

## Application of organic fungicide in controlling basal stem rot disease for mature oil palm

*Aplikasi fungisida organik untuk pengendalian penyakit busuk pangkal batang pada tanaman kelapa sawit produktif*

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### Abstrak

*Ganoderma* merupakan patogen utama pada perkebunan kelapa sawit. Beberapa usaha pengendalian telah dilakukan namun belum ditemukan fungisida pengendali yang efektif. Penelitian ini bertujuan untuk mengoptimasi aplikasi fungisida organik yang dikombinasi dengan hormon yang telah teruji secara *in vitro* efektif mematikan *Ganoderma* sp. khususnya berkaitan dengan penetapan dosis dan interval waktu pada tanaman kelapa sawit berumur 13 tahun. Kegiatan ini merupakan aplikasi lanjutan pada perlakuan terbaik dari studi satu tahun sebelumnya yaitu aplikasi fungisida organik tiap minggu (1m) dan tiap dua minggu (2m). Perlakuan yang diuji adalah dosis fungisida organik yakni 0 (0x), 1 kali (1x), dan 2 kali (2x). Hasil percobaan menunjukkan aplikasi fungisida organik terbaik adalah aplikasi tiap minggu sekali dengan dua kali dosis (1m.2x), berdasarkan parameter penghambatan pembentukan tubuh buah *Ganoderma* sp., pembentukan akar primer dan sekunder, dan membukanya daun tombak. Perlakuan ini juga meningkatkan hasil TBS sebesar 70% dan bobot TBS 78% dibandingkan dengan kontrol. Hasil ini menunjukkan bahwa aplikasi fungisida organik dapat memulihkan kesehatan kelapa sawit yang terinfeksi *Ganoderma* sp.

[Kata Kunci : *Ganoderma* sp, fungisida organik, dosis, frekuensi aplikasi, panen]

### Abstract

*Ganoderma* is a major pathogen in oil palm crops. Some efforts related to control the growth of *Ganoderma* have been conducted but still have not found an effective method. This study aims to develop an organic fungicide that has been tested *in vitro*, which effective in controlling the growth of *Ganoderma*. The optimization carried out includes the determination of the dose and time interval for application in 13-year-old mature oil palm. This organic fungicide application was the continuation of application during the previous year especially for the two best treatment which is application organic fungicide every week (1w) and every two weeks (2w). In this study, the treatments tested were

three levels dose of organic fungicide (0, 1x and 2x) and two types of frequency application, i.e. every week (1w) and every other week (2w). The results showed that the best application of organic fungicides was every week application with twice doses (1w.2x), based on the parameters of the inhibition of *Ganoderma*'s fruiting body formation, primary and secondary root formation, the opening of spear leaves, and harvesting parameters. The application of organic fungicide able to recover the oil palm infected *Ganoderma* sp., with increasing the fresh fruit bunch and its weight around 70% and 78%, respectively.

[Keyword: *Ganoderma* sp, organic fungicides, dose, frequency of application, yield]

### Introduction

*Ganoderma* sp. that caused basal stem rot disease is a major pathogen in oil palm cultivation. Nowadays, *Ganoderma*'s infection is increasingly widespread so that the level of loss is even greater. Paterson (2019) stated that the spread of *Ganoderma* infection is caused by extreme climate change and it is predicted that after 2050 there will be a decline in palm oil production if there is no significant action for controlling the *Ganoderma*. A lot of efforts have been widely practiced by planters both in Indonesia and Malaysia. However, they have not find a significant results. Some of the techniques of controlling the basal stem rot disease caused by *Ganoderma* that have been carried out included the manufacture of isolation trenches, soil mounding, using big planting holes and generating resistant plants. However, these efforts have not resulted maximum results. Hushiarian *et al* (2013) describes the effective steps that can be taken to prevent *Ganoderma* attack, by detection the early stages of infection through molecular approaches using PCR, RAPD, ELISA and other advance technology such as electronic nose (Kresnawaty *et al.*, 2020), up to the application of biological controls utilizing bacterial endophyte which enviromentally friendly.

