THESIS

SUPPRESSION OF BASAL STEM ROT DISEASE OF OIL PALM USING WATER YAM PLANT (*Dioscorea alata L.*)

This thesis was written to fulfill one of the requirements to accomplish Bachelor Degree (S1) of Plant Protection at Faculty of Agriculture, Sriwijaya University

Rahmad Fadli
05081281621032

PLANT PROTECTION STUDY PROGRAM
DEPARTMENT OF PLANT PEST AND DISEASE
FACULTY OF AGRICULTURE
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SUMMARY

RAHMAD FADLI. Suppression of Basal Stem Rot Disease of Oil Palmusin Using Water Yam Plant (Dioscorea alata) (Supervised by **SUWANDI**).

Stem rot caused by *Ganoderma boninense* Pat., is one of the main important diseases that attack oil palm. This disease is difficult to control because the pathogen inhabiting soil and its symptoms appear after the disease has become severe. The purpose of this study was to determine the effectiveness of water yam plant in suppressing stem rot disease on sterile and non-sterile soil, and to see the effect of water yam plant exudated on the growth of *G. boninense* mushrooms. The study consisted of experiments on sterile and non-sterile soil in the greenhouse as well as in the laboratory. Experiment in greenhouse used pots planted with oil palm seedlings with *G. boninense* inoculum and / or water yam plants. Research in the laboratory used pathogen inoculums exposed by water yam plants that grown accentically on water agar media. Observations were made on the disease variables, namely the percentage of the number of root necrosis, pathogenic aggressiveness and the decaying of inoculum sources; growth variables, namely dry weight, leaf area, height, and root length; and the diameter of the growth of the pathogen inoculums. The results of the study showed that the treatment of water yam plants in unsterile soil could suppress the aggressiveness of *G. boninense*, but did not affect decaying process of the pathogen inoculums and plant growth. The treatment of water yam plants did not affect pathogens and plant growth in sterile soil. In the laboratory experiments, no suppression was found on the exudate of the roots of the water yam plant on the growth of *G. boninense* culture. *G. boninense* inoculation and water yam planting did not significantly cause growth inhibition of oil palm seedlings.

Keywords: Oil Palm, Water yam, Pathogen Inoculum

APPROVAL SHEET

SUPPRESSION OF BASAL STEM ROT DISEASE OF OIL PALM USING WATER YAM PLANT (*Dioscorea alata L.*)

THESIS

As one of one of the requirements to accomplish Bachelor Degree (S1) of Plant Protection at Faculty of Agriculture, Sriwijaya University

By:

Rahmad Fadli
05081281621032

Indralaya, April 2020

Supervisor

Dr. Ir. Suwandi, M.Agr
NIP. 196801111993021001

Approved by,
Dean of Faculty of Agriculture

Prof. Dr. Ir. Andy Mulyana, M.Sc.
NIP. 196012021986031003

Thesis entitled "*Suppresion of basal stem rot disease of oil palm using water yam plant (Dioscorea alata L)" by* Rahmat Fadli had been defended in fornt of Thesis Examination Committee of Faculty of Agriculture, University of Sriwijaya on 21 December 2022 and had been revised accordingly as suggested by examination board team members.

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Examination Committee

1. Dr.Ir. Suwandi, M.Agr. NIP. 196801111993021001	Ketua	(……..)
2. Arsi, S.P., M. Si. NIP. 19851017201510510	Sekretaris	(……..)
3. Dr. Ir. Harman Hamidson NIP. 196207101988111001	Anggota	(……..)
4. Prof. Dr. Ir. Siti Herlinda NIP. 196510201992032001	Anggota	(……..)
5. Dr. Ir Suparman SHK NIP. 196001021985031019	Anggota	(……..)

Indralaya, April 2020

Head of Department
Plant Pest and Diseases

Dr. Ir. Suparman SHK
NIP. 196001021985031019

STATEMENT OF INTEGRITY

The undersigned below:

Name	: Rahmad Fadli
Student Identity Numb	: 05081281621032
Title	: *Suppresion of basal stem rot disease of oil palm using water yam plant (Dioscorea alata L)"*

Hereby stated that all of data and information presented in this thesis is my own result of observation under my supervisor, except those clearly mentioned their source. If in this thesis is found any plagiarism in the future, I will be ready to accept academic punishment from University of Sriwijaya.

This statement is made under conscious without pressure from anyone or any party.

Indralaya, April 2020

Rahmad Fadli
NIM. 05081281621032

BIODATA

Born in Seri Tanjung, Ogan Ilir, Rahmad Fadli is the fourth son of four children. He is the son of Mr. Ismail and Mrs. Siti Hodijah. Starting education at Elementary School SDN 2 Seri Tanjung, Ogan Ilir completed in 2009. Junior High School of SMPN 1 Tanjung Batu, Ogan Ilir. Then in 2012 continued his study in Senir high school in SMAN 1 Tanjung Batu and completed in 2015. During his studentship in SMA, the author was assigned as OSIS and ROHIS apparatus and active in joining various competition on science and nations development.

In 2016, the author was accepted as student in Plant Protection Study Programme, Faculty of Agriculture, Universitas Sriwijaya through SBMPTN student admission scheme. In 2017, the author was assigned as expert staff of academic and achievement of Plant Protection Student Association. The author was also active in organization and joining various competitions at the level of department, faculty up to national level.

ACKNOLEDGMENT

I would like to extend special thanks to The Mightiest Allah SWT for the blessing and grace for me, so that I can finish research and write this thesis entitled Suppression of basal stem rot disease of oil palm using water yam plant (*Dioscorea alata* L).

. The author also thanks to Dr. Ir. Suwandi, M.Agr as the supervisor of this thesis who had supervised dan gave a lot of suggestions from the beginning of the work until the completion. The author also thanks to all of my friends, the members of Gano PTN 2019 team who had paid a lot of attention and provided suggestions to the author until the submission of this thesis. A lot of thanks also go to my parents and family and all parties who have been very supportive to the author.

The author realizes that there many weaknesses in this undergraduate thesis. Therefore, the author appreciates every constructive critic and suggestion with the hope that this work can give contribution as additional information to the existing literatures. Thank you.

