in phosphoenolpytuphate regeneration at C4 and CAM plants and can be a K-Substitute for some plants.

Table 3. Least squares linear regression results based on soil chemical properties changes of different plant age, in Kinali Pasaman and Koto Balingka Sub-district

No	Variable	Regression. Coefficient	Std. Error	Significant. Value (tn)
1	pH	0.06167 a	0.04621	0.2238 > 0.05
2	SOM (%)	-0.22000 a	0.44736	0.6379 > 0.05
3	Total N (%)	-0.05333 a	0.04583	0.2827 > 0.05
4	Available P (ppm)	0.22000 a	4.97976	0.9660 > 0.05
5	Ca exch.	0.00500 a	0.03107	0.8767 > 0.05
6	Mg exch.	-0.02667 a	0.04013	0.5276 > 0.05
7	K exch.	-0.00333 a	0.01084	0.7674 > 0.05
8	Na exch.	-0.01667 a	0.04352	0.7131 > 0.05
9	CEC (cmol/kg)	-1.17333 a	0.96691	0.2643 > 0.05

Remark CEC= cation exchange capacity

The effect of age oil palm in Kinali, Pasaman and Koto Balingka sub-district on some soil chemical properties: pH, SOM, Total N, available P, Ca-exch, Mg-exch, K exch, Na exch, cation exchange capacity (CEC) was not significant (Table 3).

3.5. Soil Physical Properties

Soil degradation process at small oil palm plantation in research location much depended on land use change from natural forest into oil palm plantation. Based on soil degradation classification and criteria [23], one of factors indicating soil physical properties was soil bulk density. Soil physical properties of Andisols in research location (Kinali, Pasaman, and Koto Balingka sub district) are presented in Table 4.

Statistical analysis by linear regression indicated that there was no influence of oil palm age in Kinali, Pasaman and Koto Balingka sub-district on soil physical properties to water content, bulk density, particle density, water content at pF 2.54 and pF4.2, plant available water for top soil (0-20 cm) and sub-soil layer (20-40 cm) are not significant (Tabel.5).

3.6. Bulk Density (BD)

For the top (0-20 cm) and the lower (20-40 cm) soil layer, the value of soil bulk density was classified into low for soil under 10-15 and >15 years old of oil palm plantation, and medium for soil under 5-10 years old of oil palm plantation. Bulk density values at the top 0-20 cm and the lower (20-40cm) soil layer was considered to be low for soil under 10-15 and >15 years old of oil palm plantation age. While under 5-10 years old oil palm plantation, the soil bulk density was medium. For the top 0-20 and 20-40 cm soil layers, the soil bulk density values was classified as low.

Table 4. Soil physical properties at smallholder oil palm plantation in Kinali, Pasaman and Koto

Location	Age (y)	Depth (cm)	Water Content	Bulk Density	Particle Density	Water Content (pF2.54)	Water Content (pF 4.2)	Plant Available Water
			(%vol)	(g/cc)	(g/cc)	(%vol)	(%vol)	(%vol)
Kinali	5-10	0-20	49.45	0.83	2.47	44.15	25.25	18.90
		20-40	46.35	0.81	2.38	40.20	26.20	14.00
	10-15	0-20	54.10	0.55	2.35	52.65	20.70	31.95
		20-40	60.75	0.52	2.51	60.80	18.95	41.85
	>15	0-20	59.45	0.56	2.22	58.15	25.50	32.65
		20-40	56.15	0.58	2.20	51.85	21.30	30.55
Pasaman	5-10	0-20	60.65	0.57	2.23	58.05	23.25	34.80
		20-40	58.75	0.51	2.23	55.95	16.00	39.95
	10-15	0-20	52.85	0.69	2.35	50.05	23.20	26.85
		20-40	50.55	0.79	2.46	50.10	25.25	24.85
	>15	0-20	48.65	0.74	2.34	45.40	22.15	23.25
		20-40	55.95	0.81	2.43	48.80	25.30	23.50
Koto Balingka	5-10	0-20	54.7	0.82	2.39	49.0	21.0	28.00
		20-40	56.5	0.62	2.21	43.6	18.4	25.20
	10-15	0-20	61.6	0.55	2.16	55.9	20.5	35.40
		20-40	63.3	0.66	2.24	57.8	25.1	32.70
	>15	0-20	62.25	0.57	2.12	52.6	18.3	34.30
		20-40	59.85	0.65	2.32	52.05	17.0	35.05

Balingka sub district, West Pasaman District

Based on BD data of soil at all research location, it can be concluded that there was an effect of oil palm age on soil BD. The BD value of soil increased under 5-10 years old oil palm, but it decreased (low) under oil palm age above 10 years old. Soil BD is one of the most studied soil physical properties, either at field or at laboratory scale. This is due to the fact that it highly correlates to land management for cultivating oil palm, especially for root penetration, soil aeration, and soil tillage. There was variation of soil BD value from each sampling point. Variation in bulk density of Andisols under oil palm plantation was caused by the variation in the SOM on the top and lower layer,soil texture, structure, types of clay minerals, root depth of oil palm, and types of soil fauna.

