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Study of Soil Biological Properties in Producing Plants and Immature Plants of Oil Palm in Aek Nabara Utara Plantation PTPN III

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ABSTRACT

The maintenance of soil fertility stability and soil health heavily relies on the biological properties of the soil. This study aims to investigate the biological properties of soil in immature plantations (TBM III) and mature plantations (TM 18) located in Aek Nabara Utara Plantation PTPN III, Bilah Hulu District, Labuhanbatu Regency. The research methodology employed survey and descriptive methods to analyze various parameters. The parameters measured in this study include C-Organic (%), Soil Respiration (mg/CO2), Total Microbes (CFU/ml), and Total Fungi (CFU/ml). The research findings indicate increased microbes, fungi, and respiration from immature plants (TBM III) to mature plants (TM 18). This increase can be attributed to environmental factors. Numerous ground cover plants at the research site facilitate the growth and reproduction of microbes and fungi. As the number of microbes and fungi increases, so does the respiration rate.

Keywords: *Oil Palm, Biological Properties of Soil, Mature Plants, Immature Plants, Microbes*

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1. INTRODUCTION

Indonesia has witnessed the widespread expansion of palm oil, which has emerged as a regional growth and economic development catalyst. In 2015, the total area dedicated to oil palm plantations in Indonesia reached a staggering 11,260,277 hectares, resulting in a palm oil production of 31,070,015 tons. This upward trend continued in 2016, with the area expanding to 11,914,499 hectares and palm oil production reaching 33,229,381 tons (Dirjenbun, 2016). It is worth noting that the presence of vegetation significantly influences the characteristics of the soil, which are shaped by the intricate interplay of its physical, chemical, and biological properties (Derakhshan Babaei, 2021).

Different soil microbes, including Kv, Km, and Naik (2019), can be found in various land uses. These microbes play distinct roles in the soil ecosystem, contributing to the maintenance of soil fertility and structure (Chandra et al., 2016). The presence of soil microbes can serve as a bioindicator for soil fertility, and there are specific criteria to consider, such as soil respiration, C/N ratio, and total microbial population (Purba et al., 2021). Soil fertility refers to the ability of the soil to provide sufficient nutrients for plant growth (Munawar, 2018).

Land plays a vital role in human life, and its function is closely tied to society's ever-changing priorities and needs. Consequently, policies are necessary to ensure effective land management and preserve soil quality (Karlen et al. 2019). The diverse characteristics of soil are of utmost importance when it comes to planning and managing land. Neglecting proper land management practices has led to a decline in microbial populations, biodiversity, soil quality, and fertility.

Soil organisms indicate soil fertility because the more soil organisms there are, the better the soil is in good condition. Soil organisms have specific roles in the ecosystem, including as decomposers in providing nutrients in the soil and playing a role in improving the physical properties of the soil. Soil organisms can be bioindicators of soil fertility because they positively respond to soil processing, play a role in decomposition and nutrient cycling, bind heavy metals, and suppress pathogenic organisms (Lestari et al., 2019). Apart from that, the biological properties of the soil have an important role in maintaining the stability of soil fertility and health. According to (Hanafiah et al. 2009), the influence of macro and micro soil biota on the composition of the soil body, soil fertility, the fertility of the plants growing on it, and the environment is very important. Various soil biological attributes are starting to be widely used as indicators of soil quality and health.