Indralaya, April 2020

Rahmad Fadli
NIM. 05081281621032

CONTENTS

Chapter 1
INTRODUCTION

1.1. Background

Indonesia has abundant natural resources which make the country has potential to be the rich and advanced country in the world. The fact that the country is passed by the equator, has made the country has approximately 20.000 plant species or 10% of the plant species in the world (Ditjenbun, 2017). The many types of plants that can live in Indonesia are supported by environmental conditions that are very suitable so that they are very strategic and have good economic value. such as oil palm, rubber, coffee, and other plant species plantation, which continue to experience rapid growth in such environment. Indonesian palm oil itself has the largest area in the world which reaches 14 million ha and continues to grow every year reaching more than 500 ha (Ditjenbun, 2017) Indonesian palm oil as the world's largest producer has an important role in national development in the economy. This role can be seen from the large production and export value of non-oil and gas CPO (Crude palm oil), both as industrial raw materials, cooking oil, as well as as a substitute for biofuel, detergent, soap, compost from empty fruit bunches and various other products (Ministry of Trade RI, 2013).). However, the many roles or benefits of oil palm cultivation also have some serious problems that until now have not found a way to overcome them. The problem started from the attack of plant pest organisms (OPT) stem rot disease caused by the fungus G. boninense Pat. which is very destructive and may cause the death of the plant (Susanto et al., 2013)

Root rot disease caused by pathogenic fungi has reached a dangerous phase in some areas with the percentage of oil palm plant mortality reaching 40% per plantation area (Susila, 2006). The root rot disease of oil palm is one of the main diseases of oil palm. Symptoms of stem rot disease are difficult to detect if only through physiology or morphology because: the disease does not show symptoms and signs of infection at the mild attack level, while at the severe attack level the symptoms appear typical such as fruiting bodies and stunted (Susanto et al., 2013), fruits of the infevted plants fail to ripe, plants tilted due to rotting roots, releasing fruiting body (mycelium), then the plant dies (Govender et al., 2017). Various

control methods have been carried out to control oil palm trunk base rot disease (Fitriani et al., 2017) but it does not produce results in the long term, because the fungus can move to a new inoculum on other plants. Therefore, until now the only control that is considered capable of suppressing the disease is by chopping the plants, and making isolation areas for diseased oil palms (Priwiratama et al., 2014).

The abundance of annual plants in Indonesia, which are classified as very large, has the potential to control cultivated plant pathogens such as perennial herbaceous plants or bulbous shrubs that can live throughout the year and contain many primary compounds or secondary metabolic compounds that are either toxic or allelopathic, such as annual herbaceous plants. Kumalawati et al., 2018). Annual herbaceous plants such as yam (*Dioscorea alata* L.) have fine roots that stimulate and produce exudate from secondary metabolic processes (Pelima, 2012). The exudate formed in the rhizosphere layer is very beneficial for endophytic microbes so that pathogens that will attack the yam will be blocked by endophytic microbes that are ubiquitous against pathogens or are toxic to other pests (Tamaroh et al., 2018). So that this yam plant has the potential to be a biological control against the fungus *G. boninense* which causes stem rot disease. This is also based on the existence of biological control using herbal plants against white root fungus on rubber plants (Suwandi et al., 2017).

Based on this potential, the authors are interested in conducting experiments on oil palm seedlings on sterile and non-sterile soils to determine the effectiveness of yam plants against stem rot disease and to conduct experiments to see the effect of yam plant exudates on the growth of the fungus *G. boninense.*

1.2. Formulation of the problem

As for the formulation of the research problem, how is the effectiveness of yam plants in suppressing stem rot disease of oil palm on sterile and non-sterile soils and how is the effect of yam plant exudates on the growth of the fungus *G. boninense*

1.3. Objectives

The objective of the study was to see how the effectiveness of yam plants against stem rot disease of oil palm on sterile and non-sterile soils and to see the effect of yam plant exudates on the growth of the fungus G. boninense

1.4. Hypothesis

The hypotheses of thisresearch were:

1. It is suspected that the root rot disease of oil palm can be suppressed and the growth of diseased plants can be improved by planting yam in sterile soil conditions.
2. It is suspected that the root rot disease of oil palm can be suppressed and the growth of diseased plants can be improved by planting uwi in non-sterile soil conditions.
3. The root exudate of the purple yam plant is thought to suppress the growth of the fungus G. boninense which causes pan rot disease.

1.5. Benefit

The benefits of the research are being a source of literature on the topic of the effect of tuber root exudates on oil palm stem rot disease, as well as being a source of information for researchers and oil palm plantation business actors in controlling or suppressing the growth and spread of the fungus G. boninense inoculum.

CHAPTER 2
LITERATURE REVIEW

2.1. Palm oil

Oil palm is a plant that was first grown in the West African region. At first, oil palm was only considered as a tropical forest tree, but over time, after various studies, oil palm is proven to be useful as a source of vegetable oil. Oil palm cultivation is growing rapidly, especially in Southeast Asia, more specifically in especially Indonesia, the largest producer of palm oil (Syahfitri, 2007). The entrance of oil palm plant into Indonesia occurred during the Dutch colonial period in 1948, the plant was used as a collection in the Bogor Botanical Gardens, then it became a roadside plant in North Sumatra, until it was finally cultivated on a plantation scale (Susila, 2006). Oil palm cultivation in Indonesia has been recorded to have reached 14,677,560 ha or 0.77% of the total area of Indonesia and continues to grow to reach 25.42% per year (Ditjenbun, 2017). The size of the oil palm plantation areahas been increasing. The classification system or taxonomy of oil palm plants is as follows (ITIS, 2020):

Kingdom : Plantae
Division : Tracheophyta
Class : Magnoliopsida
Order : Arecales
Family : Arecaceae
Genus : Elaeis Jacq.
Species : Elaeis guineensis Jacq.

2.1.1. Palm Oil Morphology

The morphology of oil palm plants according to (Purba and Sipayung, 2017; Rosa and Zaman, 2017), are as follows:

1. Root (radix)

The root type of this plant is fibrous with fairly dense branches and thick fibers as the plant ages. As a monocot plant, the radicle as a potential root in oil palm seedlings will continue to grow until it reaches more than 15 cm down. In productive age plants, oil palm roots can reach deeper than 8 m.

