The change of microbial communities in rhizomicrobiome due to the land management

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Abstract. The soil ecosystem plays an important role in soil health, nutrient availability, and agriculture productivity. Ecosystem alteration from natural forest into oil palm plantation has occurred in the past few years. Therefore, it is needed to study the microbial abundance which has a great role in the nutrient cycle. This experiment was conducted in August 2018 to January 2019. The experiment was arranged as randomized block design consisted of six ecosystems (natural forest, 2008 oil palm plantation, 2009 oil palm plantation, 2010 oil palm plantation, 2011 oil palm plantation, and 2018 oil palm plantation) and provided with four replications, using total plate count. The results showed that natural forest had the highest microbial communities of rhizomicrobiome (total bacteria 35.73x10⁹, PSB 13.88x10⁶, total actinomycetes 18.63x10⁶, and total fungi 1.53x10⁵) CFUg⁻¹, followed by 2008 oil palm plantation which had the highest NFB 7.76x10⁶ CFUg⁻¹. 2011 oil palm plantation had the lowest microbial communities of rhizomicrobiome (total bacteria 11.06x10⁹, PSB 2.93x10⁶, NFB 7.76x10⁶, total actinomycetes 2.91x10⁶, and total fungi 0.26x10⁵) CFUg⁻¹. The research revealed that the alteration of natural forest to agricultural ecosystem influences the richness of microbial population in rhizomicrobiome which has a great role soil health, nutrient availability, and agriculture productivity.

1. Introduction

Rhizomicrobiome has a great role in ecosystems such as the natural forest and oil palm ecosystem. Communities of Rhizomicrobiome interacts with vegetation above it [1] forming an external digestive system that maintains nutrient cycle in the ecosystem [2]. Communities of rhizomicrobiome have a great role in mobilizing nutrient absorption that supports vegetation growth that consists of Bacteria, Fungi, Actinomycetes [3,4,5,6]

Communities of rhizomicrobiome have a great role in the nutrient cycle. Accordingly to [7] fungi become the main factor at decomposition process of solid organic matter and recalcitrant followed by bacteria into simpler and more soluble form, while Actinomycetes have ability to degrade solid polymers into simple compound in the form of sugar which supply energy to fungi, thereby increasing the rate of organic matter, therefore organic matter content in soil become the source of energy and nutrient in ecosystems such as nitrogen and available phosphate.

Ecosystem changes lead to changes in communities of rhizomicrobiome. Accordingly to [8] communities of rhizomicrobiome interacts with plant roots directly, therefore different types of plant will produce different exudate composition. Accordingly to [9] microbial abundance is also influenced by the age of the plant due to the increasing age of the plant, so the root volume will increase which is...
directly proportional to the volume of exudate produced and serves as a carbon source for rhizobio
microbes. Our objective was to determine the ecosystem changes toward the changes in commu
nities of rhizomicrobiome, which has a great role in nutrient cycle and the sustainability of eco
system.

2. **Material and methods**

2.1. **Ecosystem characteristic**

This Research was Conducted at the Kalianusa Oil Palm Plantation North Sangatta, East Kalimantan, from August 2018 to January 2019. The height of the research location was around 100 meters above sea level. Soil samples were collected from rhizosphere palm oil and natural forest with a soil auger and stored in a cool box. The soil studied was a ultisol [10] base on base saturation between 13.67-30.80%. the surface 0-10cm was a silt loam with silt 58-64%. The soil has C/N ratio from all ecosystem between 6.42-10.33 or low until average.

| Ecosystem Description | Coordinate |
|-----------------------|------------|
| Natural Forest        | N°41°09.0’ | E°117°10’23.4” |
| IP 2018               | N°42°13.5’ | E°117°16’42.9” |
| MP2008                | N°40°05.6’ | E°117°15’52.2” |
| MP 2009               | N°40°08.1’ | E°117°14’39.1” |
| MP 2010               | N°40°37.4’ | E°117°13’05.5” |
| MP 2011               | N°41°22.3’ | E°117°13’03.8” |

IP: Immature Plant, MP: Mature Plant

Tools that need to be prepared in this research are Brush, Belgi soil auger, GPS, rope, plastic bag, Cool box, total plate count tools, C-organic laboratory tools, total nitrogen laboratory tools, and phosphate laboratory tools. The material used in this research are, soil sample with 0-10 depth from rhizosphere [11,12] that was taken with the coordinates based on table 1, nutrient agar, pikovskaya, Ashby free nitrogen, yeast extract media, and Potato dextrose agar [13].

