Total microbes and soil respiration on land without applications and with the application of oil palm empty fruit bunches in different depths

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Abstract. Oil palm empty fruit bunches as a by-product of palm oil fresh fruit bunches processing are generally applied in oil palm plantation areas. This research aim was to determine the effect of oil palm empty fruit bunches application on total microbes and soil respiration. This research used a factorial randomized block design. Factor I is the sampling area, consisting of areas without application and area with the application of oil palm empty fruit bunches (OPEFB). Factor II is the depth of soil sampling, consisting of a depth of 0-10 cm, depth of 10-20 cm, depth of 20-30 cm and depth of 30-40 cm. The total microbes in the area with OPEFB application were 33.373 x 10^6 CFU ml^-1 with soil respiration of 2.257 mg CO_2 day^-1. On land without OPEFB application, total microbes were 16.64 x 10^6 CFU ml^-1 with soil respiration of 12.20 mg CO_2 day^-1. On differences in the depth of soil sampling, the highest total microbes were found at a depth of 10-20 cm i.e. 33.998 x 10^6 with soil respiration of 19.14 mg CO_2 day^-1. The application of oil palm empty fruit bunches had a positive contribution to increase total microbes and respiration in the soil.

1. Introduction

The area of oil palm plantations in Indonesia in 2017 was recorded at 12.3 million hectares with palm oil production of 35.36 million tons [1]. About 20% to 23% of total palm oil production is oil palm empty fruit bunches [2]. Palm Oil Mill with 60 tons hour^-1 capacity will produce 62.400 tons of oil palm empty fruit bunches (assuming the working hours is 20 hours day^-1, working days in 1 year is 260 days), thus the area that can be applied is 1.560 ha year^-1 (assuming the application dosage of empty bunches is 40 tons ha^-1 year^-1). The application of empty bunches on immature plants is done by placing or arranging on the circle (around the tree) at a distance of 30 cm to 50 cm from the base of the oil palm stem with a dose of 200 kg tree^-1 and in producing plants applied an empty area between oil palm plant. The distribution was carried out evenly with a dose of 40 tons ha^-1 year^-1 [3-4].

Various studies on the use of oil palm empty fruit bunches as raw material for various products have been carried out as an effort to increase product value, such as environmentally friendly bioplastics [5], bio-briquette charcoal raw material [6], biochar raw material as soil conditioner [7] and compost raw materials as organic fertilizer [8]. One potential of empty bunches that is large enough is as soil conditioner material [4].

The use of oil palm empty fruit bunches as a soil conditioner has double functioning, in addition to adding nutrients to the soil, it also increases the content of soil organic matter which is indispensable for improving soil physical and biological properties [9]. Soil organisms are a major component in all soil ecosystems [10]. Although the total biomass of soil organisms is lower than the humus fraction or...
mineral fraction, the activity of the organism is very important in determining the functioning of the soil ecosystem. Soil organisms control nutrient cycle processes, soil structure dynamics, degradation of soil pollutants, and others that affect the dynamics of plant populations that grow on it [11].

The activity of microorganisms can assist plant growth, affect soil fertility and destroy toxic organic compounds. The biological activity of soil microorganisms can be estimated by measuring O\textsubscript{2} gas uptake or CO\textsubscript{2} gas emissions because it is the result of respiration from organism activities [12].

Research on the effect of oil palm empty fruit bunches application in Begerpang, PT. PP London Sumatera, Deli Serdang, Sumatera Utara, Indonesia showed total microbes in oil palm empty fruit bunch application land, four times higher than on land without oil palm empty fruit bunch application. At a depth of 0-10 cm, the highest total microbes were found at 13.80 x 10\textsuperscript{6} CFU ml\textsuperscript{-1} [13]. The population of microorganisms in the soil besides being influenced by mineral matters and organic matters is also influenced by climatic conditions and soil moisture [14].

This research was conducted in a different location, namely the Sei Silau, PT. Perkebunan Nusantara III (Persero), Asahan, Sumatera Utara, Indonesia which aimed to determine the effect of oil palm empty fruit bunch application on total microbes and soil respiration at different depths.

2. Materials and Methods

2.1. Material

Soil sampling was carried out in Sei Silau, PT. Perkebunan Nusantara III - Asahan District, Sumatera Utara Province, Indonesia. The material used in this research was aggregate soil taken from two different blocks, namely Block 206, area with oil palm empty fruit bunches application (dose of 40 tons ha\textsuperscript{-1}, evenly distributed between trees) and Block 186, area without the application of oil palm empty fruit bunches. Observation variables were total microbes and soil respiration, soil samples used was undisturbed soil samples [15-16-17]. The aggregate soil was taken using hoes at a depth of 0-10 cm, 10-20 cm, 20-30 cm and 30-40 cm from the ground. Analysis of total microbes used the plate count method and soil respiration used the JAR method (CO\textsubscript{2} capture) was carried out at the Soil Biology Laboratory, Faculty of Agriculture, University of Sumatera Utara

2.2. Methods

This research used Factorial Randomized Block Design, consisting of two factors. Factor 1 was the sampling area (A), there are 2 levels, namely A0: the area without the application of oil palm empty fruit bunches and A1: the area with oil palm empty fruit bunches application. Factor 2 was the depth of soil sampling (D), consisting of 4 levels, namely D1: a depth of 0-10 cm, D2: a depth of 10-20 cm, D3: a depth of 20-30 cm and D4: a depth of 30-40 cm. Hence, 8 combinations of treatments were obtained with three replications. The results of the observations were arranged on the list of variance and the significant results were continued with the Least Significant Difference (LSD) test at the level of 5% and 1%.