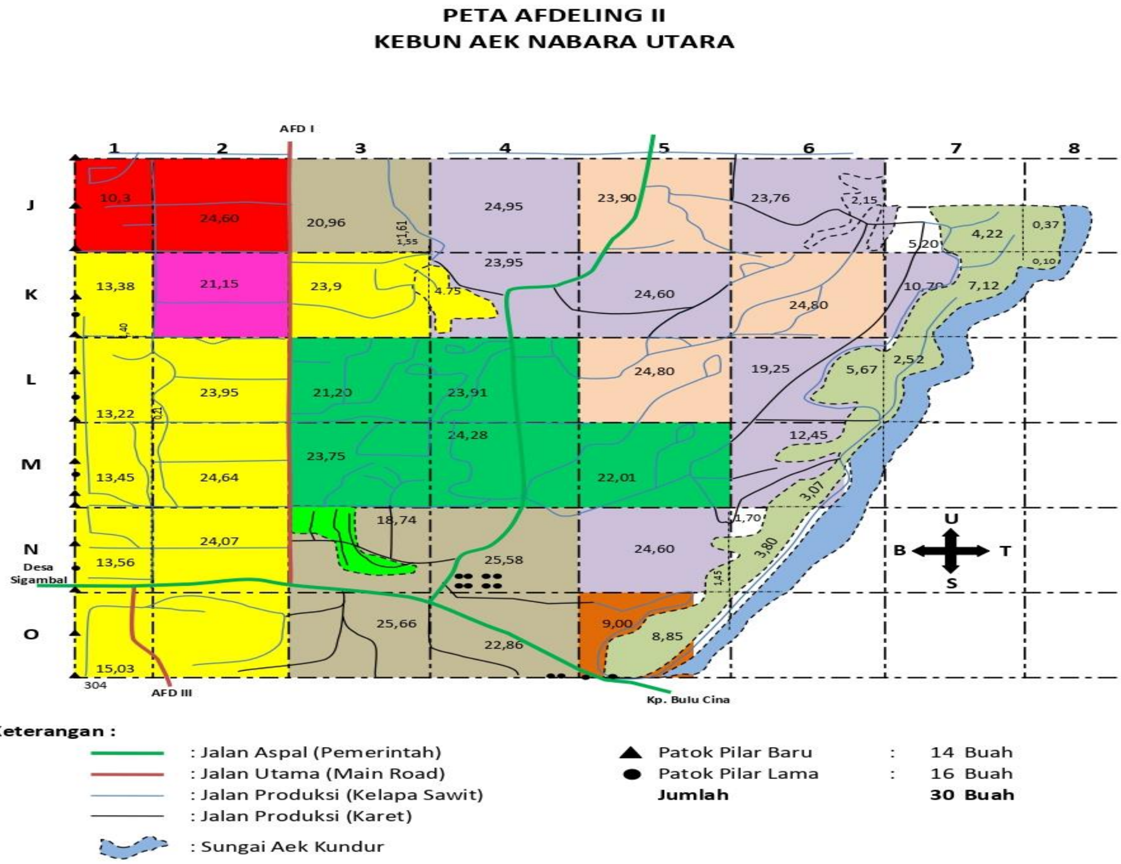
Land productivity estimation heavily relies on soil's biological attributes, particularly the microorganism population. This is because soil microorganisms are crucial in breaking down organic matter. Therefore, it becomes imperative to understand the variations in the biological properties of soil. These variations can be assessed by measuring soil respiration, total microbial population, total population of fungi, and soil organic matter.

2. MATERIALS AND METHOD

Time and Place

The study is scheduled to be conducted for approximately four months, specifically from October 2023 to January 2024, at Afdeling II, Kebun Aek Nabara Utara, PT Perkebunan Nusantara III, Labuhanbatu Regency, North Sumatra. The location is situated at coordinates E: 99058'40" and N: 01059'20", with an elevation of 29 meters. The analysis of soil samples was performed at the Soil Chemistry and Biology Laboratory, as well as the Research & Technology

Laboratory, both of which are part of the Faculty of Agriculture at the University of North Sumatra (USU) in Medan.



WARNA	Keterangan	Luas (Ha)
Budidaya Kelapa Sawit		
	TM 2001	9,00
	TM 2002	110,14
	TM 2010	70,92
	TM 2015	34,90
	TM 2018	28,00
	TM 2020	194,25
	TBM III 2021	21,15
Jumlah Kelapa Sawit		468,36

WARNA	Keterangan	Luas (Ha)
Budidaya Karet :		
	TM 2006	168,79
	TM 2015	112,90
Jumlah Karet		281,69
Lain-lain :		
	Pondok	4,32
	Lapangan Sepak Bola	1,00
	Lain-lain	10,16
Jumlah Lain-lain		15,48
TOTAL AREAL STATEMENT AFD II		765,53

Figure 1. Map of soil sampling points in the field.

Tools and Materials

The materials used in this research were mineral soil samples from Mature Plants (TM 18) and Immature Plants (TBM III) of oil palm at a depth of 0-30, which were taken in a disturbed/incomplete/disturbed manner (Disturbed soil samples). The tools used are GPS (Global Position System), abney level, soil drill, field knife, hoe, cutter, plywood or board, plastic bags, rubber bands, labels, stationery, camera, office software, Arc-GIS software, applications Avenza MAP and analysis equipment in the laboratory.

