

Analysis of physical and chemical characteristics of soil in coffee plantations in the Mount Puntang Social Forestry Area, West Java

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KEYWORDS

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ABSTRACT The physical and chemical characteristics of the soil are important aspects for assessing the quality and level of soil fertility. Altitude affects climate elements which will affect the physical and chemical properties of the soil. Field studies and laboratory analysis have been carried out to determine some of the physical and chemical characteristics of the soil at an altitude of 1200 m 1300 m 1500 m above sea level in the social forestry area of the Gunung Puntang coffee plantation, West Java Province. The aim of the study was to analyze the physical and chemical properties of the soil at various altitudes in the social forestry area of the Gunung Puntang coffee plantation. The research was conducted in the highlands of Gunung Puntang, Bandung Regency, West Java Province. The study used survey methods, field observations and laboratory analysis and then random sampling of soil for laboratory analysis was carried out. Parameters observed and analyzed were soil physical properties, namely soil water content, soil texture class and soil chemical properties, namely pH, organic matter content, nitrogen, C/N ratio, P₂O₅ and K₂O content. Soil samples were analyzed at the Cimanggu Soil Research Institute Laboratory, Bogor. The results showed that the highest soil available water content was found at an altitude of 1300 m asl, namely, 15.83% at a depth of 30 cm, with a silty loam texture. While pH (4.50 - 6.00), C-organic (1.99 - 4.32 %), N-total, (0.18 - 0.32 %) C/N-ratio (11 - 14 %), P2O5 (8 -13 ppm) and K2O (461 - 579 ppm).

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1. INTRODUCTION

Plant growth does not only depend on the availability of nutrients in the soil, but also must be supported by good physical and chemical soil conditions. Coffee (*Coffea* sp.) is one of the important export commodities from Indonesia. Data shows that Indonesia exported coffee to various countries worth US\$ 588,329,553.00, although there were also records of imports worth US\$ 9,740,453.00 (Ardianti & Fibrianto, 2017). Outside and within the country, coffee has also been known by the public for a long time (Prastowo et al., 2010). Supriatna (2022) said that Bandung Regency is the largest coffee-producing area. Having a land area of 13,378.18 hectares, more than 50% of the total area of West Java Arabica coffee plantations is located in this area. Bandung Regency can produce coffee up to 7,680.37 tons/year. Gunung Puntang coffee is one of the best coffees from West Java which has just won an award at the 2016 Expo Specialty Coffee Association of America (SCAA) contest in West Java (West Java).

Information about the chemical properties of the soil can be used as a guide in selecting coffee planting locations and determining the right dose of fertilizer according to plant needs (Núñez et al., 2020; Maro et al., 2013). Thus, the management of coffee plants can be more effi-

cient and production costs can be reduced (Amaralet al., 2011; Hanisch et al., 2011). The ability of the soil to provide nutrients for plants depends on soil chemical properties such as pH, organic carbon, and mineral content in the soil (Kufa, 2011). Several research results have proven the effect of altitude on the physical quality and taste of coffee (Leonel et al., 2007; Silva et al., 2016). Altitude affects air temperature and rainfall (Ping et al., 2013; Saeed et al., 2014). The higher the place, the lower the air temperature and the higher the rainfall and the more fertile the soil (Sari et al., 2013; Beusekom et al., 2015). Changes in these two climatic factors will have an impact on the process of decomposition of organic matter and chemical composition in the soil and the fruit ripening process (Somporn et al., 2012). The main obstacle in utilizing land for agriculture is low soil fertility caused by physical and chemical constraints that limit plant growth. Based on these problems, to improve the quality and increase the level of soil fertility, it is necessary to conduct an initial study of the physical and chemical properties of the soil, both of which are very important as an indication of soil fertility. The main obstacle in utilizing land for agriculture is low soil fertility caused by physical and chemical constraints that limit plant growth. Based on these problems, to improve the quality and increase the level of soil fertility, it is necessary to conduct an initial study of the

physical and chemical properties of the soil, both of which are very important as an indication of soil fertility.