2. Trunk (*Calius*)

The shape of the stem of the palm plant is generally upright and has no branches. This unbranched stem is because the growing point is only at the top where the leaf midrib is formed, it makes the oil palm midrib firmly stick even though it is old and even dead and dry. Therefore, manual cutting is needed to Avoid the dead trunk become a medium for the growth of pathogens or pests in general.

3. Leaves (Folium)

Leaves of oil palm have differences in each phase from seed to production. When still in the nursery, the leaves are single elongated with a tapered tip until they continue to grow, splitting in two and over time will be like a comb with leaf bones horizontally from the midrib.

4. Flowers (Flos)

Flowers from the oil palm will begin to form after the age of 1.5 years after planting in the field. This flower appears in the axil of the leaf midrib and will continue to grow

5. Fruit (Fructus)

Morphologically, the fruit of oil palm is oval in shape with compound fruit or fruit bunches. The weight of 1 fresh fruit bunch (FFB) can reach more than 10 kg. Oil palm fruit itself consists of layers of pericarpium and endocarpium flesh. In this part of the fruit flesh or pericarpium, it contains the yield of vegetable oil or what is often called as vegetable oil.

2.1.2. Palm Oil Growing Requirements

According to Rosa and Zaman (2017), several conditions for growing oil palm in order to grow and develop optimally are as follows:

a. Climate

For the climate, oil palm can live in almost every condition or condition of the tropics with rainfall of more than 2,000 mm/year, duration of sunshine 5-7 hours/day, pH 5-5.5, optimal temperature 24-380C, and humidity 80-80C. 90%.

b. Soil

Soil conditions on oil palm plantations can be almost all types of soils ranging from podzolic, latosol, hydromorphic, alluvial, gley, and organosol. However, oil palm will be optimal on loose, fertile, flat soil and has a good drainage system. The condition of the soil will also be more optimal if the slope of the land is not more than 150 with an altitude of 1-500 meters above sea level.

2.2. Basal stem rot disease

In the process of cultivation, oil palm plants have several major important diseases that can reduce production rates with severity until they reach the death of the plant itself (Goh et al., 2014). One of the main important diseases isbasal stem rot disease caused by fungi. The fungal pathogens that cause stem rot have been identified since 1920 AD in oil palm plantations in West Africa and was identified as Ganoderma (Boulord *et al.*, 2017).

Along with the expansion of the area of oil palm plantations in the world and its introduction into various trophic areas, the pathogens that cause this disease are carried and spread rapidly. At the beginning it was found that this fungus only attacks old plants, but gradually the Ganoderma fungus continues to increase in severity in attacking plants (Susanto *et al.*, 2013). One of the Ganoderma fungi that attacks Southeast Asia oil palms, especially Indonesia, is dominated by the species *G. boninense* (Risanda, 2008).

2.2.1. Taxonomy of *Ganoderma boninense*

The taxonomy of the fungus that causes stem rot in oil palm is as follows (Index Fungorum, 2020):

Kingdom : Fungi

Phylum: Basidiomycota

Class : Agaricomycotina

Order: Polyporales

Family : Ganodermataceae

Genus : Ganoderma K. Karst

Species: *Ganoderma Boninense* Pat.

2.2.2. Disease Life Cycle

The cycle of the fungus *G. boninense* begins with fungal spores attaching to the host through wind, water or other factors. The spores then develop to form fine filaments or hyphae which over time will fuse to form a network of threads or mycelium (Risanda, 2008). This mycelium is responsible for absorbing nutrients and secreting enzymes produced by fungi in the surrounding environment in order to make it easier for fungi to break down complex organic compounds in the host. In the last stage, the mycelium will continue to develop to form clumps into a hard fruiting body and new spores on the underside of the fruiting body which are grayish white (Hidayati et al., 2015).

In the life cycle of the fungus that causes root rot of oil palm trunks, it is very viable and quickly spreads through the roots between intersecting oil palm plants. In addition, the fungus *G. boninense* has many known alternative hosts from the palm tribe and various other plant species, so far 44 plant species from 34 families have been recorded as potential hosts (Afandi et al., 2018).

2.2.3. Symptoms of G. *boninense infection*

Symptoms of the fungus that causes root rot of oil palm basal stem are difficult to know because the development of the symptoms shown by the fungus itself, if there is a fruiting body of the fungus, means that the severity of the attack is very serious and of course it will be difficult to overcome and already reduce production by more

than 50% (Rakib et al., 2017). However, physiological changes ofthe oil palm plant as the host can be seen as several symptoms, such as leaf color that is yellowish necrosis, spear leaves do not expand, and other leaves are pale and sticking downwards (Govender et al., 2017).

In severe attack symptoms, the base of the oil palm trunk will be blackish in color, releasing sap which will eventually become porous so that the plant will easily fall and die (Goh et al., 2014). This physiological symptom of oil palm is not the main symptom which is only caused by *G. boninense* fungal infection but can also be caused by other diseases. Microscopically the symptoms can be seen with the cortical tissue turning brown to white, easily crushed (Susanto et al., 2013). The stele tissue turns black and hyphae and spores will be found in the infected tissue parts (Boulord et al., 2017).

2.2.4. Basal Stem Rot Disease Control

Control of oil palm basl stem rot disease in the short term aims to reduce the rate of infection while in the long term, it aims to prevent oil palms from being attacked by *G. boninense.* Some of the control methods that can be carried out include:

2.25. Monitoring early detection of disease

Monitoring is carried out by observing the physiological visible symptoms of oil palm plants and microscopically from plant tissues that are starting to show signs and knowing the level of disease intensity on the infected trunk (Govender et al., 2017)2. 2. Technical culture

Technical cultural control is carried out by performing sanitation on plants as well as during rejuvenation or early planting on plantation land. Various possible sources of inoculum such as stems, roots to oil palm trunk base, or other wild plants are collected in one place and then chopped or reduced to be processed so that natural decay occurs and turn to compost (Rosa and Zaman, 2017).