3. Results and Discussions

3.1. Total Microbes

Soil Health refers to the ecological equilibrium and the functionality of a soil and its capacity to maintain a well-balanced ecosystem with high biodiversity above and below surface, and productivity [18]. Soil microbial activity and diversity play important roles in the sustainability by keeping essential functions in soil health, involving carbon and nutrient cycling [19-20].

The research results showed that the application of oil palm empty fruit bunches as mulch had a very significant effect on total microbes in the soil (Table 1). The average value of total microbes in the oil palm empty fruit bunch application land was 33.373 x 10\textsuperscript{6} CFU and total microbes on land without oil palm empty fruit bunches application was 1.664 x 10\textsuperscript{6} CFU. The utilization of fresh fruit bunches processing waste in the form of oil palm empty fruit bunches can increase the total microbes in the soil.
The soil microbial biomass is the living part of the soil organic matter, formed by fungi, bacteria, protozoa, and algae, and represents an important source of nutrients that may supply plant demands due to its rapid cycling [21].

**Table 1.** Total microbes in the application land and without the application of oil palm empty fruit bunches

| Treatment                  | Depth 0-10 cm | Depth 10-20 cm | Depth 20-30 cm | Depth 30-40 cm | Average  
|----------------------------|---------------|---------------|---------------|---------------|---------
| Without application of OPEFB | 1.943         | 1.830         | 1.453         | 1.430         | 1.664a  
| Application of OPEFB       | 11.760        | 66.167        | 33.933        | 21.633        | 33.373  b 
| Average                    | 6.852         | 33.998        | 17.693        | 11.532        |

Note: numbers followed by different letters indicated a treatment that is significantly different from F 0.01 based on the LSD test.

Judging from the depth of soil sampling, the average value of total microbes at a depth of 10-20 cm was higher than the depth of 0-10 cm, 20-30 cm and 30-40 cm. This showed that there is sufficient food/energy supply, suitable temperature, adequate water availability and soil ecological conditions that support microbial development [16]. Food tissue on the surface and in the soil is very dependent on the supply of C from the root exudate and plant litter [11].

3.2. Soil Respiration

Microbial respiration (soil respiration) is defined as oxygen uptake or carbon dioxide evolution by bacteria, fungi, algae and protozoans, and includes the gas exchange of aerobic and anaerobic metabolism [22]. Soil respiration results from the degradation of organic matter (e.g. mineralization of harvest residues). This soil biological activity consists of numerous individual activities; the formation of CO$_2$ is the last step of carbon mineralization.

Soil respiration on oil palm empty fruit bunches application land was higher than on land without oil palm empty fruit bunch application. The average soil respiration in oil palm empty fruit bunch application land was 2.257 mg CO$_2$ day$^{-1}$ and on land without oil palm empty fruit bunch application was 1.220 mg CO$_2$ day$^{-1}$ (Table 2). This difference in the value of soil respiration showed that microbial activity in oil palm empty fruit bunches application land was higher than in land without oil palm empty fruit bunch application. CO$_2$ release is very dependent on the physical and chemical properties of the soil [15].

**Table 2.** Soil respiration in application land and without the application of oil palm empty fruit bunches

| Treatment                  | Depth 0-10 cm | Depth 10-20 cm | Depth 20-30 cm | Depth 30-40 cm | Average  
|----------------------------|---------------|---------------|---------------|---------------|---------
| Without application of OPEFB | 1.600         | 1.257         | 1.308         | 0.714         | 1.220 a  
| Application of OPEFB       | 2.799         | 2.571         | 2.057         | 1.600         | 2.257 b  
| Average                    | 2.200         | 1.914         | 1.683         | 1.157         |

Note: numbers followed by different letters indicated a treatment that is significantly different from F 0.01 based on the LSD test.
The application of oil palm empty fruit bunches can increase soil microbial activity. Aside from being a source of organic matters, oil palm empty fruit bunches also contribute nutrients needed by microbes as an energy source. In every one ton of oil palm empty fruit bunches containing 42.8 % C; 2.90% K₂O; 0.80 % N; 0.22 % P₂O₅; 0.30% MgO and other soil microelements such as 10 ppm B, 23 ppm Cu, and 51 ppm Zn [2].

Several field experiments on the application of oil palm empty fruit bunches as mulch on oil palm plantations have been carried out on several types of soil. The main concern for the application of oil palm empty fruit bunches was aimed at returning nutrients transported through harvesting and adding organic matter to oil palm plantations. The addition of organic matter is needed to prevent degradation of land quality due to a decrease in the content of organic matter, especially on land that has been planted with oil palm 2 to 3 cycles (1 life cycle of oil palm is 25 years) [4].

4. Conclusions
Oil palm empty fruit bunches are wastes produced from oil palm fresh fruit bunches processing. The use of oil palm empty fruit bunches as mulch contributes positively to increase total microbes and soil respiration. The highest total microbes were found at a depth of 10-20 cm, namely 33.998 x 10⁶ CFU with soil respiration of 1.914 mg CO₂ day⁻¹. At different depths (0-10 cm, 10-20 cm, 20-30 cm, 30-40 cm) microbial activity in term of respiration was also different. In general, the deeper the soil, the lower soil respiration

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