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Indonesia has a very high biodiversity including spices. This material are increasingly being used as a source of bioactive phytochemicals for prevention of pathogenic diseases (Okogbenin *et al.*, 2014; Liu *et al.*, 2017; Kothikar & Konche, 2017; Dzoyem *et al.*, 2014). Some types of spices which are often used as active ingredient components for organic fungicides have broad spectrum anti-fungal activity such as galangal, turmeric, ginger, essential oils, garlic, leaves of neem, tea, coffee, eucalyptus, both in a combination or derivative formulae. The active ingredient is reported to be effective as an anti-fungal both in food, humans, animals and plants (Berquist, 2003; Beckerman, 2008; Stockman & Oppong, 2006). However, still no report that they were used to overcome the pathogenic fungus *Ganoderma* in the oil palm. Based on the previous research by Santoso *et al.*, (2013), the application of organic fungicides and hormones were tested separately either in vitro or in vivo. The addition of hormones in organic fungicide formulation increases the effectiveness of the organic fungicide in the control basal stem rot disease caused by *Ganoderma* in the oil palm seedling. Hence, we use organic fungicides based on garlic ingredients to take the advantage of its natural components. This organic fungicide has been used in several attempts, one of those was in Widiastuti *et al.* (2016). From the treatment tested, frequency application of every weeks and every two weeks resulted in the inhibition of *Ganoderma* growth as shown by no appearance of the *Ganoderma*'s fruiting body and the highest yield of oil palm fresh bunches (Widiastuti *et al.*, 2016). On a molecular basis, the utilization of organic fungicides showed significant results, approximately 96.4% killed *Ganoderma*. In addition, the development of reproductive organs (sex ratio) increases within 10 to 12 weeks. However, to obtain an effective application of organic fungicides in the long term observation, the optimization of the dose and application frequency are importantly needed. This study aims to obtain the optimum conditions of application of organic fungicides on oil palm infected with *Ganoderma* sp. especially for the second year application.

### **Materials and Methods**

#### *Application of organic fungicides and hormones*

The experiment was carried out in the 13-year-old oil palm plantation located in Cislak Baru, Banten with the mortality rate due to *Ganoderma* sp around 2-3% per ha. In the experimental area, organic fungicide application has been carried out for three months, from 24 March until June 2014. The source of organic fungicides was from local plant extract containing activities of

phytohormones and fungicides (garlic and clove). In order to understand the long term effect of organic fungicide, we tried to continue the application for three months in the following year, start from 20 May 2015 up to August 2015. The doses and frequency of application shown in Table 1.

In this study, each treatment were applied to 8 plants samples and 25 plants as control. Organic fungicides were applied to the base of the stem tissue that had been cleaned from *Ganoderma* sp. colonization. Application of organic fungicide was done by spraying the dilute solution and incubating for 30 minutes, then the hormones consists of Gibberellin, Auxin and Zeatin were applied. After the application of organic fungicides and hormones, the stem tissue where has been scraped, were piled up using soil mounding. Soil mounding mixture consists of sub-soil, ash and sludge (5: 1: 1, v / v / v) were then applied 10 kg per plant. Soil mounding application focused on parts which has hollow to prevent landslides, then the frond was placed on the top of soil mounding. In addition, organic fertilizer was given at a dose of 1.5 kg each stem using pocket system in the hair root area.

#### *Observation of plant development after the application of organic fungicides and hormones*

To study the long term effect of organic fungicides on *Ganoderma* symptom in oil palm trees, the observations were made at 2, 4, 6, 8, 10 and 12 weeks in the second year applications start on May 20th. Observations parameters were included the formation of *Ganoderma*'s fruiting body, primary and secondary root formation, and spear leaves. To determine the yield rate including the number, weight and average weight of fresh fruit bunches was calculated from 14th until 23rd weeks after organic fungicide application finished in the second year on August.