3.Chemical

Chemical control is carried out by injecting and spraying at the base of the stem or source of fungal inoculum with systemic fungicides such as those from the Triazol group or others with concentrations for spraying 0.25% as much as 3-5 l/stem or by injection of 20 ml/stem every 6 months (Widiantini et al., 2018).

4. Biological

Utilization of living things such as yam plants as control agents against pathogens that cause stem rot disease of oil palms such as *Trichoderma, Penicillium*, etc. In addition, it can also be done with arbuscular vascular mycorrhizae (MVA). This biological control can be done by spraying the fungal culture or grow yam plant at the base of the stem or in the hole before planting (Widiantini et al., 2018).

2.3. Yam Tuber

Yam r plant as a plant that produces sweet tuber belong to vegetable plant that is rich in carbohydrate sources. Yam tubers are also known as water yam, coconut yam, and several other names according to the region in Indonesia. The classification of yam plants according to ITIS (2020), is as follows:

Kingdom : Plantae
Division : Trachephyta
Class : Magnoliopsida
Order : Dioscoreales
Family : Dioscoreaceae
Genus : *Dioscorea* L.
Species : *Dioscorea alata* L.

2.3.1. Morphology and Biology

The yam plant as a member of the Family of Dioscoreaceae has more than 600 species worldwide. Morphologically, the length of the yam tuber reaches 15-30 cm, the diameter of the yam varies from 5-15 cm (Winarti et al., 2011). The tuber flesh has a purple, white, or yellowish color for *D. alata* species. Tuber plants that belong to herb plants have vine characteristics so they need a vine or a place to propagate. The leaves are love-shaped, green with compound flowers from the leaf axils (Ministry of Agriculture, 2009). On the stems of yam near the axils of the leaves it has a purple color and the other parts are green. For the tubers themselves, this yam in general is in the ground but when the plant is old, it will produce tubers from the leaf axils that hang small or commonly called air tubers (Kumalawati et al., 2018).

2.3.2. Growing Conditions

Yam plants are generally able to live well in tropical areas, either in a field, gardens, or the area surrounding swamps with an altitude of 1-800 meters above sea level up to 2000 meters above sea level (Ministry of Agriculture, 2009). Rainfall required ranges from 1000-2000 mm/year with 40% humidity and pH 5.5-6.5. The environmental conditions desired by the *D. alata* plant, if fulfilled, will grow optimally, but if it is not, like in the dry season, the plant will not grow optimally with tubers rest and maintain water content in the stems, so that when the rainy season comes, the plants will start to produce new shoots and tuber growth will be faster and larger (Directorate General of Horticulture, 2015).

2.3.3. Yam Tuber Content

The yam plant has quite a lot of sap or mucus, especially the *D. alata* species. The sap or mucus contains dioscorin (C12H12O2N) alkaloid compounds which are easily soluble in water (Tamaroh et al., 2018). In addition, the tubers contain calories, protein, fat, carbohydrates, calcium, phosphorus, zinc, vitamin B1, vitamin C, and others. Carbohydrate content in yam tubers is mostly in the form of starch, and also contains inulin, amylose, amylopectin, and fiber. (Winarti et al., 2011; Indrastuti et al., 2012).

CHAPTER 3
RESEARCH IMPLEMENTATION

3.1. Time and place

The research was carried out in the Phytopathology laboratory and greenhouse of the Department of Plant Pest andDiseases, Plant Protection Study Program, Faculty of Agriculture, Sriwijaya University, starting from July 2019-March 2020.

3.2. Tools and materials

The tools used in this research include trays, petri dishes, pots, Erlenmeyer flasks, ose needles, Bunsen, autoclave, laminar airflow, incubators and analytical balances. While the equipment used in the field includes hoes, and net. The materials used included MEA media (Malt extract agar), ethanol, alcohol, plastic warp, PP plastic, *G. boninense* fungal inoculum, yam seeds, oil palm seeds, and pieces of rubber wood. For materials in the field in the form of sterile soil, non-sterile soil, and sand.

3.3. Methodology

The study consisted of three experiments, namely:

1. Experiments on unsterilized soil nurseries in greenhouses

The experiment used a completely randomized design consisting of 6 treatments and 5 replications. The treatments used included (1) oil palm (OP), (2) Oil palm-*G. boninense* (OP G), (3) Oil palm- yam plant (OP A), (4) Oil palm-*G.boninense*- yam plant (OP G A), (5*) G. boninense*-yam plant (GA), (6) *G. boninense* (G).

2. Experiments on sterile soil nurseries in greenhouses

The experiment used sterilized soil using the same design and treatment as the experiment on unsterilized soil.

3. Experiment on agar media in the laboratory

The experiment used 2 treatments with 5 replications. The treatments tested were purple yam root exudate and autoclaved control of yam tuber

3.4. Research Procedure

This research was carried out through several steps as follows:

1. Greenhouse experiment

a. Preparation of *G. boninense* inoculum

Inoculum *G. boninense* planted on rubber wood media measuring 8 x 5.5 cm as many as 250 sticks. The wood is obtained from rubber farmers who are rejuvenating in the Gelumbang area, Muaraenim Regency. The wood is soaked for 24 hours in water and then put into PP plastic size of 1 kg as many as 4 pieces which at the end of the plastic are given a 0.5 inch diameter and 2.5 inch long of a pipe. After that, it was sterilized using an autoclave 2 times. Before the second sterilization, 20 ml of malt extract was added, cotton was added to the tube and then covered with aluminum foil, and tied with a rubber band. After that, *G. boninense* was inoculated in laminar airflow which was then incubated at room temperature in the incubator.

b. Preparation of oil palm seedlings

Oil palm seedlings were obtained from oil palm seedling units of private companies in Indonesia. The palm seedlings were then planted in pots that are ready for planting. For the maintenance of oil palm seedlings, it was watered every day and sanitation or cleaning was carried out from weeds that grow in pots.

c. Preparation of yam seedlings

The yam seedlings used were purple varieties. All varieties of yam were obtained from the Indralaya area. Yam tubers are then planted in a tray in a shaded place until young leaves appear. During seeding, the tubers were watered every morning and treated by cleaning the weeds until they were ready to transplant into pots.

