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Research Article

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Soil physicochemical properties in respect to plant health in *Ganoderma*-infested oil palm plantation

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ABSTRACT

Basal stem rot caused by *Ganoderma boninense* is a major disease of oil palm in Indonesia. Environmental factors associated with disease can be used as the basis for developing disease control. This study aims to describe the physical and chemical properties of oil palm plantations land mineral soil land that is infested with basal stem rot. Soil composite samples were randomly collected from diseased and healthy palm circle from an oil palm plantation in Mesuji, South Sumatra. The results showed that the texture and nutrient status of diseased and healthy plants were not significantly different, namely they had the same low analytical values in terms of the content of N, C-organic, CEC, Mg, Ca, Na, and K_2O. The ratios of C/N, exchangeable K and exchangeable acidity in healthy and diseased soils were both moderate to high. The content of available P and total P was very high (43−134 ppm) and was found to be higher in the soil of diseased plants than in healthy plants. These results indicated that high availability of P nutrients may favor *G. boninense* infection in oil palm plantation.

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INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is an important plantation crop in Indonesia as a producer of vegetable oil and other processed products (Purba & Cipayung, 2017). Oil palm has a high economic value and has significance for the development of national plantations. Besides being able to create jobs that lead to community welfare, it is also a source of foreign exchange income, considering that Indonesia is one of the main producers of Crude Palm Oil (CPO) (Hartono, 2013). Oil palm plantations in Indonesia have a total land area of 14,456,611 hectares and palm oil production reached 47,120,247 tons in 2019 (Directorate General of Estate Crops, 2020). In order to get maximum yields and high production, the health of oil palm plants is very important and avoids pests and diseases (Nadhrah *et al*., 2015).

The most important disease in oil palm plantations in Indonesia is Basal Stem Rot (BSR). To date, 15 species have been reported to be associated with BSR disease, including *Ganoderma boninense*, *Ganoderma chalceum*, *Ganoderma miniactocinctum*, *Ganoderma tornatum*, and *Ganoderma zonatum*. Species *Ganoderma* spp. which is more virulent than other species and as the cause of BSR disease in some cases is *Ganoderma boninense* (Purnama *et al*., 2012). This disease is very detrimental because it can kill oil palm plants (Turner, 1981). It was estimated that the economic loss due to the basal stem root was 67.73% of the attainable oil palm yield (Kamu *et al*., 2021). The observable symptoms of the basal stem rot disease are chlorotic leaves, the appearance of fruiting body, collapsed plants, and the existence of holes on the basal stem (Lisnawita *et al*., 2016). This makes it difficult to prevent and control diseases caused by *Ganoderma* infection.

Currently, the control strategy that continues to be developed is to manage the bioecology of *Ganoderma*, which is a control that is able to reduce the amount of initial pathogen inoculum to a level that does not cause economic losses, with an approach to natural ecosystems, and is sustainable (Hushiarian *et al*., 2013). Soil for agriculture in addition to supporting roots also serves as a provider of nutrients for plant growth, so that soil quality greatly influences plant health (Janvier *et al*., 2007). Good soil quality is healthy soil so that it can support sustainable plant growth. Healthy soil depends on the physical, chemical and biological processes that take place in the ecosystem. In relation to plant diseases, certain physical, chemical and biological processes can shape the character of soil that makes healthy plants (Cepeda, 2006). Environmental factors associated with disease can be used as the basis for developing disease control. This study aims to describe the physical and chemical properties of oil palm plantations on land mineral soils that are infested with BSR disease.

MATERIALS AND METHODS

Study Site

Sampling was carried out in an oil palm plantation located in Mesuji, Ogan Komering Ilir, South Sumatra. The test block was a sample block (25 Ha) of first-generation plants with a population of 135 trees/ha which were selected to represent a total of 543 Ha of land planted in 1997. Basal stem rot attack on healthy land was 51 out of 36.758 trees (0.14%). In this block, 28 soil samples were collected consisting of 14 samples of soil from diseased palm (plants infected with *Ganoderma*) and 14 samples of healthy plant soil. Healthy plants were selected at a distance of 20 – 40 rows from diseased plants (Figure 1).

Soil Sampling and Preparation

The sampling method follows the soil sampling procedure. Soil sampling was carried out in the circle area of oil palm trees close to the base of the trunk (20−30 cm). Soil samples were taken using a Dutch Auger at four points around the plant representing the cardinal points with a depth of 0-20 cm with a total mass of about 250 grams for each sample, then the sample was air-dried at room temperature for 5 days, filtered through a sieve and air-dried at room temperature for 5 days then composited. The ready sample then taken to the laboratory for physicochemical analyses.