### **Results and Discussion**

Basal stem rot disease caused by *Ganoderma* sp. begins with symptoms of closed leaf buds, so that the leaves looked elongated and shaped like a spear. In relatively old oil palm plants, the lower leaves fall out and hanged from the point attached to the trunk. This symptom is followed by the fall of young leaves which turn green to pale yellow. At the end, the base of the stem starts to blacken as a sign of the emergence of *Ganoderma* (Corley & Tinker, 2015). Those indication were then used as the observation parameters.

The important steps to decide the application of organic fungicides should consider the number of application and the dosage which will be used. Therefore, the conditions required for successful resistance management are in contrast to those necessary for effective disease control. However, the frequency of applications and dosage should be optimally balanced, leading to an effective and

Table 1. Frequency of application and concentration of organic fungicides and hormones per palm tree in each treatment  
 Tabel 1. Frekuensi aplikasi dan konsentrasi fungisida organik dan hormon pada tiap pohon kelapa sawit untuk masing-masing perlakuan

Treatment Perlakuan	Frequency Frekuensi	Concentration of organic fungicide (%) Konsentrasi fungisida organik (%)	Hormones concentration (ppm) Konsentrasi hormon (ppm)
Control/ Kontrol	-	-	-
1w.0x/1m.0x	-	-	-
1w.1x/1m.1x	Once per week	10	15
1w.2x/1m.2x	-	20	30
2w.0x/2m.0x	-	-	-
2w.1x/2m.1x	Every two weeks	10	15
2w.2x/2m.2x	-	20	30

sustainable disease control (Van den Berg *et al.*, 2016). Widiastuti *et al.*, (2016) reported that the best treatment was to manage the application of organic fungicide every week and every two weeks based on root growth, regrowth of *Ganoderma*'s fruiting body, and spear leaf development. The application of organic fungicide also increasing the number of fresh fruit bunches and oil yield (Widiastuti *et al.*, 2016). Based on Widiastuti *et al.*, (2016), the experimental area was then treated with the re-application of the organic fungicide. This study therefore assesses the best combination of dosage and the frequency of applications to optimize the management of organic fungicide.

#### *The effect of organic fungicide application on the oil palm infected by Ganoderma*

The parameters observed were fruiting body formation after fungicide organic application. In the control group, *Ganoderma*'s fruiting body was observed in the week-2 up to week-12. The significance found in the week-6. In the treated group, *Ganoderma*'s fruiting body was not found at all (data not shown). This data shows that after three months application of organic fungicides, the growth of fruiting body was inhibited.

The primary root was observed only in the 1w.1x and 2w.2x treatment group, especially in the week 6 up to 8, but not in the control group. While secondary root development was observed also in the 1w.1x and 2w.2x treatment group. The 1w.0x group which is no application of organic fungicides in the second year, shows no development of secondary root. The data revealed that the organic fungicides application induce root formation both secondary and primary root. *Ganoderma* sp. infect the oil palm through the root and this infection causes the root to rot and the plant could not absorb water and nutrient that caused spear leaves formation. The formation of root in the oil palm treated with organic fungicide will recover the root function as water and nutrient absorption.

One of the *Ganoderma* symptom is yellowing start from the lower leaves and expanded to the middle part of the crown and form the spear leaves (Hushiarian *et al.*, 2013). This condition might related to the lack of water and nutrient intake as

negative results of *Ganoderma* colonization in the stem of oil palm. It became more severe when the trunk of oil palm which responsible to transporting the nutrients to the crown part has been rotten. It eventually results in the un-opening of spear leaves (Bahari *et al.*, 2018). Our study found that control plants have a tendency to form spear leaves. Whereas the treatment of organic fungicides every week (1w.1x, 1w.2x) and every two weeks (2w.0x, 2w.1x, and 2w.2x) showed that spear leaf formation also occurred but decrease in their numbers as observed in week 12 (Table 2). These results indicated that the application of organic fungicides inhibits the development of *Ganoderma* sp., then positively regulated the water and nutrients uptake from the root, causing the opening of spear leaves. It leads to the increasing of photosynthesis rate so that the development of plants and its bunches formation will be improved. Some of the factors affecting plant productivity are the quality and quantity of photosynthetic incident light (or photosynthetic active radiation, PAR), the availability of temperature and water, the availability and the use of mineral resources, photorespiratory losses, and the prevalence of contaminants in the environment and in the soil (heavy metals, etc) (Jaafar & Ibrahim, 2014).