The yam seeds used were purple varieties. All varieties of uwi were obtained from the Indralaya area. Uwi tubers are then planted in a tray in a shaded place until young leaves appear. During seeding, the tubers were watered every morning and treated by cleaning the weeds until they were ready to transplant into pots.

d. Yam seedling transplant

Transplant yam seedling into the experimental pot after having three leaves. Planting is done on the edge of the oil palm seedlings and given a length of 1 m of wood so that the yam can lean on.

e. *G. boninense* inoculum planting

The inoculum of the fungus *G. boninense* that colonized rubber wood was planted in pots that had previously been planted with oil palm seeds and yam plants. The inoculum must be planted until it is in contact with the base of the oil palm stem.

3.4.2. Laboratory test

a. Preparation of water agar media

Water agar medium was made with a concentration of 30 g/L which was poured into a glass jar covered with aluminum foil and sterilized by autoclaving for 20 minutes.

b. Preparation of cultures of *G. boninense*

Preparation of media for fungal growing used MEA (malt extract agar) media with a concentration of 20 g/L which was sterilized in an autoclave for 20 minutes.

Then the media was poured into a petri dish and the fungi were grown from existing cultures

c. Yam extract preparation

Preparation was done by taking yam tubers as treatment which were sterilized using H2O2.

d. Planting yam tubers and *G. boninense* on water agar media

The tubers that had been prepared previously were planted in the middle of the agar surface then planted *G. boninense* at the edges of the media as many as 10 cultures with a diameter of 0.5 cm.

3.5. Variable Observed

3.5.1. Influence on Pathogenicity and Inoculum Potential

a. Percentage of Total Root Necrosis

Observational variables to calculate the percentage level of root necrosis was determined by the formula:

$$I = \frac{n}{N} \times 100\%$$

Note:

I = Disease incidence;

n = Number of infected roots;

N = The total number of roots (Susanto, 2013).

b. Pathogen Aggressiveness

To observe the aggressiveness of stem rot disease pathogens, we use the symptoms on palm roots that were infected by the pathogen using the formula**:**

$$PNA = \frac{n}{N} \times 100\%$$

Note:

PNA = Percentage of root necrosis;

n = length of the necrotic root;

N = observed root length (Yulianti et al., 2017).

c. Inoculum Weathering

Observations on the level of weathering of wood media as a source of nutrients for fungal growth were calculated using the formula**:**

$$P = \frac{W_1 - W_2}{W_1} \times 100\%$$

Note:

P = Percentage of weathering of wood media

W_1 = Initial dry weight

W_2 = dry weight after observation (Herliyana, 2014).

3.5.2. Influence on Growth

a. Dry Weight

The dry weight of oil palm on sterile and non-sterile soil was obtained with oil palm seedlings at the end of the 84th observation after planting (HST) which was

weighed after being in the oven for three days at a temperature of 800C (Setiawan, 2017).

b. Leaf area

Leaf area was obtained by calculating the average leaf length x width of each seedling on sterile and non-sterile soils ranging from 7 days after planting to 84 days after planting. The formula used is**:**

$$A = P\ x\ L\ x\ K$$

Note:

A = Leaf area

P = Leaf length

L = Leaf width

K = Constant 0.55 (Susilo, 2015).

c. Plant height

Plant height was measured from the measurement of the height of oil palm seedlings for each treatment on sterile and non-sterile soil starting from 7 days after planting to 84 days after planting.

d. Root Length

Root length was measured for each oil palm seedling, planted on sterile and non-sterile soil at the age of 84 days after planting**.**

3.5.3. Effect of inoculum exposure

The effect of exposure to pathogenic inoculum on yam plants in the laboratory was observed after 7 days of exposure to two treatments of yam plants and yam plants which were autoclaved. Then the diameter of the growth of *G. boninense* colonies was calculated for four days.

3.5.4. Symptoms and Morphological Characteristics

Symptoms observed at 84 DAP (3 months) included the leaves, roots, and stem base of oil palm seedlings. Morphological characteristics that were also observed

included fruiting bodies (mycelium) that grew, the shape and size of the spores of the post-experimental and pre-experimental pathogenic inoculum, then the characteristics of the post-experimental fungi isolated from the roots, and oil palm seedling stem base from each treatment were observed on MEA+RBBR and MEA+ Tanin media.

3.6 Data analysis

Data analysis was performed using analysis of variance (ANOVA), T test, F test, and 5% BNJ test of mean defferences.

CHAPTER 4
RESULTS AND DISCUSSION

4.1. Results

4.1.1. Symptoms of Root Rot Disease (BPB)

Symptoms of infection from the fungus *Ganoderma boninense* on isolated test plants showed symptoms in the form of spots on oil palm leaves starting at 4 weeks after planting which were reddish in color and gradually expanded to reach the entire leaf (Figure 4.1). Then the symptoms that appeared were also found in the roots with a color that tends to be dark gray-black, the presence of porous and unusual branching with the base of the root branches being dark and swollen with lumps of hyphae of the fungus *G. boninense* (Figure 4.2).

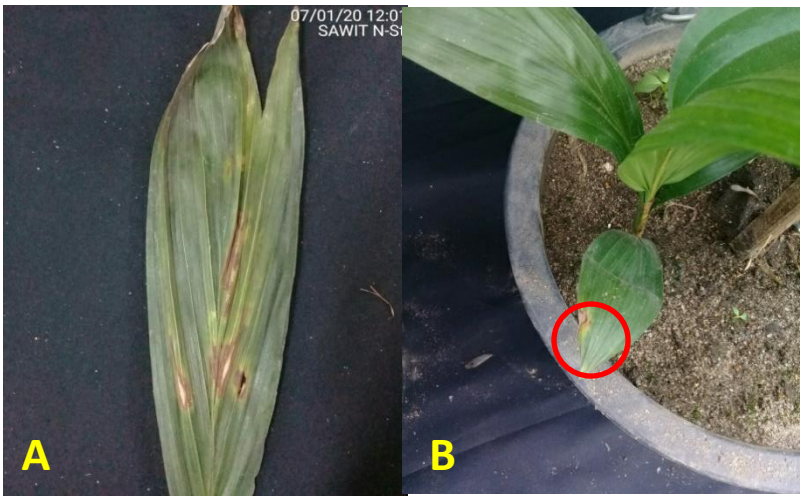

Figure 4.1. Symptoms of palm stem base rot disease on leaves with moderate symptom intensity (A) and mild symptoms (B)