Research Method

This research uses a direct survey method by selecting representative areas in predetermined oil palm plantation areas using the Purposive Random Sampling method. The observations carried out were by taking soil samples from 2 locations 100 meters apart in the field, and sampling was carried out at a depth, namely from a depth of 0-30 cm, three samples each at the same depth to examine the biological properties of the soil. Soil sampling was carried out on the following land: Immature Plants (TBM III) and Mature Plants (TM 18).

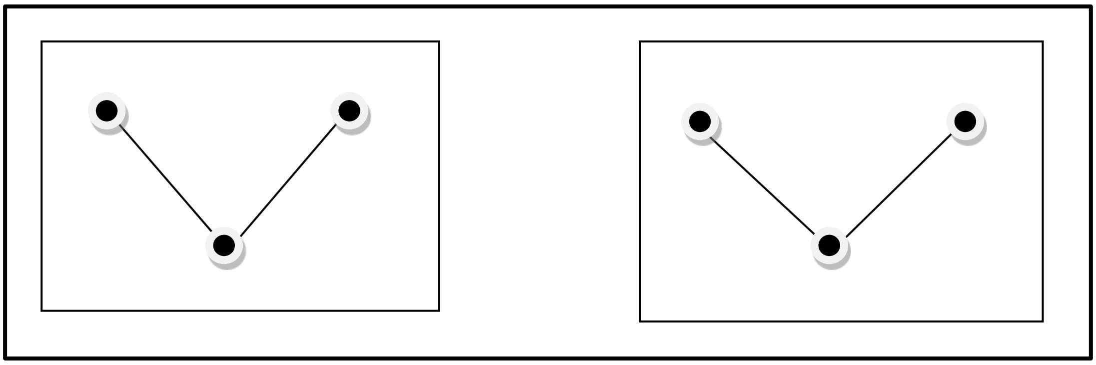


Figure 2. Taking soil sample points in the field

The parameters measured in this study are C–Organic (%), Soil Respiration (mg/CO2), Total Microbes (CFU/ml), and Total Fungi (CFU/ml).