2.2. **Total plate count method**

Isolation of soil microbes was carried out using the Total Plate Count technique [14]. 20 g of soil sample was input into a test tube containing 180 mL of physiological NaCl (0.85%) and a dilution series to the level of 10^-8 was carried out by taking a 0.1 mL suspension dilution in each test tube containing 9 mL physiological NaCl. Taking 0.5 mL each at a 10^-1 and 10^-4 dilution level was carried out and microbial culture was carried out on PDA media to isolate fungi, taking 0.2 mL each at 10^-5 and 10^-6 dilutions for actinomycetes in the medium of Water Yeast Extract which is a medium with sufficiently low nutrient content and is ideal for isolation of actinomycetes [3], and taking 0.2 mL of dilution levels 10^-5, 10^-6 and 10^-7 respectively, to be cultured on NA, Ashby, and Pikovskaya media in order to isolate bacteria. Each dilution series is carried out in 4 replications. After obtaining culture results from all replications in each sample, then samples were observed seven days after dilution for fungi and bacteria, and 3-10 days after dilution for actinomycetes [15] TPC results are processed into data in the form of CFUg^-1 which are calculated taking into account the dry weight of the soil.
3. Result and discussion

Table 2. Abundance communities of Rhizomicrobiome.

| Ecosystem     | Total Bacteria | Phosphate solubilizing Bacteria | Nitrogen-fixing Bacteria | Total Actinomycetes | Total Fungi |
|---------------|----------------|--------------------------------|--------------------------|---------------------|-------------|
| Natural forest| 35.73          | 13.88                          | 12.74        | 18.63   | 1.53        |
| IP 2018       | 18.82          | 10.21                          | 12.56        | 19.99   | 0.89        |
| MP 2008       | 32.42          | 8.96                           | 17.77        | 16.72   | 0.30        |
| MP 2009       | 15.06          | 5.67                           | 6.06         | 3.90    | 0.58        |
| MP 2010       | 13.00          | 3.87                           | 5.79         | 3.63    | 0.47        |
| MP 2011       | 11.07          | 2.93                           | 7.76         | 2.91    | 0.26        |

IP: Immature Plant, MP: Mature Plant

Showed natural forest and 2008 oil palm plantation had the highest total bacteria abundance. Natural forest and 2008 oil palm plantation had the highest total bacteria abundance because those ecosystem have a canopy that intersects each other which cause indirect sunlight on the soil surface and suppresses evaporation and achieved micro-climate stability that supports the total bacteria growth [16]. According to [17] total bacterial activity in rhizomicrobiome maintaining the nutrient cycle and influenced by soil physical and chemical properties. Based on this, high bacterial abundance indicated that the ecosystem could be classified as a healthy ecosystem. Microbial abundance in rhizomicrobiome could be used as an indicator in assessing soil health in both forest and artificial ecosystem such as oil palm plantation.

Ecosystem changes from natural forest to agricultural land could change the abundance of total bacteria of rhizomicrobiome. Table 2 showed a decrease in total bacteria abundance of rhizomicrobiome after the natural forest was converted to 2018 oil palm plantation and then continued to decrease until 2011 oil palm plantation. After that, total bacteria abundance increased in 2010 and 2009 oil palm plantation even though still under natural forest and 2008 oil palm plantation’s total bacterial abundance.

