Performance of Some Soil Physical Properties of Arabica Coffee Plantation in Solok Regency

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Abstract. Arabica coffee also known as mountain coffee is one of the plantation crops that has great potential to be developed on agribusiness scale in Solok Regency due to its suitability on agro-climate region for growth and also may provide great expectation of financial benefit for farmers as well as for economical aspect for the region. A study of soil physical properties under different age of arabica coffee was conducted from April to November 2020 in Lembah Gumanti, Pantai Cermin and Danau Kembar subdistricts, Solok Regency, West Sumatra. The aim of this study was to analyse some of soil organic matter, particle size distribution (soil texture), bulk density, total porosity, and aggregate stability index on different ages from five locations of arabica coffee plantation. Results showed that the soil physical properties of the arabica coffee of 1, 4, 8, and 13 years old, and secondary forest has been changed. The only the soil permeability of the 20-40 cm depth showed significantly different. These may be due to the difference in organic matter application and management in different age of arabica coffee plantation.

Keywords: Arabica coffee, plant age, soil physical

1. Introduction

Coffee is one of commodities that has a great potential to be developed in an agribusiness sector. The case studies in this research are in Lembah Gumanti, Pantai Cermin, and Danau Kembar District Solok Regency. This area has been subjected to the development of Arabica coffee since the last few years in the two villages, namely Nagari Air Dingin and Simpang Tanjung Nan IV which have an altitude between 1,000-1,800 m a.s.l. Fulfillment of plant growth requirements such as altitude, temperature, and soil depth can effectively support the productivity of coffee plants so as to strengthen the economy of local farmers.

The existence of coffee plantations in Lembah Gumanti, Pantai Cermin, and Danau Kembar Subdistricts begin from former Passiflora edulis gardens in the hills and uncovered soil that was formerly cleared of forests overgrown with grass, reeds, and ferns. Forest destruction started when Passion fruit farming was developed. The decline in the price of Passion fruit has made a no longer farmers’ interest in cultivating this fruit. This has been going on since 2005 and then switched to other horticultural commodities and fruits. This deforested stretch of forest needs restoration to avoid further potential of land degradation.
Soil physical properties that need attention is the problem of structural degradation of soil due to management functions. Changes in forest land use, plant age, and soil cultivation techniques will reduce soil function. On relatively uncovered soil, raindrops will directly hit the soil surface so that a lot of soil aggregate is crushed into single soil grains so that it can reduce the hydrological function of the forest and reduce soil physical fertility in the long term. The purpose of this study was to examine the effect of Arabica coffee cultivation on soil physical properties in the area planted with Arabica coffee in Solok Regency.

2. Materials and Methods
The study was conducted from April to November 2020 in small holder arabica coffee plantations in Aie Dingin and Simpang Tanjung Nan IV, Solok Regency, West Sumatra. Soil analysis was carried out at the Physics Laboratory of the Department of Soil, Faculty of Agriculture, Andalas University.

Study are divided into four stages, namely preparation, preliminary survey, main survey, and laboratory analysis. Preparation stage consist of collecting secondary informations (rainfall data, maps, literature review and additional information needed). The preliminary survey consisted of initial surveying the research area, determine the location of soil observations and sampling. The main survey consists of observations in the field according to the specified sample points and corrections to the preliminary survey which can be seen from the map of the sample points and is followed by random sampling of soil samples.[1]. The fourth stage is soil analysis in the laboratory which is taken from each point for parameters and analysis methods in accordance with soil analysis techniques. [2]. Soil analysis parameters were soil organic matter, particle size distribution (soil texture), bulk density, total porosity, and aggregate stability index. Data are calculated and compared with the criteria.

3. Results and Discussion
3.1 Condition of The Study Site
The soil type in the study site is classified as Inceptisols as issued by Center for Soil and Agro-climate Research (1990). Based on rainfall data, this study area has a wet climate condition without dry months. Rainfall ranges from 1,768 - 2,795 mm/year. Danau Kembar District and Lembah Gumanti District belong to climate type A refer to very wet category [13][14].
Figure 1. Slope map

Figure 1 shows that the research area has a topography with the following land area, namely flat (0-8%) is 1.897,91 ha or equal to 9,74%, sloping (8-15%) is 4.898 ha or as much as 25,15%, rather steep (15-25%) of 3.522 ha or 28,09%, steep (25-40%) as much as 7.772 ha or 39,91% and very steep (>40%) of 1.385 ha or 7,11%.
The study area covers an arabica coffee plantation on several different ages, as 1, 4, 8, and 13 years old respectively and also secondary forest areas used as a natural parameter.