2. METHOD

This research was conducted at the location of the Gunung Puntang Arabica coffee plantation, West Java Province, at 3 different altitude points, namely; 1200 m, 1300 m, 1500 m above sea level, altitude measurement using GPS. The survey method used is a combination of field observations, soil sampling and laboratory analysis. Soil samples to determine soil water content and texture class were taken at a depth of 0-15 cm and 0-30 cm at each elevation level. Soil sampling to analyze its chemical properties was carried out randomly using a soil drill so that it can represent existing field conditions. Laboratory analysis included soil water content, soil texture class, pH (H₂O and KCl), C-organic (Walkley and Black methods), N content (Kjeldahl method), C/N ratio, P₂O₅ (Bray-1 method) and K₂O (Morgan method) was carried out at the Cimanggu Soil Research Institute Laboratory, Bogor. The research flowchart can be seen in Figure 1.

3. RESULTS AND DISCUSSION

The results of laboratory analysis of soil physical properties at several elevation points in the social forestry area of the Puntang Mountain coffee plantation can be seen in Table 1.

3.1 Soil Physical Characteristics

3.1.1 Soil Water Content

Plant growth is directly proportional to the availability of water, where growth will be limited to water conditions that are too low or too high. Table 1 presents the results of a laboratory analysis of water availability in the Gunung

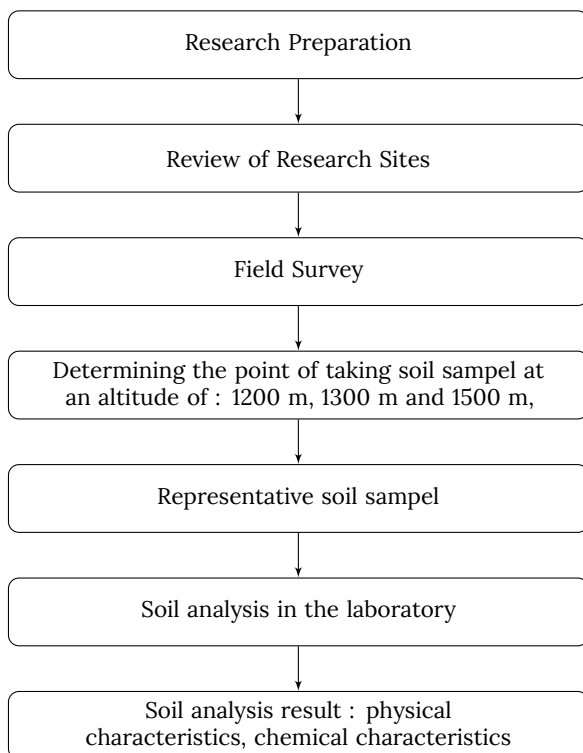


FIGURE 1. The Research Flowchart

Puntang coffee plantation, which shows that the upper part (1,500 meters asl) has an average soil water content at a field capacity level of 39.45%, and at a permanent wilting point of 27.95% , so it has groundwater availability of around 11.50%. Available water is the difference between field capacity (FC) and wilting point (WP), the amount of which is influenced by soil texture (Sutanto, 2005). In the middle section (1,300 meters asl) has an average soil water content at field capacity level of 43.95%, and at permanent wilting point of 28.12%, so it has groundwater availability of around 15.83%, higher than water content at an altitude of 1,200 m asl and 1,500 m asl. At the bottom (1,200 meters asl) the average soil water content at the field capacity level is 41.68%, and at the permanent wilting point is 27.60%, so that the availability of ground water is around 14.08%, the average water content is the highest average is found at an altitude of 1,300 m above sea level at a depth of 30 cm, namely, 15.83% and as the depth of the soil increases, the amount of groundwater content tends to increase. According to Hanisch et al. (2011), the depth of the soil layer determines the volume of groundwater storage, the deeper the greater, so that the water content and availability increases. Furthermore Darusman (2002), states that the capacity of soil to hold water based on soil texture is found to be highest in dusty loam soil textures, namely, the water content is between 2.00 – 2.50 inc feet-1. In accordance with the results of the analysis of texture and water content in this study which are presented in Table 2. Differences in soil water content according to the height of the place studied can be seen in the curve in Figure 2.