Soil Physicochemical Analyses

Soil physicochemical analyses was conducted using a standardized procedure (Soil Research Institute, 2009) at the Chemical Laboratory of PT. Sampoerna Agro, South Sumatra. The parameters analyzed on the physical properties was texture and chemical properties were pH, organic content, and mineral content [Total N, Organic C, Cation Exchange Capacity (CEC), Bray P, Exchangeable K, Ca, Mg and Na]. Analyses method for the physical properties using the Hydrometer and for chemical properties using Spectrophotometry and Titrimetry.

RESULTS

Soil Physical Analysis

Analysis of soil texture on healthy and diseased plants that both had sandy clay loam texture classes based on the USDA classification system (United States Department of Agriculture, 1987). There were no significant differences between contents of each soil fraction of diseased soil samples compared to that of healthy soil (Table 1).

Soil Chemical Analyses

The results of chemical analysis showed that the soil of the test block had a slightly acidic and acidic pH. The soil sample of diseased plants had a pH of 5.56, while the soil sample of healthy plants had a pH of 5.43. The macronutrient content in the soil of healthy and diseased plants has a very low to very high range. Nutrient status in diseased and healthy plants had the same low analytical values in terms of the content of N, C-organic, CEC, Mg, Ca, Na, and K2O (Table 2) and did not differ significantly between the two except for Ca content. Exchangeable Ca was significantly higher in diseased plant soil (2.16 cmol(+)/kg) than in healthy plant soil (1.62 cmol(+)/kg) (Figure 2).

Figure 1: Location of soil sampling in endemic *Ganoderma* of oil palm plantation in Mesuji, South Sumatra

Tabel 1: Comparison of the composition of physical parameters of sand, silt, and clay in the endemic *Ganoderma* oil palm plantation in Mesuji, Ogan Komering Ilir, South Sumatera

Physical Parameter	Plant Health	
	Diseased palm	Healthy palm
Texture Sand (%)	54.89	53.84
Texture Silt (%)	21.48	21.35
Texture Clay (%)	23.63	24.81
Texture Classification	Sandy clay loam	Sandy clay loam

Table 2: Soil chemical properties of endemic *Ganoderma* oil palm plantation in Mesuji, Ogan Komering Ilir, South Sumatera

Chemical Parameter	Unit	Plant Health	
		Diseased Palm	Healthy Palm
pH H20		5.56 (SA)	5.43(A)
N	%	0.17 (L)	0.14 (L)
Organic Carbon	%	2.04 (M)	1.76 (L)
C/N		12.00 (M)	12.57 (M)
CEC	cmol(+)/kg	9.55 (L)	7.45 (L)
Exchangeable K	cmol(+)/kg	1.09 (VH)	0.79 (H)
Exchangeable Mg	cmol(+)/kg	1.13 (M)	0.85 (L)
Exchangeable Ca	cmol(+)/kg	2.19 (L)	1.62 (VL)
Exchangeable Na	cmol(+)/kg	0.14 (L)	0.11 (L)
P205 Bray	ppm	133.65(VH)	42.88 (VH)
P205 HCl 25%	(mg/100g)	134.10 (VH)	85.33 (VH)
K20 HCl 25%	(mg/100g)	32.03 (M)	16.12 (L)
Exchangeable H^+	cmol (+)/kg	0.55 (M)	0.58 (M)

Classification of soil chemical properties based on Eviati and Sulaeman [18]. A=acidic, SA=slightly acidic; VL=very low; L=low; M=medium; H=high; VH=very high