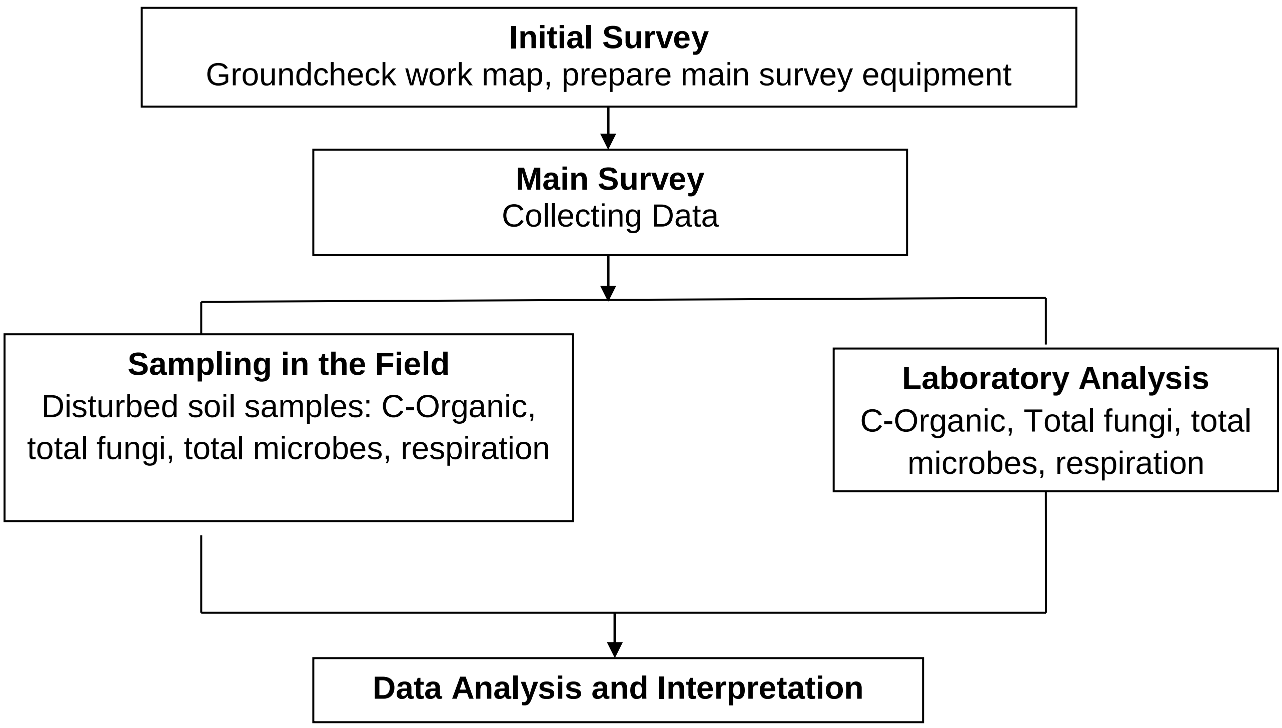


Figure 3. Research Stage Flowchard

3 RESULT AND DISCUSSION

3.1 Total Microbes, Total Fungi, and Soil Respiration

Microbes play an important role in the survival of the plants above them. Soil microbes play a role in the decomposition, distribution, and mixing of organic matter and are enemies of pathogens that want to attack plants (Widyati, 2013). The results of the analysis of soil microbes, soil fungi, and soil respiration can be seen in Table 1.

Table 1. Total Microbes, Total Fungi, and Soil Respiration

No Code	Sample	Total Microbes (CFU/ml)	Total Fungi (CFU/ml)	Soil Respiration (mgCO/day)
1	TBM III A	22×10^5	30×10^4	1,714
2	TBM III B	20×10^5	28×10^4	1,200
3	TBM III C	36×10^5	23×10^4	3,942
4	TM 18 A	55×10^5	35×10^4	5,142
5	TM 18 B	37×10^5	27×10^4	1,200
6	TM 18 C	56×10^5	35×10^4	5,657

Source: Results of analysis in the Soil Chemistry and Biology laboratory, Faculty of Agriculture, University of North Sumatra (2023)

Based on Table 1, it can be seen that there are differences in total microbes in immature plants (TBM III) and mature plants (TM 18) at Aek Nabara Utara Plantation PTPN III. Table 1 shows an increase in total soil microbes in TBM III and TM 18. TBM III A has a total of 22 x 10^5 microbes to TM 18 A with a total of 55 x 10^5 microbes, TBM III B has a total of 20 x 10^5 microbes to TM 18 B with a total microbes 37 x 105, TBM III C has a total of 36 x 10^5 microbes to TM 18 C with a total of 56 x 10^5 microbes.

Table 1 also shows an increase in total fungi in TBM III and TM 18. TBM III A had a total of 30 x 10^4 fungi to TM 18 A 35 x 10^4, TBM III B had a total of 28 x 10^4 fungi to TM 18 B 27 x 10^4, TBM III C has a total of 23 x 10^4 fungi to TM 18 C 35 x 10^4. This increase in the number of microbes is thought to be caused by environmental conditions where there are many ground cover plants at the sampling location, which can increase the amount of organic matter content in the soil. This is in line with research (Sakiah et al. 2018) that shows that the provision of organic material will increase the microbial population and the rate of carbon and nitrogen mineralization. Apart from using organic materials for themselves, microbes will also provide nutrients that are ready to be used by cultivated plants to support the productivity of these plants. The greater the number of microbes in the soil, the higher the plant's productivity. Many plants that grow on TM 18 oil palm can become organic material that cannot be separated from the role of soil organisms. As environmental engineers, soil fauna (snails, earthworms, millipedes, ants, and termites) directly break down organic material originating from litter. In their activities, they bite and chew the litter into smaller pieces to facilitate the decomposition process of soil microorganisms (Widyati 2013).

Each microorganism has specific requirements for its growth. If the environment is not suitable, growth will decrease, affecting the total population. The physical and chemical properties of the soil also determine the growth and activity of microorganisms. Physical properties influencing microbial activity include temperature, osmotic pressure, surface pressure, radiation, viscosity, and adsorption phenomena. Meanwhile, the chemical properties that influence it are water, pH, quality and quantity of organic and inorganic nutrients, air, and compounds that encourage and inhibit growth, oxidation, and reduction (Marianah 2016).