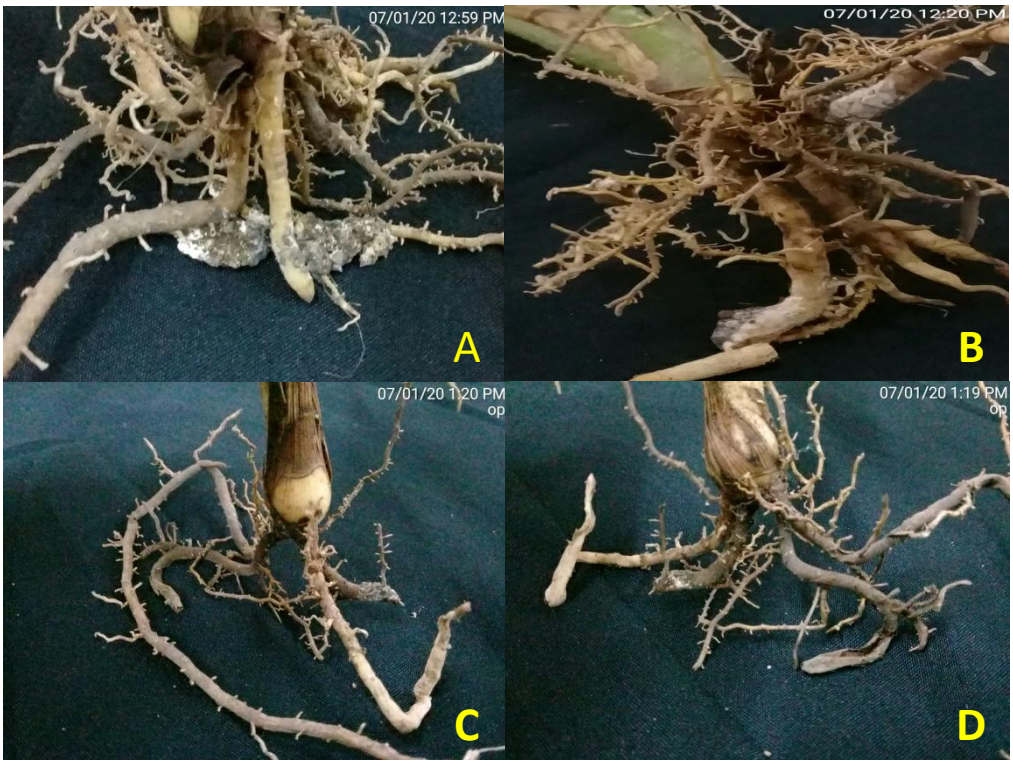

Figure 4.2. Symptoms of BPB disease attack on oil palm roots with symptoms of fungal hyphae at the root tip (A), fungal hyphae at the root base (B), abnormal root growth (C), porous roots (D)

In addition to the leaves and roots of oil palm seedlings, symptoms of BPB disease are also visible from thestem base of the plant. Observation of the symptoms on thestem base was observed by cutting it perpendicularly so that a color difference that tends to darken to blackish gray at the base of the hump can be seen (Figure 4.3) 4.3)

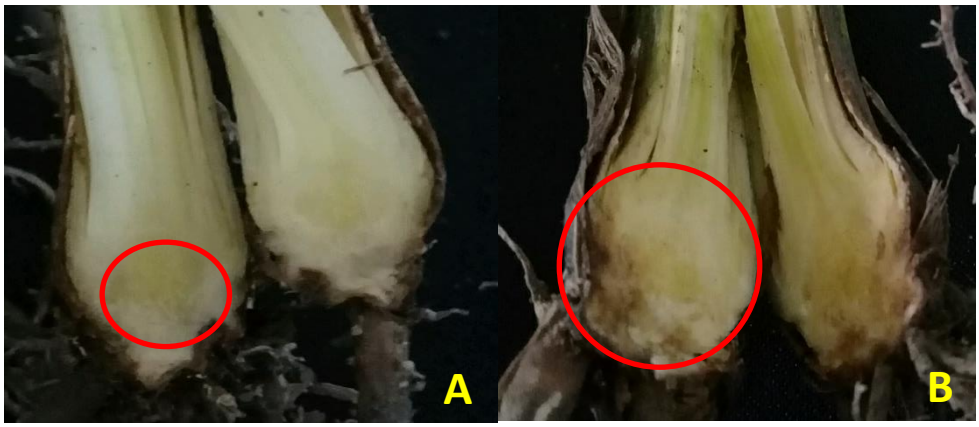

Figure 4.3 Symptoms of BPB disease attack on oil palm stem base in the treatment of herbaceous plants (A) and treatment without herbaceous plants (B)

4.1.2. Influence on Pathogenicity and Inoculum Potential

4.1.2.1. Percentage of Total Root Necrosis

The percentage of root necrosis of oil palm seedlings inoculated with *G. boninense* (OP G) was not significantly different (P = 0.342) with seeds inoculated and planted with yam plants (OP G A) on non-sterile soil**.** On the sterile soil was also not significantly different (P=0.145) the same as the treatment on non-sterile soil (Figure 4.4 and Appendix 1).

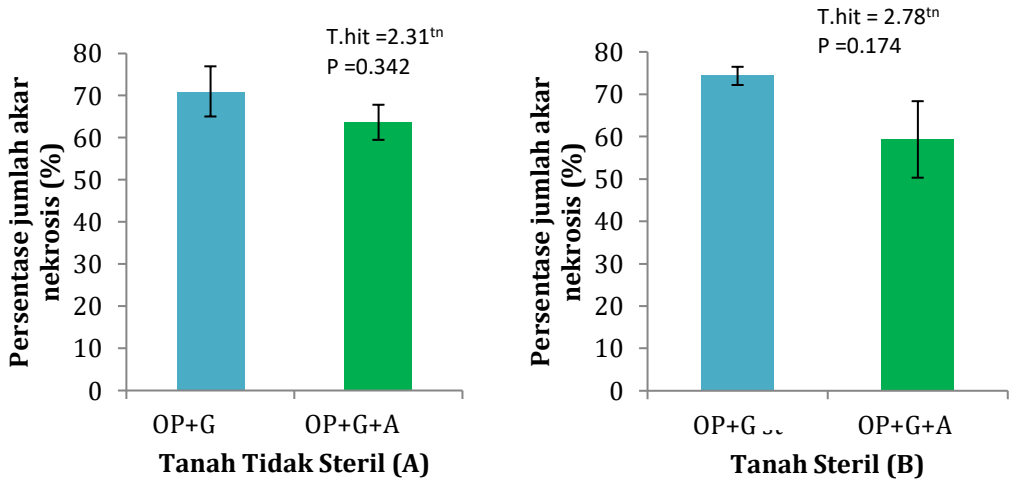

Figure 4.4. Percentage of necrotic root rot in non-sterile soil treatment (A) and sterile soil treatment (B)