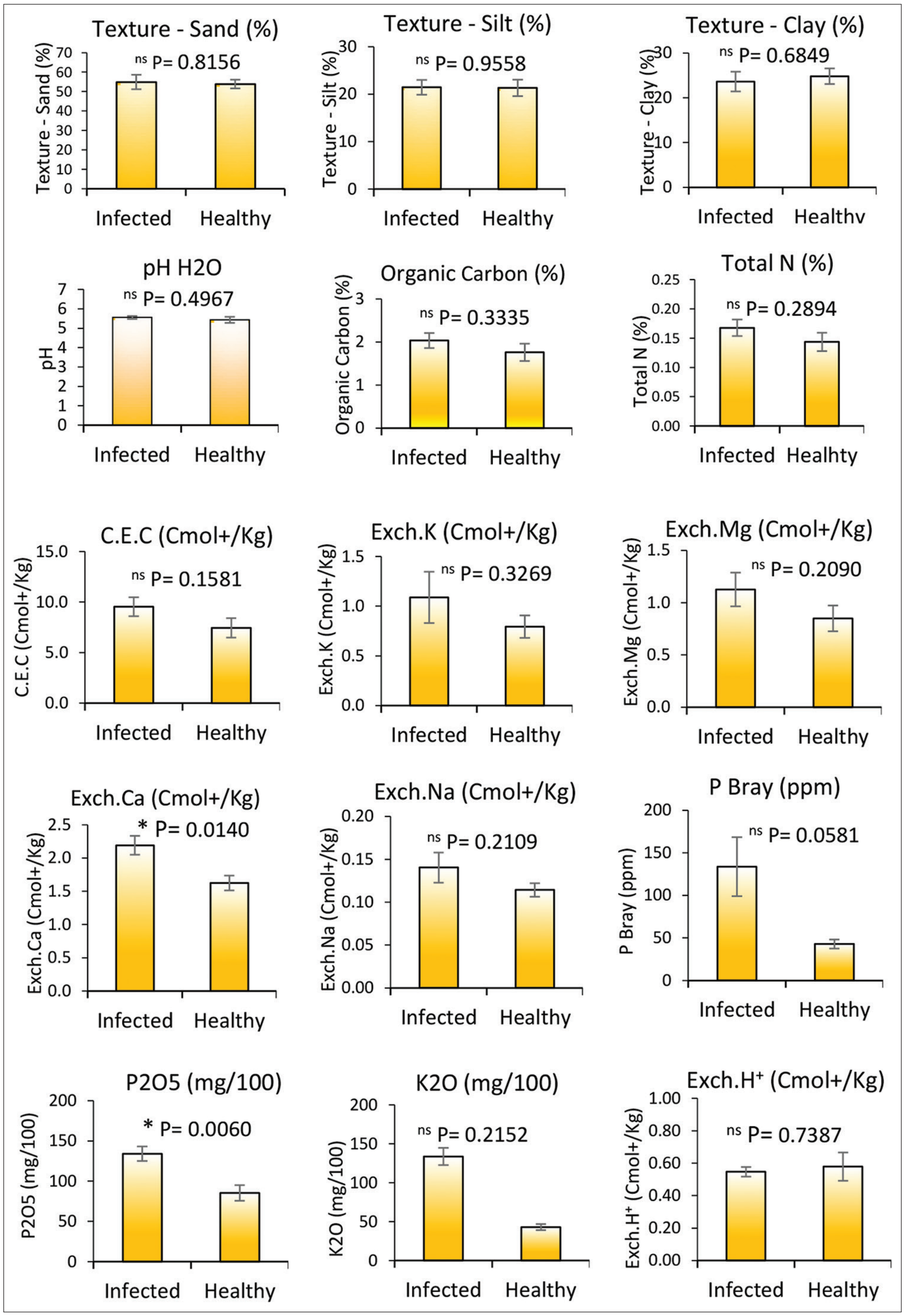

Figure 2: Comparison of soil physical and chemical properties analysis between diseased soil (Infected) and healthy soil (Healthy) of endemic *Ganoderma* oil palm plantation in Mesuji, Ogan Komering Ilir, South Sumatera

The C/N ratio in both soil samples had values with the same range, namely 12 for diseased plant soil and 12.57 for healthy plant soil. The content of CEC, K, Mg, Ca, Na were 9.55, 1.09, 1.13, 2.19, and 0.14 cmol(+)/kg, respectively, in diseased plant soils which tended to be higher, but not significantly different ($P \geq 0.05$) with healthy plant soil (Figure 2). Otherwise, the total P content and available P in both groups of samples were categorized as high. Diseased plant soils were detected to have the highest yields of 134.10 mg/100 and 133.65 ppm and were significantly different when compared to healthy plant soils containing 85.33 mg/100 and 42.88 ppm (Figure 2).

DISCUSSION

In the soil, clay has an important role, especially with regard to the absorption of soil nutrients, while the presence of sand in the composition of the growing media will make it more porous so that it will support faster root growth and become one of the main causes of the transmission process, the existence of root contact between plants that have been infested with *G. boninense* and healthy plants (Semangun, 2000). This is also reinforced by Susanto *et al*. (2013) which explains that the higher the percentage of soil sand fraction will increase the incidence of basal stem rot disease and shows that the speed of *Ganoderma* infection in sandy soils is due to the physical properties of loose sandy soil or high porosity so that the roots plants will move more quickly to the source of *Ganoderma* inoculum.