3.1.2 Soil Texture

Soil texture is one of the most frequently determined soil properties. This is because soil texture is closely related to the movement of water and solutes, air, heat movement, soil volume weight, specific surface area, soil compaction easiness (compressibility) and others (Purkait, 2010 in Putri et al. (2016)). The ability of the soil to bind water is influenced by several factors, one of which is soil texture. Different soil textures have different abilities to hold water.

The soil texture at the three elevation points studied has two texture variations, namely the texture class of silty

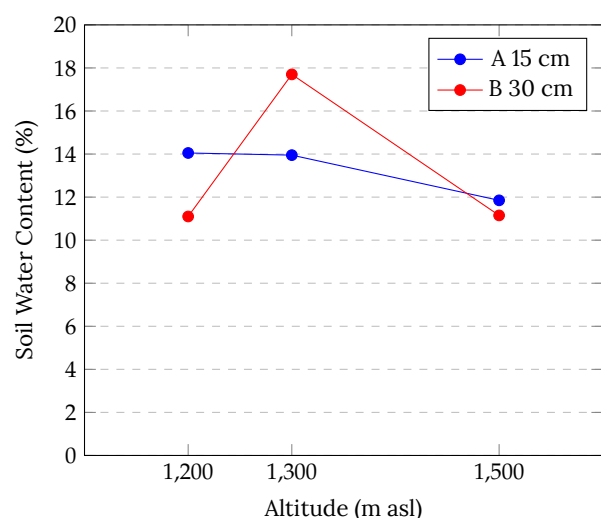


FIGURE 2. The Content of Soil Water Content According to the Altitude ASL = Above the Sea Level

TABLE 1. Results of the Analysis of the Physical Characteristics of the Soil Samples on the Mount Puntang Coffee Plantation, West Java Province

No	Altitude (meters asl)	Depth (cm)	Soil Water Content (%)			Texture			
			Field Capacity (FC)	Permanent Wilting Point (WP)	Water Available	Sand (%)	Silt (%)	Clay (%)	
1	1500	0-15	I. 41,30	I. 27,50	I. 13,80	30	55	15	
			II. 39,30	II. 29,40	II. 9,90				
		40,30 ^{ave*}			28,45 ^{ave*}				11,85 ^{ave*}
		15-30	I. 38,90	I. 27,20	I. 11,70				
			II. 38,30	II. 27,70	II. 10,60				
		38,60 ^{ave*}			27,45 ^{ave*}				11,15 ^{ave*}
ave* 0-30			39,45	27,95	11,5	Silty loam			
2	1300	0-15	I. 44,20	I. 28,90	I. 15,30	22	51	27	
			II. 39,10	II. 26,50	II. 12,60				
		41,65 ^{ave*}			27,70 ^{ave*}				13,95 ^{ave*}
		15-30	I. 42,20	I. 30,00	I. 12,20				
			II. 50,30	II. 27,10	II. 23,20				
		46,25 ^{ave*}			28,55 ^{ave*}				17,70 ^{ave*}
ave* 0-30			43,95	28,12	15,83	Silty loam			
3	1200	0-15	I. 42,40	I. 30,50	I. 11,90	3	56	41	
			II. 43,90	II. 27,70	II. 16,60				
		43,15 ^{ave*}			29,10 ^{ave*}				14,05 ^{ave*}
		15-30	I. 42,70	I. 25,60	I. 17,10				
			II. 37,70	II. 26,60	II. 11,10				
		40,20 ^{ave*}			26,10 ^{ave*}				14,10 ^{ave*}
ave* 0-30			41,68	27,6	14,08	Silty clay			