Table 5. Changes of soil analysis of different plant age of oil palm in Kinali, Pasaman and Koto Balingka Sub-district.

No	Variable	Regression . Coefficient	Std. Error	Significant Value
		(0-20 cm)		
1	Water Content (%)	0.25000 a	0.84693	0.7825 > 0.05
2	Bulk Density (g.cc^{-1})	-0.02867 a	0.01940	0.2136 > 0.05
3	Particle Density (g.cc^{-1})	-0.01533 a	0.01896	0.4641 > 0.05
4	Water Content pF 2.54 (%vol)	0.49333 a	0.88214	0.6058 > 0.05
5	Water Content pF 4.2 (%vol)	-0.34000 a	0.30076	0.3215 > 0.05
6	Plant Available water (%vol)	0.83333 a	1.04656	0.4705 > 0.05
		(20-40 cm)		
1	Water Content (%)	0.86667 a	1.09031	0.4712 > 0.05
2	Bulk Density (g.cc^{-1})	0.00200 a	0.02346	0.9361 > 0.05
3	Particle Density (g.cc^{-1})	-0.01533 a	0.01896	0.4641 > 0.05
4	Water Content pF 2.54 (%.vol.)	1.93000 a	1.14981	0.1685 > 0.05
5	Water Content pF 4.2 (%.vol.)	0.58000 a	0.74263	0.4784 > 0.05
6	Plant Available water (%.vol.)	1.35000 a	1.79552	0.4939 > 0.05

Type of Andisols found in research location had unique characteristics. The parent material of the soil was derived from volcanic ash and other volcanic materials during Mount Talamau eruption. The soil is dominated by allophane mineral or Al-humate complex, high proportion of silicate and allophane-colloid material, imogolite, ferryhydrite with the soil particle density (PD) between 2.08 to 2.53 g/cm3, and high SOM content [7] and [18]. . Therefore, the BD of the soil became low (0.38-0.90 g/cm3). Based on the data of soil water content in Andisols shown in Table 2, it explains that the value of field capacity (pF 2.54) on the topsoil (0-20 cm) was between 43.2 to 58.7 % volume (the difference was 13.5 % volume) and for subsoil (20-40 cm the value was between 39.6 to 62.7 % volume (the difference was 23.1 % volume). Meanwhile, the water content at permanent wilting point condition (pF

4.2) for layer 0-20 cm and 20-40 cm showed the value between 18.2 to 27.3 % volume (the difference was 9.1 % volume).

The variation of water content at the top 0-20 cm soil with the difference value was 23.1% volume and it was really determined by the soil organic matter content, texture and clay mineral types (allophane) that positively correlated to available water. For the top(0-20 cm) soil the value of available water was between 17.9 to 35.4 % (the difference was 17.5 % volume) and for sub (20-40 cm) soil the value of available water was between 13.5 to 44.5 % volume (the difference was 31.0 % volume).

However, based on the criteria of soil physical properties [6]. the available water pore in Andisols Pasaman sub-district which was planted with oil palms at the age of 10-15 years old and above 15 years old had a very high-class of the available water (> 20% by volume) and only for Andisols that was planted with oil palms at the age of 5-10 years, the available water was classified into a high class (15-20% volume). The topsoil 0-20 cm and 20-40 cm soil layer have a moderate class (10-15% volume). The overview of the available water content had a positive correlation with water content at field capacity (pF 2.54). Andisols have unique and distinct properties: low bulk density, high water retention, high permeability, stable structure, high amount of active Al and or Fe, variable charge and high phosphate fixation [22].

According to Gardiner and Miller [19] soil water content at field capacity and permanent wilting point and available water in the soil will vary and determined by many factors and interactions and the interrelations between the classes of soil texture, organic matter content, the depth of the water table which is related to the position of land slope. For example, Gardiner and Miller [19], explained that for land with silty clay texture, the variation of the available water is between 0.13 to 0.19% volume and field capacity of moisture content is between 0.30 to 0.42% volume, and for a land with texture of silty clay loam, the variation of available water is between 0.13 to 0.18% volume and the water content of field capacity is between 0.30 to 0.37% volume. Generally, it can be explained that the Andisols in Pasaman sub-district has 23.50-39.95 % available water content.

Andisols has typical physical properties and it was assumed that such properties are closely related to the high content of allophane. Allophane is composedof hollow spheres in diameter 35-50Å. This mineral has many holes that allow water molecules in and out [8]. Based on these properties, Andisols has high soil water content or water retention. Since it has the hollow soil , this soil is vulnerable to erosion. The data for groundwater absorption (pF) or water retention, practically it is really essential in delineating relationships between energy retention that affects important processes in the soil and water movement and nutrient uptake for oil palms, like good dissolution of fertilizer that is given to oil palms.