According to Puspika and Pinem (2018), the higher sand content in soil infested with *G. boninense* indicates that the soil contains less organic matter when compared to healthy plant soil. Organic matter is a source of food for soil microorganisms, so if a soil has a low organic matter content, the abundance of health agents will also be low, while the population of *G. boninense* will continue to increase. This is also in line with what was explained by Susanto *et al.* (2013) and Goh *et al.* (2020), that the role of organic matter in suppressing the development of pathogens is not only by increasing soil microbial activity, but also by improving root health to make plants more resistant to disease.

Characterization results from soil samples taken from plantation soils in Mesuji District, Ogan Komering Ilir, South Sumatra, tend to have slightly acidic and acidic soil characteristics. Soil chemical properties that affect the rate of *Ganoderma* infection in the soil, one of which is pH. Based on laboratory tests, *G. boninense* can grow in the pH range of 3.0–8.5 with an optimal temperature of 30 °C and its growth is impaired at 15 and 35°C, and cannot grow at 40 °C (Susanto *et al*., 2013). An increase in soil pH can directly affect the increase in the intensity of basal stem rot disease. The increase in the intensity of this disease is caused by the increasing number of pathogenic populations that infect plants (Bande *et al*., 2016).

The availability of nutrients is also influenced by the nature of the soil, one of which is the total amount of cations that can be exchanged in the soil which is called the Cation Exchange Capacity (CEC). Soil CEC describes the ability of the soil to hold or absorb plant nutrients in the form of cations available to plants, so the higher the CEC value, the more nutrients it can absorb (Nazari *et al*., 2020). However, soils that were severely exposed to basal stem rot disease had higher CECs than *Ganoderma* suppressive soils (Goh *et al*., 2020).

Anticipation that can be done at the low nutrient content is by good soil management and providing adequate and balanced nutrient elements in the area around the plate or plant rhizosphere area. The addition of organic matter, such as the application of oil palm bunches or compost, participates in increasing the improvement of nutrients in the soil (Nazari, 2020).

The ratios of C/N, exchangeable K and exchangeable acidity in healthy and diseased soils were both moderate to high. There are several nutrients that have high to very high levels, namely phosphorus and potassium. The high phosphorus content in both samples in both diseased plant soil and healthy plant soil was caused by phosphorus (P) ions bound by metals such as Al, Fe, Mn that had been released, so that they were available in the soil solution. The liberation of phosphorus ions from these metals is assisted by soil organic matter which has organic acids capable of binding Al, Fe, and Mn metals from the soil solution. Then form complex compounds that are difficult to dissolve (Puspika & Pinem, 2018).

Soil of diseased plants had a higher available P content than healthy plants. Similar results were found in the study of Goh *et al*. (2020) who reported high levels of available P in basal stem rot conducive soils compared to those of suppressive soils. The total P content in the *Ganoderma* endemic land in Mesuji, South Sumatera was much lower than in the heavily affected area of *Ganoderma* in Malaysia, which was in the range of 275−960 ppm.

The chemical condition of the soil of diseased plants appeared to be higher than that of the soil of healthy plants, in fact, it did not show any significant effect on the presence of *G. boninense*. This is because overall the two soil groups are categorized as low in terms of soil chemical fertility. Therefore, the difference in nutrient content has no effect on plant health. The presence of nutrients, both macronutrients, performs its role through plants. Plants with adequate nutrients will grow healthy and resistance to pathogen infection will increase, so that plants are not susceptible to disease.

CONCLUSIONS

Physical properties (texture) and chemical properties (nutrient status) in basal stem rot diseased and healthy soil were not significantly different, namely they had the same low analytical values in terms of the content of N, C-organic, CEC, Mg, Ca, Na, and K2O. The ratios of C/N, exchangeable K, and exchangeable acidity in healthy and diseased soils were both moderate to high. The content of available P and total P was very high (43−134 ppm) and was found to be higher in the soil of diseased plants than in healthy plants. These results indicated that high availability of P nutrients may favor *G. boninense* infection in oil palm plantation.