In the literature, the notion of photosynthetic efficiency involves several different terms including photosynthetic rate, carbon assimilation quantity yield, and PSII photochemical efficiency, which is often expressed as a variable to maximum fluorescence ratio (Xu & Shen, 2000). Both photosynthetic rate and quantum yield are related to leaf, cell, and chloroplast characteristics and environmental conditions. Photosynthetic rate is often expressed as the number of CO<sub>2</sub> fixed or O<sub>2</sub> molecules produced per unit leaf area per unit time, while the quantum yield is expressed as the number of CO<sub>2</sub> fixed or O<sub>2</sub> molecules absorbed per photon. Raising the CO<sub>2</sub> gives an advantage of economically important crops, such as oil palm as the C3 plants. The photosynthesis efficiency of the entire plant is crucial for agriculture, forestry, ecology, etc. when it comes to analyzing food and fuel productivity and many other users of products (Jaafar & Ibrahim, 2014).

Table 2. The dynamics of the percentage of oil palm tree with spear leaf at 2 to 12 weeks after the application of the organic fungicide in the second year

Tabel 2. Dinamika persentase pembentukan daun tombak pada pengamatan minggu ke-2 hingga 12 setelah aplikasi fungisida organik tahun kedua

Treatment Perlakuan	Weeks / Minggu					
	2	4	6	8	10	12
Control/Kontrol	0	0	0	4	16	8
1w.0x/1m.0x	0	0	0	0	0	0
1w.1x/1m.1x	25	25	25	25	25	0
1w.2x/1m.2x	13	13	13	13	25	13
2w.0x/2m.0x	13	13	13	13	13	0
2w.1x/2m.1x	0	0	0	13	38	13
2w.2x/2m.2x	13	25	25	38	38	38

#### The effect of organic fungicide application on the oil palm yields

The number of fresh fruit bunches (FFB) is observed to estimate the production of bunches which will be obtained. The application of organic fungicide every week and every two weeks with twice doses (1w.2x and 2w.2x) showed the highest number of FFB compared to other treatments. While the control group (K) showing the lowest number of fresh fruit bunches formation (Table 3). This showed that the treatment of organic fungicides was able to recover the oil palm condition and improving the number of fresh fruit bunches.

The application of organic fungicides appears to positively affect the oil palm development in terms of yield production. Based on the total fresh fruit bunches and weight bunches harvested, the application of organic fungicides once a week with twice the dose (1w.2x) produces the highest results (Table 4). The increase of the number of fresh fruit bunches and the weight of fresh fruit bunches is around 70% (around 0.93 additional fresh fruit bunches) and 78% (increasing 17.70 kg) respectively compared to control (K) without organic fungicide. The best application of organic fungicides to the plants every week is in harmony with the results of Widiastuti *et al.* (2016), revealed about the increase of the complexity of the roots system and average weight of the bunches after 3 months application.

According to Minarsih *et al.*, (2018), data observation of the type and number of plant flowers palm oil that has been treated with organic fungicides for 12 weeks indicates that sexual development tends to increase, although the results are quite fluctuated. This data emphasizes that the application of organic fungicides every week helps oil palm which infected with *Ganoderma* to gain a

better yield rate in terms of the number of fresh fruit bunches and their weight as well. Though it might be the accumulation response of the organic fungicide application from the last year application, since there was also hormone application in the first year (Widiastuti *et al.*, 2016).