**Figure 2.** Research location
3.2 Soil Physics

3.2.1 Soil organic matter
It can be seen from Figure 3 that the topsoil has a higher organic matter content compared to the SOM below it. This can be influenced by the input of organic matter from plant litter that accumulates on the soil surface and rotting roots and other plant biomass, decomposing and contributing organic matter to the soil.[3]. The impact of soil cultivation techniques can also affect the content of organic matter in the soil. Coffee plantations at the age of 8 and 13 have an increase in organic matter content in the 20-40 cm depth. In this garden, routine soil tillage is carried out 3 times a year also did not experience slash and burn during the land clearing process compared to coffee aged 1 year, 4 years and forest. Organic material that comes from burning or often called charcoal, carbon black or pyrolysis carbon which is formed intentionally or accidentally is found in soil, sediment.[4]. Carbon derived from combustion is thought to be more stable in the soil than other organic matter due to its fused aromatic ring structure and fire residue isolated from the soil in the long radiocarbon age[5]. The results of field experiments, the carbon residue from this combustion decomposes faster than the remaining organic matter with 25% lost over 100 years[6].

3.2.2 Particle size distribution
Table 1 shows that a fine and medium soil particle sized has the ability to hold water and high nutrients. The clay fraction has a low colloid size, so it has a large specific surface area, so it has the ability to absorb and store high water, helps form aggregates and provides nutrients, excellent capillarity, slow water release and poor aeration [15].

Table 1. Particle size distribution under different ages of arabica coffee plantation

| Depth (cm) | Age (year) | Sand (%) | Silt (%) | Clay (%) | Criteria       |
|------------|------------|----------|----------|----------|----------------|
| 0-20       | 1          | 37.85    | 26.37    | 35.79    | clayey clay    |
|            | 4          | 21.31    | 37.39    | 41.30    | clay           |
|            | 8          | 27.31    | 48.46    | 24.23    | clay           |
|            | 13         | 30.81    | 51.96    | 17.24    | silty loam     |
|            | secondary forest | 26.36    | 24.41    | 49.24    | clay           |
| 20-40      | 1          | 51.49    | 26.78    | 21.74    | sandy clay loam|
|            | 4          | 22.10    | 32.12    | 45.78    | clay           |
|            | 8          | 29.03    | 49.98    | 21.00    | clay           |
|            | 13         | 41.61    | 40.81    | 17.59    | clay           |
|            | secondary forest | 35.64    | 52.07    | 12.29    | silty loam     |

3.2.3 Bulk density
Table 1 shows that soil bulk density at a depth of 20-40 cm increased in compare to the depth of 0-20 cm. The lower bulk density at 0-20 cm depth was due the influence of organic matter that affecting soil structure. The topsoil, which is rich in organic and loose matter always, has a lower bulk density than compacted subsoil [7]. Higher organic matter content causing loose and clumpy soil.

3.2.4 Total porosity
The total porosity was also affected by soil texture. The texture of the coffee plant is dominated by silt and clay. The pore size of the fine-textured soil is very small but has a large number and the porosity does not show the distribution of pore size in the soil [8].
3.2.5 Soil permeability
In general, soil permeability at different ages have fast criteria. The coffee plantation which has a smooth structure but in both depths is dominated by high organic matter. Organic matter can play a role in improving soil structure by binding soil particles to form a stable aggregate so that it will absorb water faster and the permeability is higher [9]. High organic matter content can affect the size of macropores so that it will increase the rate of soil permeability [10].

3.2.6 Aggregate stability index.
The aggregate stability index is also influenced by the content of organic matter in the soil. The organic materials serve as the glue between each soil aggregate. Organic material derived from plant and animal remains, as well as organic material resulting from soil microbial synthesis and root secretions serve to cement soil grains into soil aggregates[11]. Organic matter that is somewhat plastic is able to make the soil structure and soil aggregate more stable and improve soil porosity, aggregate stability index, and soil aggregation[12].

![Figure 3](image-url)

**Figure 3.** Soil organic matter (%) under different age of arabica coffee plantation
Figure 4. Bulk Density (g/cm$^3$) of soil under different ages of arabica coffee

Figure 5. Total porosity under different ages of arabica coffee plantation
Figure 6. Soil permeability (cm/hour) under different ages of arabica coffee plantation.

Figure 7. Aggregate stability index of soil under different ages of arabica coffee

4. Conclusion
The relationship between soil physical properties and age of coffee plants at the age of 1 year, 4 years, 8 years, and 13 years experienced significant findings in the organic matter content of topsoil layer and soil permeability values in layers of topsoil. There was a significant difference in soil physics changes at each age of coffee and forest, besides this age was used by organic matter input and soil processing systems that were applied differently at the age of coffee plants aged 1 year, 4 years, 8 years, 13 years to the forest.
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