Abundance and diversity of bacteria associated with healthy and infected oil palm rhizosphere of *Ganoderma boninense* in Bahilang, North Sumatra

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**Abstract.** Basal stem rot (BSR) caused by soil-borne pathogen, *Ganoderma boninense*, is one of the constraint factors in palm oil production in the world. The presence of rhizosphere microbes such as bacteria is an important factor whose presence can be beneficial to plants or become a pathogen. Unfortunately, information about the abundance and diversity of bacteria associated with healthy and infected oil palm rhizosphere of *G. boninense* is still limited. This research aims to compare the abundance and diversity of bacteria associated with healthy and infected oil palm rhizosphere of *G. boninense*. Soil samples were taken from a healthy and infected oil palm rhizosphere in the Bahilang, North Sumatra. The results showed that the abundance and diversity of bacteria from the healthy rhizosphere were higher than infected rhizosphere. In a healthy rhizosphere, the abundance and diversity of bacteria were higher at soil depths of 10-20 cm compared to soil depths of 0-10 cm. Otherwise, the abundance and diversity of bacteria in the infected rhizosphere were higher at depths of 0-10 cm.

1. Introduction

A serious problem faced by oil palm plantations in North Sumatra is basal stem rot disease (BSR) caused by soil-borne pathogen, *Ganoderma boninense*. The high incidence of BSR in North Sumatra is because oil palm plantations in North Sumatra are old. In addition, due to the decrease in soil quality such as decreased biological, chemical and physical properties of the soils.

This condition is caused by changes in the ecological balance due to the use of pesticides, planting oil palm on marginal land that is poor in nutrition, especially potassium [1]. Soils that are nutrient-poor will cause plants to be easily infected by pathogens due to the abundance and low diversity of soil microbes.

The potential of *G. boninense* as a soil-borne pathogen is closely related to the abundance and diversity of microbes found in the rhizosphere. The rhizosphere is an ideal area for growing and developing soil microbes such as fungi and bacteria. Soil microbes are important factors in the sustainability of the nutrient cycle in the ecosystem, play a role in plant nutrition [2], plant health [3], soil structure [4], and soil fertility [5].
Growth of microbial populations and their activities in the soil depend on interactions between plant species and soil [6]. According to [7], the composition of bacterial communities results from interactions between soil types, plant species and their rhizosphere.

In essence, plant health is determined by the health of the rhizosphere. Therefore, this study aims to compare the abundance and diversity of microbes in the healthy and infected of oil palm rhizosphere to be used to determine BSR control strategies.

2. Material and methods

2.1. Soil samples collection
Bulk soil samples were obtained from healthy and Ganoderma infected soil by purposive sampling from 8 different sites (0-10, and 10-20 cm depth) in Bahilang, North Sumatra. Bahilang is an oil palm plantation with around 10.5 years old plants from the first generation with Alluvial clay. The soil was taken using a ground drill from four points in the rhizosphere of the sample plants. 200 g each composite soil samples were put in a plastic bag by labelling the date of collection, location, and depth of the sample. Furthermore, soil samples are further processed in the laboratory.

2.2. Bacteria isolation
Bacterial isolation from each sample was carried out by serial dilution methods. One gram soil is taken from each soil sample and then diluted with 9 ml of sterile water and homogenized. 0.1 ml of solution was put into 0.9 ml sterile distilled water in an Eppendorf (10^{-1}) and so on until 10^{-7}. 0.1 ml was taken from dilution of 10^{-5}, 10^{-6}, and 10^{-7} from each sample and grown in petri dishes with nutrient agar, and keep them for 2x24 hours in the room with temperature about 27°C. All bacterial colonies that grew were observed for morphology such as the colour and shape of the colony. Each bacterial colony with the same morphology counted the number of colonies, while all single colonies that grow separately were selected and made pure culture.