Natural forest ecosystem had the highest abundance of phosphate solubilizing bacteria in rhizomicrobiome. The abundance Natural forest had a higher diversity of vegetation that impact diversity of exudate, therefore, impact the diversity of phosphate solubilizing which could use some specific composition exudate to growth [9]. Phosphate solubilizing bacteria in rhizomicrobiome had a decreasing trend at the beginning of conversion time of natural forest into oil palm plantation and gradually rose by time because age of plant correlated with root volume and exudate volume that produced by plant toward soil as source of energy for phosphate solubilizing bacteria of rhizomicrobiome [18]. In addition, ecosystem change could also affect microbes that play a role in the nutrient cycle such as nitrogen-fixing bacteria.

2008 oil palm plantation had the highest abundance of nitrogen-fixing bacteria in rhizomicrobiome followed natural forest and 2018 oil palm plantation. 2008 oil palm plantation had the highest abundance of nitrogen-fixing bacteria indicated that this ecosystem has stabilized and nutrient cycle such as nitrogen could work properly the same as a natural forest because of there was management cultivation at oil palm ecosystem. According to [18] the change ecosystem could effects kind of exudate that available in the soil therefore even though bacterial abundance in 2008 oil palm ecosystem higher than a natural forest, but the diversity of nitrogen-fixing bacteria in the natural forest could be higher than in oil palm ecosystem. Based on visual observation 2008 oil palm plantation had moss that covered the soil that indicated this ecosystem had high moisture which could support
nitrogen-fixing bacteria the growth. According to [19] the presence of the moss on the soil indicates the temperature under the shade of oil palm below 30°C with ± 20% air humidity which support growth of the moss and soil microbes. In addition, ecosystem changes could also affect the abundance of the microbes such as actinomycetes in rhizomicrobiome.

The highest actinomycetes of rhizomicrobiome abundance were founded in a natural forest ecosystem, 2008 and 2018 oil palm plantation. natural forest and 2008 oil palm ecosystem had a high abundance of actinomycetes due to the high volume of exudates that produced by plan roots along with increasing plantation age which was directly proportional to root volume [9]. 2018 oil palm plantation had a high abundance of actinomycetes because the conversion natural forest toward oil palm ecosystem only been occurring for 3 months when this research was conducted, therefore there was still remaining roots from the natural forest before. Accordingly to [20] Actinomycetes has a special ability to degrade solid polymers from organic litter such as the remaining roots into sugar which were used as energy sources.

Ecosystem change could also affect the abundance of fungi in rhizomicrobiome because the process of decomposition of organic matter was also carried out by the other microbes such as fungi in rhizomicrobiome. 2009-2001 oil palm plantation, the abundance of Actinomycetes was not significantly different due to the influence of plant canopies that had not to intersect fully, therefore sunlight could hit directly toward soil that increased evapotranspiration and caused fluctuation in the soil microclimate. In addition, although not significantly different from the Actinomycetes abundance in a 2009-2011 oil palm plantation, it has a tendency to increase, indicating that the abundance of actinomycetes increased with the increasing age of plantation accompanied by an increase in root volume and volume of exudate produced [7].

Natural forest had the highest fungi of rhizomicrobiome abundance compared to oil palm plantation. this was because the natural forest was an ecosystem that has a more diverse type of vegetation, therefore the production of organic matter, exudates and decaying wood that could be used as energy sources were higher than oil palm plantation [18], the lowest abundance of fungi in rhizomicrobiome was found in palm oil ecosystem because there was fungicide application with triadimenol 250.7 g/L [21] to prevent Ganoderma boninense from infecting oil palm ecosystem which its residues hamper the growth of total fungi in rhizomicrobiome [22].

4. Conclusion
The highest communities of Rhizomicrobiome were found in the natural forest for total bacteria, phosphate solubilizing bacteria, total Actinomycetes, and total fungi which prove that natural forest was healthier ecosystem than oil palm plantation. The highest abundance of nitrogen-fixing bacteria was found in the 2008 oil palm plantation ecosystem. While 2011 had the lowest microbial communities of rhizomicrobiome which showed that ecosystem alteration leads to the change of rhizomicrobiome.

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