Source: Cimanggu Soil Research Institute Laboratory, Bogor, processed data 2023

Remark :

asl = above the sea level

*) = average

loam and silty clay. Table 1 presents the fact that at an altitude of 1500 m asl, the content of sand is 30.0%, silt is 55.0% and clay is 15.0%. So the soil is included in the texture class of silty clay. In the middle part or at an altitude of 1,300 meters above sea level there is a sand content of 22.0%, 51.0% silt and 27.0% clay, so it is classified in the silty loam texture class. This means that the soils at an altitude of 1500 m and 1300 m asl in the Puntang coffee plantation area on average have a relatively balanced composition of sand, silt and clay particles. This composition is an ideal composition for soil textural classes, so that it can provide optimum conditions to support plant growth in terms of the physical properties of the soil concerning soil texture Haryati (2014).

While at the bottom (altitude of 1,200 meters above sea level) the content is 3.0% sand, 56.0% dust and 41.0% clay, so it is included in the Silty clay texture class. It can be seen that almost every altitude has a relatively high dust content compared to other textures. This indicates that the location of the plantation is on a mountain slope with an altitude of more than 1,000 meters above sea level. It can also be seen that at the lowest elevation (1,200 meters asl) the clay content is higher than at higher altitudes (1,300

meters-1,500 meters asl). This indicates that there is still a composition of lowland mineral materials at that altitude, while at the altitude above it the influence of volcanic (volcanic) mineral materials becomes more dominant.

3.2 Soil Chemical Characteristics

The results of the analysis of several soil chemical characteristics such as pH, organic matter (C, N, C/N ratio), P₂O₅, and K₂O are presented in Table 2.

3.2.1 pH, C-Organic, N and C/N Ratio

Table 2 presents the results of soil chemical analysis which illustrates that the pH at all elevations is in the range of 5.5 - 6.0, meaning that it is included in the acid to slightly sour category. At an altitude of >1,300 meters asl and an altitude of <1,300 meters asl the soil pH is higher than 5.5, the C-organic content in Mount Puntang ranges from 1.99% (low criterion) to 4.32% (high criterion) while C/ N ratio 11-14 (moderate criteria). C-organic content tends to increase at higher altitudes as shown in Figure 3. At higher altitudes, the decomposition process of litter is slow, resulting in accumulation of C-organic in the soil (Bhattacharyya

TABLE 2. Results of the Analysis of the Physical characteristics of the soil samples on the Mount Puntang coffee plantation, West Java Province

No	Altitude (m asl)	pH		Organic Mater			Criteria (ppm)	P ₂ O ₅ ³⁾ (ppm)	K ₂ O ⁵⁾ (P ₂ O ₅ ,K ₂ O)	Criteria
		H ₂ O	KCl	C (%) ¹⁾	N (%) ²⁾	C/N (C, N, C/N)				
1.	1.500	6,0	5,1	4,32	0,32	14	H, VL, M	8	579	VL, VH
2.	1.300	5,5	4,5	3,52	0,28	13	H, M, M	7,7 ⁴⁾	461	M, VH
3.	1.200	5,8	4,8	1,99	0,18	11	L, L, M	13	461	L, VH

Source: Cimanggu Soil Research Institute Laboratory, Bogor, processed data 2023

Remark : asl = above the sea level, ppm = part per million
 H = High, VL = Very Low, L = Low, M = Moderate, VH = Very High
 1) Analysis using the Walkley & Black method,
 2) Analysis using the Kjeldahl method,
 3) Analysis using the Olsen method,
 4) Analysis using the Bray-1 method,
 5) Analysis using the Morgan method