4.1.2.2. Pathogen Aggressiveness

The aggressiveness of the pathogen as measured by the percentage of necrotic root length showed no significant difference in sterile soil treatment (P = 0.227), while the non-sterile soil was significantly different (P = 0.016) (Figure 4.5 and Appendix 2**)**

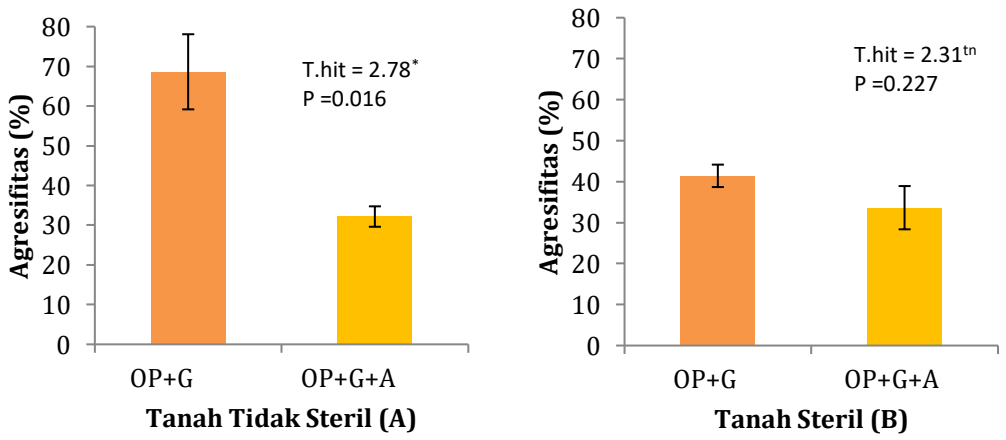

Figure 4.5. Percentage of aggressiveness of root rot disease in non-sterile soil (A) and sterile soil (B)

4.1.2.3. Inoculum Weathering

Weathering of wood media inoculated on non-sterile soil had no significant effect (P=0.338) while on sterile soil treatment had no significant effect (P=0.143). However, there is a tendency for weathering of wood media in the treatment between the two not to inhibit or suppress the weathering process (Figure 4.6 and Appendix 3).

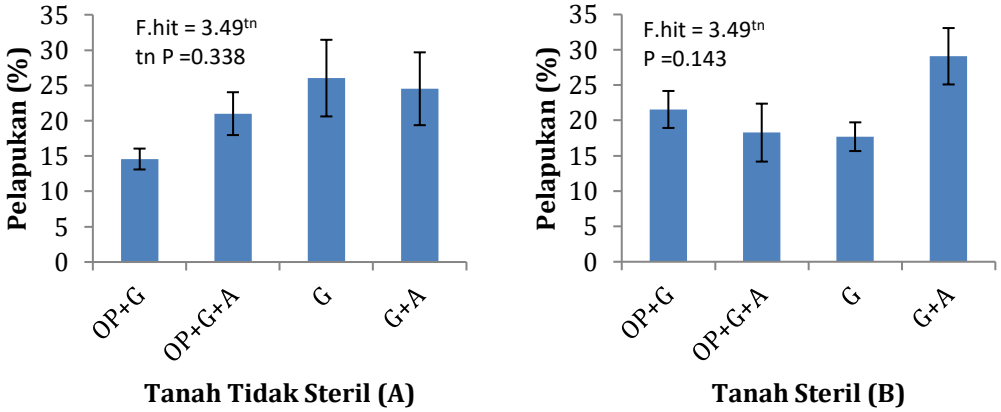

Figure 4.6. Percentage of weathering of wood media on non-sterile soil treatment (A) and sterile soil (B)

4.1.3. Influence on Growth

4.1.3.1. Plant Dry Weight

The growth of oil palm seedlings measured as plant dry weight after 2 months was not significantly (P=0. F.hit = 3.49tn P =0.168 y treatment on non-sterile F.hit = 3.49tn P =0.197 on sterile soil which had no significant effect (P=0.197). Even though, plants inoculated with *G. boninense* and/or yam plants tended to cause growth inhibition (Figure 4.7 and Appendix 4).

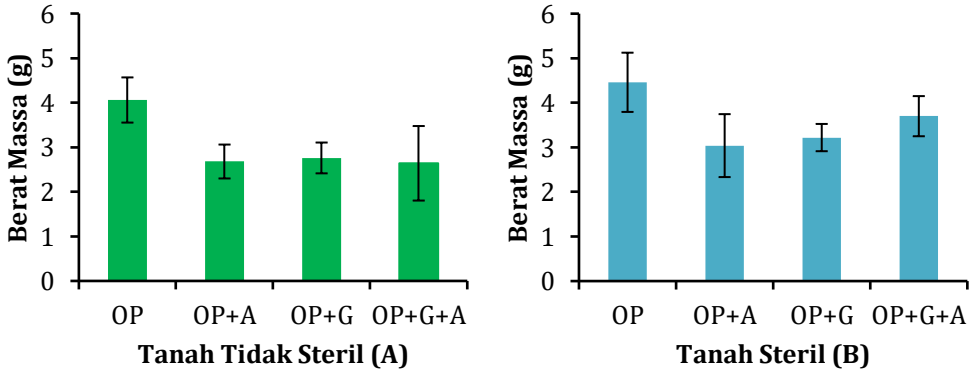

Figure 4.7. Weight Mass of oil palm seedlings planted in unsterile soil (A) and sterile soil (B)

4.1.3.2. Palm Leaf Area

Observations made for calculating the leaf area of oil palm seedlings ranging from 7 DAP to 84 DAP were not significantly different between treatments both on sterile soil and on non-sterile soil. There was a tendency of growth inhibition in the treatment of *G. boninense* inoculation and/or planting of yams aged 56-84 days after planting on non-sterile soil (Figure 4.8, Figure 4.9 and Appendix 5).