3. Result and discussion
Soil samples from healthy and infected rhizosphere in this study did not differ in physical and chemical properties (Table 1). All soil samples have acid soil pH (4.96 - 5.17), relatively low organic matter, low N-total, and low C / N ratio (5-10%). The content of organic matter greatly affects the soil microbial population because organic matter is used as a constituent of the body and an energy source for soil microbes [8]. According to [9], soil in old plants has a low content of organic matter because intensive land management has been carried out. Besides monoculture cultivation without rotation causes loss of soil organic matter.

| Table 1. Chemical and physical characteristics of the soils samples in this research |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
|                                | Healthy rhizosphere | Infected rhizosphere |
|                                | S2   | S4   | S6   | S8   | S1   | S3   | S5   | S7   |
| Clay (%)                       | 32   | 40   | 8    | 6    | 34   | 31   | 9    | 8    |
| Silt (%)                       | 29   | 15   | 11   | 11   | 24   | 23   | 12   | 13   |
| Sand (%)                       | 39   | 45   | 81   | 83   | 42   | 46   | 79   | 79   |
| pH (CaCl2)                     | 5.08 | 5.04 | 5.02 | 5.17 | 4.96 | 5.06 | 4.96 | 5.06 |
| N-total (%)                    | 0.29 | 0.29 | 0.15 | 0.11 | 0.17 | 0.11 | 0.17 | 0.11 |
| C-organik (%)                  | 2.88 | 3.06 | 1.39 | 1.00 | 1.70 | 1.01 | 1.70 | 1.01 |
| C/N                            | 9.93 | 10.55| 9.26 | 9.09 | 10.0 | 9.18 | 10.0 | 9.18 |
| Ca (C mol kg^{-1})             | 2.41 | 1.31 | 1.31 | 0.80 | 1.30 | 1.33 | 1.30 | 1.33 |
| Mg (C mol kg^{-1})             | 1.31 | 0.81 | 0.69 | 0.45 | 0.78 | 0.64 | 0.78 | 0.64 |
| K (C mol kg – 1)               | 0.63 | 0.58 | 0.25 | 0.22 | 0.37 | 0.40 | 0.37 | 0.40 |
| CEC (C mol kg – 1)             | 9.52 | 9.60 | 5.10 | 4.36 | 5.54 | 5.35 | 5.54 | 5.35 |
The presence of soil microbes such as bacteria in the rhizosphere is influenced by changes in the content of organic matter. Organic matter is one of the factors that influence soil quality and health. The low abundance and diversity bacteria for each sample indicate low organic matter content.

The abundance of bacteria from healthy rhizosphere (S2, S4, S6, and S8) was higher than the infected rhizosphere (S1, S3, S5, and S7) (Figure 1). According to the concept of [10], the rhizosphere of plants is divided into 2, namely rhizosphere, an area surrounding the roots of plants, and rhizoplane, the surface area of plants. The rhizoplane area is 0-10 cm deep, while the rhizosphere is 10-20 cm deep. Bacteria are more often found in the rhizosphere area because the area near the roots of the plant is rich in nutrients derived from plant root secretion [11]; [12]. Isolates which have high abundance mean that they are able to tolerate environmental conditions in the soil rhizosphere.

**Figure 1.** The number of total bacteria from healthy oil palms rhizosphere and infected rhizosphere of *Ganoderma boninense* (■: 0-10 cm depth, □: 10-20 cm depth; CFU is colony forming units)

**Figure 2.** The number of bacteria isolates from healthy oil palms rhizosphere and infected rhizosphere of *Ganoderma boninense* (■: 0-10 cm depth, □: 10-20 cm depth)

The diversity of bacteria from the healthy rhizosphere was higher than infected rhizosphere (Figure 2). Microbial composition around the roots is very dependent on the species and age of the plant, and
soil characters, especially physical and chemical properties. In line with plant growth, microbial dynamics occur in the rhizosphere because there is a change in the structure of microbes associated with differences in root exudates and organic matter released by the roots during plant development. The presence of soil microbes in the rhizosphere and interactions between them can accelerate the process of decomposition of organic matter [13]. Therefore, the growth of microorganisms must be supported by a healthy soil. Furthermore, to organic matter, loose soil, optimal soil moisture, reducing tillage with heavy equipment, replacing the use of chemicals with alternative organic fertilizers, these steps can produce friendly soil with high microbes [14].

4. Conclusion
In conclusion these result suggest that while the abundance and diversity of bacteria was higher in the healthy rhizosphere of oil palm plants than the rhizosphere that is infected with G. boninense.

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