The data of soil physics and water levels on field capacity, plant available water that are shown in Table 4 are very useful for answering a phenomenon that occurs as a result of oil palm that are expected to come out the phenomenon of water deficit on agricultural lands planted with oil palms, as seen on Ultisol and Oxisol or on lands in arid region. Conversely, especially for Andisols in West Pasaman district, its unique characteristics are dominated by amorphous allophane clay mineral derived from volcanic ash of Talamau mountain [18]. and spread on the wet tropics in the west coast of the Sumatra island with rainfall between 3500-4000 mm per year. It shows that the phenomenon of soil water deficit on Andisols in Pasaman sub-district had not been seen yet due to the influence of oil palm cultivation at the age of 5-10 years, 10-15 years and over 15 years.

The availability of data and information about physical properties of soil as a database for commodity development of oil palm for the future on the Andisols West Pasaman district, like available water (AW), bulk density (BD), texture and organic matter content of soil, is needed to support the program of the oil palm commodity development in West Pasaman district, particularly in areas that have a soil type, Andisols. The physical properties of the soil and available water content are one of the variables to determine the quality of the land, beside climatic factors, soil fertility, and topography.

The uniqueness of Andisol characteristics, especially Andisols in West Pasaman district, which was formed from volcanic ash material or bursts of volcanic eruptions, such as volcanic ashes or volcaniclastic material from Pasaman Volcano which is dominated by the allophane complex or Al-humic, has andic characters, high content of Fe and Al crystal mineral, P retention, low bulk density

(BD) and high organic matter content. Texture with a moderate size is dominated by loam texture and porous soil spreaded on the wet tropics with 3500-4000 mm rainfall per year. The uniqueness and characteristics of this Andisols provide variability or diversity of soil physical properties and the water content [6].

Based on the uniqueness of Andisols, soil physical properties and available water were connected with the criteria, so the available water (AW) of Andisols in West Pasaman districts was classified to high class or it was provided sufficiently for the plants' need. The high content of the available water is determined by soil organic matter content, texture and amorphous allophane in clay mineral. According to Ogeh and Osiomwan [20] diversity of the characteristics of the soils also provided the diversity for soil physical properties that caused the differences to the distribution and pore size on any type of soil. If it is viewed from the aspect of soil physics, to study about the availability of water in Andisols from oil palm plantations in West Pasaman district is important to be considered since it is related to land management. Moreover, by researching about the organic matter and its texture aspects, they affect the cultivation of oil palm.

Why does the Andisol that has been planted by oil palms for 15 years still have high content of available water and low bulk density. It was caused by the clay content (smooth) with amorphous clay minerals (allophane) which had a greater water holding capasity than the sandy (coarse) soil . This happened because of the large adsorptive surface area of clay mineral, so the capacity of storing water and organic material was bigger.

Volcanic ash erupted by mount Talamau at different time causes significant difference of the mineral composition, and finally affects the soil chemical composition. According Nanzyo [21], the different mineral composition has formed Andisols with various soil chemical, physical, and fertility. Andisols has specific soil physical properties which mostly correlates to high allophane content. Among these soils, Andisols or Andosols show unique properties mostly due to abundant noncrystalline materials such as allophane, imogolite, Al-humus complexes, ferrihydrite and so on. Highly porous structures made of aggregated noncrystalline Andosols materials having a light and fluffy nature, accommodating large amount of both plant-available and hygroscopic water.

There was variation of soil water content value (field capacity, wilting point and plant available water in Tabel 5 from each sampling point. The value of Andisols at top 0-20 cm and 20-40 cm soil was considered to be high for soil layer under 5-10, 10-15, and > 15 years old oil palm plantation. High plant available water content of Andisols under oil palm plantation was caused by the SOM, texture, and type of clay minerals (allophane). Based on the criteria of soil physical properties [6], the plant water available value of Andisols was classified into high for soil under 10-15 and >15 years old of oil palm plantation.

According to Gardiner and Miller [19] water content at field capacity, permanent wilting point and water available in the soil will vary and determined by many factors, such as the interrelation between soil texture, SOM, depth of soil water surface which related to the soil slope position. For example, soil with silty clay texture, variations of the water conteat field capacity was between 0.30 to 0.42 % volume.

4. Conclusion

Linear regression of soil quality properties obtained indicated that there was no influence of oil palm age on soil chemical and physical properties. Effect of oil palm age on BD of Andisols in Kinali, Pasaman and Koto Balingka sub district showed that there was a tendency of decreasing soil BD and in soil water retention under oil palm having >15 years old, but it was no significant difference in soil chemical and physical properties. However other researches in soil biochemical properties is still needed to obtain comprehensive results.

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