Microbial respiration (soil respiration) is defined as the uptake of oxygen or evolution of carbon dioxide by bacteria, fungi, algae, and protozoa. It includes gas exchange from aerobic and anaerobic metabolism (Anderson 1982). Soil respiration is an indicator used for microbial activity in soil. Soil respiration level is an indicator of the level of decomposition of organic material that occurs at certain time intervals (Widyati 2013). Based on Table 1, it can be seen that there was an increase in respiration in immature plants (TBM III) and mature plants (TM 18) at Aek Nabara Utara Plantation PTPN III. TBM III A has respiration of 1,714 to TM 18 A of 5,142. TBM III B has respiration of 1,200 to TM 18 B of 1,200. TBM III C has respiration of 3,942 to TM 18 C of 5,657. Soil respiration in mature plants (TM 18) has a higher value compared to soil respiration in immature plants (TBM III). This shows that the microbial activity in TM 18 is higher than the microbial activity in TBM III. Microbial activity is in the humification process, the mineralization of organic soil material until it becomes nutrients available for plants (Widyati 2013).

3.2 C-Organic Soil

Soil organic C is formed through several stages of organic material decomposition. Soil C-Organic status is influenced by various external factors such as rainfall, soil type, temperature, above-ground biomass input, anthropogenic processes, soil processing activities, and CO2 content in the atmosphere (Hairiah et al., 2001; Hairiah et al., 2011; Yulnafatmawita et al. al 2011). C-Organic plays an important role in supporting sustainable agriculture, especially as an indicator of soil fertility, maintaining the availability of soil nutrients, improving soil physical properties, and maintaining the survival of soil microorganisms (Smith et al. 2013). The results of soil C-Organic analysis can be seen in Table 2.

Table 2. Soil C-Organic analysis results

No	Sample Code	C-Organic (%)
1	TBM III A	1.72
2	TBM III B	1.40
3	TBM III C	1.95
4	TM 18 A	1,56
5	TM 18 B	1.95
6	TM 18 C	1.78

Source: Results of analysis in the Research & Technology Laboratory, Faculty of Agriculture, University of North Sumatra (2023)

Based on Table 2, it can be seen that there has been a change in the percentage value of soil C-Organic content in Immature Plants (TBM III) and Mature Plants (TM 18) at Aek Nabara Utara Plantation PTPN III. Table 2 shows that between C-Organic TBM III A and TM 18 A, there was a decrease, namely 1.72% to 1.56%, and for TBM III C and TM 18 C there was a decrease, 1.95% to 1.78%. This is because the efforts made to suppress the rate of decline in soil C-Organic in oil palm plantations have not been optimal and sustainable, so soil C-Organic in oil palm plantations continues to decline as the age of the plants increases (Guillaume et al. 2016). Meanwhile, there was an increase in TBM III B and TM 18 B, namely 1.40% to 1.95%. The results of this research are in line with (Haron et al. 1998; Khasanah et al. 2015 Wisdom et al. 2017; Rahman et al. 2018) regarding that in oil palm plantations, degradation of soil c-organic content generally occurs at the beginning of planting. However, by applying appropriate technical culture, the C-Organic value tends to increase as the plant ages. The results of this research are also in line with research by Elisa et al. (2024), who found that increasing the age of oil palm plants is directly related to improving the C-organic content in the soil. The older the oil palm plant is, the more leaves, crowns, and other plant debris will be mixed with the soil. This is in accordance with the theory that the main source of soil organic matter comes from litter and plant roots. Oil palm plants are small and have a relatively shallow root system, so the input of litter and organic material into the soil is limited. When oil palm plants grow and mature, they will produce more biomass and produce more organic material such as fallen leaves and other plant residues. Mature oil palm plantations with well-developed canopies and extensive root systems tend to have higher levels of C-Organic content in the soil.

4. CONCLUSION

The number of microbes, fungi, and respiration experienced a rise from immature plants (TBM III) to mature plants (TM 18). This surge can be attributed to environmental factors. The research site boasts an abundance of ground cover plants, providing an ideal environment for the growth and reproduction of microbes and fungi. As the number of microbes and fungi increases, so does respiration.

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