The factors that determined the yield rate of oil palm has been explained clearly by Woittiez *et al.* (2017) in their review. It stated that the ripe bunches number strongly affected by the inflorescence number and also related to the leaf production (Gerritsma & Soebagyo, 1999); sex ratio (Adam *et al.*, 2011); cancellation of female inflorescence before anthesis (Pallas *et al.*, 2013) and bunches failure and ripeness development (Combres *et al.*, 2013). Several components set the bunches' weight, such as the number of spikelets, the number of flowers per spikelet, the fruit set which determined by pollination efficiency, the weight per fruitlet and also the weight of non-fruit bunches (Broekmans, 1957).

However, the average weight per bunch showed no significant differences between controls and the treatment with organic fungicides, even though the average bunches weight of 1w.2x treatment is in the top rank compare to those other treatments (Table 4). The average weight of bunches was retrieved from a total weight of fresh fruit bunches divided by total number of bunches. Oil palms continue to produce bunches of fruit until death, but replanting at 20–25 YAP is needed when palms become too large for economic harvesting or when yields fall due to the loss of palms due to pests and diseases (Woittiez *et al.*, 2017). Moreover, oil palm fruit bunches take several years to develop, and between the onset of stress factors and their impact on yield, there is a time lag of 20–30 months. That makes the effects of individual factors difficult to separate and quantify (Adam *et al.*, 2011).

Table 3. The number of FFB found in the oil palm tree at the time of 2 to 12 weeks after the application of the organic fungicide in the second year

Tabel 3. Jumlah tandan buah segar (TBS) pada kelapa sawit minggu ke-2 hingga 12 setelah aplikasi fungisida organik tahun kedua

Treatment/ Perlakuan	Weeks / Minggu						
	0	2	4	6	8	10	12
Control/Kontrol	1.88	2.04	1.96	2.12	1.92	1.44	1.68
1w.0x/1m.0x	3.50	3.38	2.63	2.50	2.50	3.00	2.13
1w.1x/1m.1x	3.63	3.00	3.50	3.50	3.38	3.13	2.88
1w.2x/1m.2x	2.50	4.88	0.44	4.38	4.38	3.63	3.50
2w.0x/2m.0x	3.50	3.63	2.88	4.88	4.38	3.13	2.75
2w.1x/2m.1x	3.57	3.50	3.38	4.13	4.00	3.13	3.13
2w.2x/2m.2x	3.25	3.38	2.88	4.00	3.88	4.00	4.75

Table 4. The number of harvested FFB, weight per bunches (kg), and average of bunches weight (kg) after the application of the organic fungicide in the second year

Tabel 4. Jumlah tandan buah segar (TBS) setelah panen, bobot tandan (kg), dan rerata bobot tandan (kg) setelah aplikasi fungisida organik tahun kedua

Treatment/ Perlakuan	Number of harvested fresh fruit bunches/ Jumlah TBS dipanen	Total bunches weight of bunches (kg)/ Total bobot tandan (kg)	Average of bunches weight (kg)/ Rata-rata bobot tandan (kg)
Control/Kontrol	1.32	22.71	17.20
1w.0x/1m.0x	1.63	30.61	18.78
1w.1x/1m.1x	1.00	17.11	17.11
1w.2x/1m.2x	2.25	40.41	17.96
2w.0x/2m.0x	0.50	7.63	15.25
2w.1x/2m.1x	1.25	18.74	14.99
2w.2x/2m.2x	1.63	26.01	15.96

### Conclusion

The application of organic fungicides with a frequency of every week with twice doses in the second year shows the increasing number and weight of fresh fruit bunches. The positive effect of this treatment is strengthened by the decrease of spear leaves. In general, the application of organic fungicide in oil palm infected by *Ganoderma* indicated to improve the plant health, decrease the number of the fruiting bodies of *Ganoderma* sp., and stimulate formation of primary and secondary roots. Further field trials with bigger plant samples are needed to confirmed the efficacy of the fungicides.

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