REFERENCES

1. Bande, L. O. S., Wahab, A., Bambang, H., Somowiyarjo, S., & Sunarminto, B. H. (2016). Correlation of physical and chemical soil characteristics with intensity of foot rot disease of black pepper. *Jurnal Littri, 22*(2), 63-70.
2. Cepeda, M. C. (2006). Assessing soil microbial populations and activity following the use of microbial inoculationts: Efffects on disease suppressiveness and soil health. Master Thesis, Auburn University.
3. Directorate General of Estate Crops. (2020). Statistical of National Leading Estate Crops Commodity 2019 – 2021. Retrieved from https://ditjenbun.pertanian.go.id/?publikasi=buku-statistik-perkebunan-2019-2021
4. Goh, Y. K., Muhammad, Z., Hanifah, M. Z, You, K. G, Qasim, A., & Adeline, S. Y. T. (2020). Determining soil microbial communities and their influence on *ganoderma* disease incidences in oil palm (*Elaeis guineensis*) via high-throughput sequencing. *Biology, 9*(12), 424. https://doi.org/10.3390/biology9120424
5. Hartono, N. (2013). Pengaruh biaya produksi terhadap pendapatan usaha perkebunan kelapa sawit (*Elaeis guineensis* Jacq) di Desa Bukit Raya Kecamatan Sepaku Kabupaten Penajam Paser Utara. *EPP, 10*(1), 20-27.
6. Hushiarian, R., Yusof, N. A., & Dutse, S. W. (2013). Detection and

control of *Ganoderma boninense*: strategies and perspectives. *SpringerPlus, 2*, 555. https://doi.org/10.1186/2193-1801-2-555
7. Janvier, C., Villeneuve, F., Alabouvette, C., Edel-Hermann, V., Mateille, T., & Steinberg, C. (2007). Soil health through soil disease suppression: Which strategy from descriptors to indicators? *Soil Biology and Biochemistry, 39*(1), 1-23. https://doi.org/10.1016/j.soilbio.2006.07.001
8. Kamu, A., Chong, K. P., Idris, A. S, Darmesah, G., & Ho, C. M. (2021). Estimating the yield loss of oil palm due to *ganoderma* basal stem rot disease by using Bayesian model averaging. *Journal of Oil Palm Research, 33*(1), 46-55. https://doi.org/10.21894/jopr.2020.0061
9. Lisnawita, Hanum, H., & Tantawi, A. R. (2016). Survey of basal stem rot disease on oil palms (*Elaeis guineensis* Jacq.) in Kebun Bukit Kijang, North Sumatera, Indonesia. *IOP Conference Series: Earth and Environmental Science, 41,* 012007. https://doi.org/10.1088/1755-1315/41/1/012007
10. Nadhrah, N. I., Nulit, R., & Nurrashyeda, R. (2015). Effect of formulated bioorganic containing *Burkholderia* GanoEB2 in suppressing *Ganoderma* disease in oil palm seedlings. *Plant Protection Science, 51*(2), 80-87. https://doi.org/10.17221/26/2014-PPS
11. Nazari, Y.cA. (2020). The conditions of nutrient status in soil and leaf elements of oil palm (*Elaeis guineensis* Jacq.) in BPSBP Kalimantan Selatan. *Ziraa'ah, 45*(3), 274-284.
12. Purba, J. H. V., & Sipayung, T. (2017). Perkebunan kelapa sawit indonesia dalam perspektif pembangunan berkelanjutan. *Jurnal Masyarakat Indonesia, 43*(1), 81-94.
13. Purnama, M. I., Prihatna, C., Gunawan, A. W., & Suwanto, A. (2012). Isolasi dan identifikasi secara molekuler *Ganoderma* spp. yang berasosiasi dengan penyakit busuk pangkal batang di kelapa sawit. *Jurnal Fitopatologi Indonesia, 8*(1), 9-15.
14. Puspika, M. A., & Pinem, M. I. (2018). The physical and chemical soil properties of the soil suppresive to existence of *Ganoderma boninense* on the oil palm. *Jurnal Online Agroekoteknologi, 6*(2), 356-361.
15. Semangun, H. (2000). *Penyakit-Penyakit Tanaman Perkebunan di Indonesia*. Yogyakarta, Indonesia: Gadjah Mada University Press.
16 Soil Research Institute. (2009). Technical quidance – second edition: Chemical analyses of soils, plants, waters, and fertilizers. Retrieved from https://balittanah.litbang.pertanian.go.id/ind/dokumentasi/juknis/juknis_kimia2.pdf
17. Susanto, A., Prasetyo, A. E., & Wening, S. (2013). Infection rate of *Ganoderma* at four soil texture classes. *Jurnal Fitopatologi Indonesia, 9*(2), 39-46. https://doi.org/10.14692/jfi.9.2.39
18. Turner, P. D. (1981). *Oil Palm Diseases and Disorders*. Oxford, UK: Oxford University Press.
19. United States Department of Agriculture. (1987). Soil mechanics level 1 - Module 3 - USDA Soil textural classification study guide. USDA Soil Conservation Service. Retrieved from https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044818.pdf