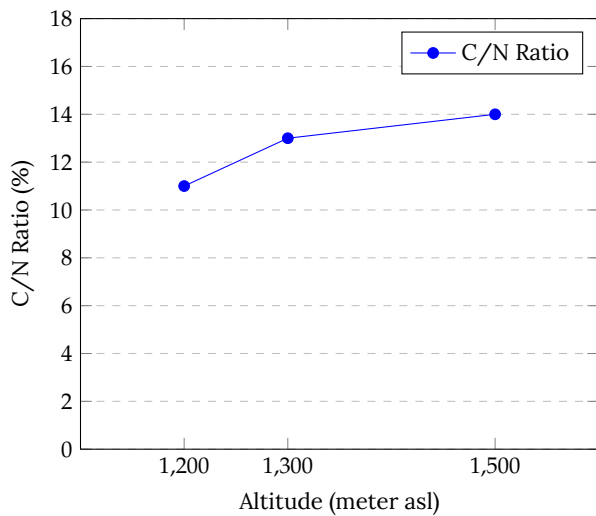


FIGURE 3. C/N ratio at Different Altitudes (Remark: ASL = Above the Sea Level)

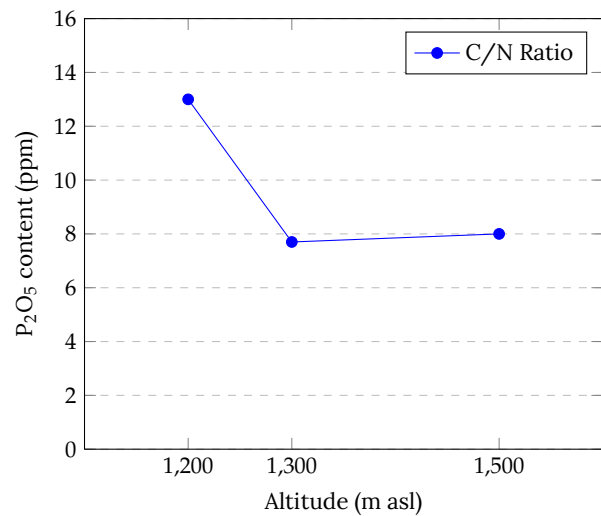


FIGURE 4. P₂O₅ Content at Different Altitudes

et al., 2008 cited in Charan et al. (2013)). Similar research results were also reported by Kidanemariam et al. (2012) in the Ethiopian region, and Sari et al. (2013) and Sipahutar et al. (2014) in the highlands of North Sumatra.

3.2.2 Content of P₂O₅ and K₂O

The P₂O₅ content in Mount Puntang ranges from very low to low criteria, or 8-13 ppm. The results showed that the P₂O₅ value decreased with increasing altitude (Figure 4). The results of this study are similar to those reported by Sari et al. (2013); Vincent et al. (2014); Sipahutar et al. (2014); Supriadi et al. (2016). Conversely, a higher P₂O₅ content is found at lower altitudes, where there is also a higher temperature. Higher air temperatures can stimulate microbial activity and available P₂O₅ content in the soil, increase microbial mineralization and P₂O₅ uptake by plants so as to increase the acceleration of the P₂O₅ cycle and available P₂O₅ content tends to be higher (Rui et al., 2012).

The K₂O content ranges from 461-579 ppm (medium criteria). Except for the content of phosphorus, organic matter, nitrogen and potassium on Mount Puntang, the higher the place, the higher the content tends to be. The research results of Supriadi et al. (2016), it was reported

that there was a significant correlation between altitude and several soil chemical properties and the physical quality of Arabica coffee beans in the highlands of Garut. The higher the location, the higher the chemical properties of the soil, such as pH, C-organic, N-total,

4. CONCLUSION

The physical and chemical characteristics of the soil at different altitudes in the social forestry area of Mount Puntang indicate that the higher the location studied, the better the soil physical properties tend to be, but not all of them apply to soil chemical characteristics. The chemical characteristics of the soil in question, such as pH, C-organic, total-N, C/N-ratio and K₂O, show characters that are in line with the physical characteristics of the soil, but the opposite conditions show that the total P₂O₅ content of the soil actually decreases with increasing altitude. Therefore this needs to be a concern so that it can be followed up by providing agroinput in order to increase the productivity of coffee fields in the area.

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