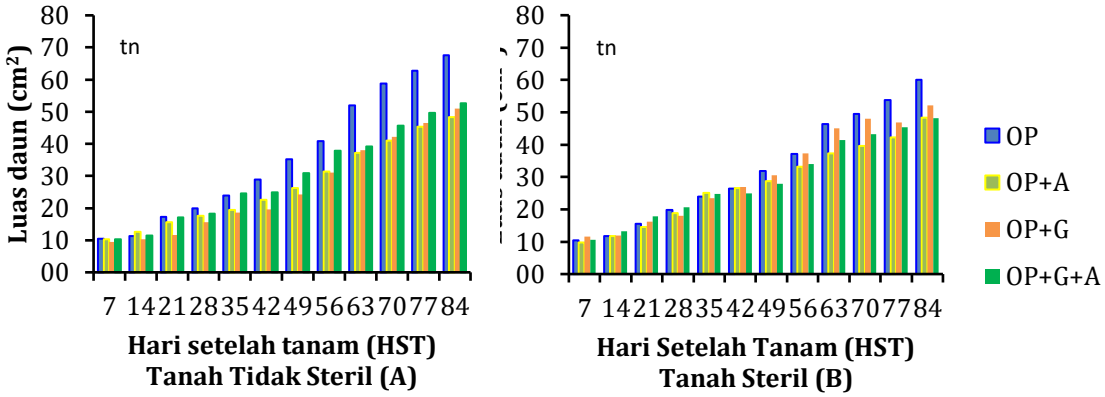

Figure 4.8. Leaf area of oil palm seedlings planted inunsterile soil (A), and sterile soil (B)

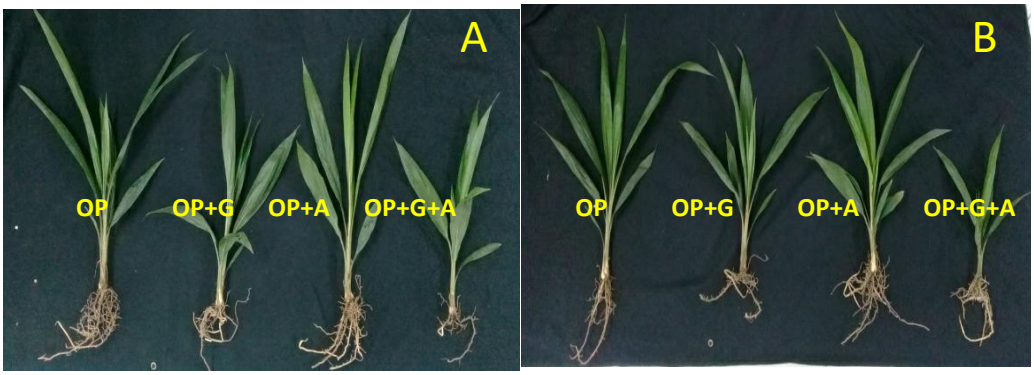

Figure 4.9. Morphology oil palm seedlings planted on non-sterile soil (A), and sterile soil (B)

4.1.3.3. Height of oil palm

The height of oil palm plants observed from 7 DAP to 84 DAP did not show no significant difference between each treatment on sterile soil and on non-sterile soil. There is a tendency of growth inhibition in the inoculation treatment *G. boninens*e and/or planting of yam in unsterilized soil from 70 DAP to 84 DAP (Figure 4.10 and Appendix 6).T

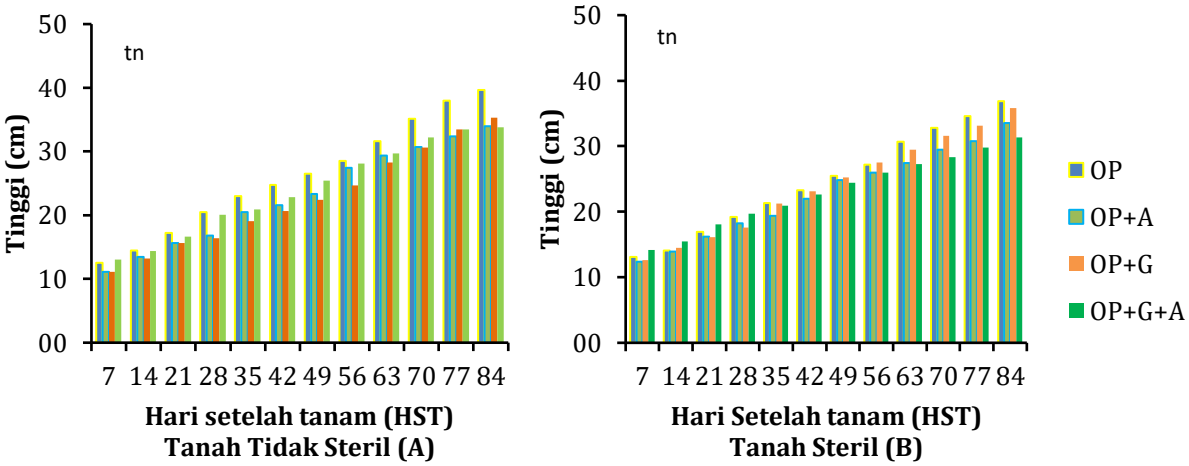

Figure 4.10. The height of oil palm seedlings on non-sterile soil (A), and sterile soil (B), tn = anova in each observation had no significant effect (P < 0.05)

4.1.3.4. Root Length

The observation of root length was carried out by calculating the root length of the oil palm seedlings in each treatment on non-sterile soils which were significantly different (P=0.0001) while the sterile soil treatments were also significantly different (P=0.01) (Figure 4.11 and Appendix 7**).**).

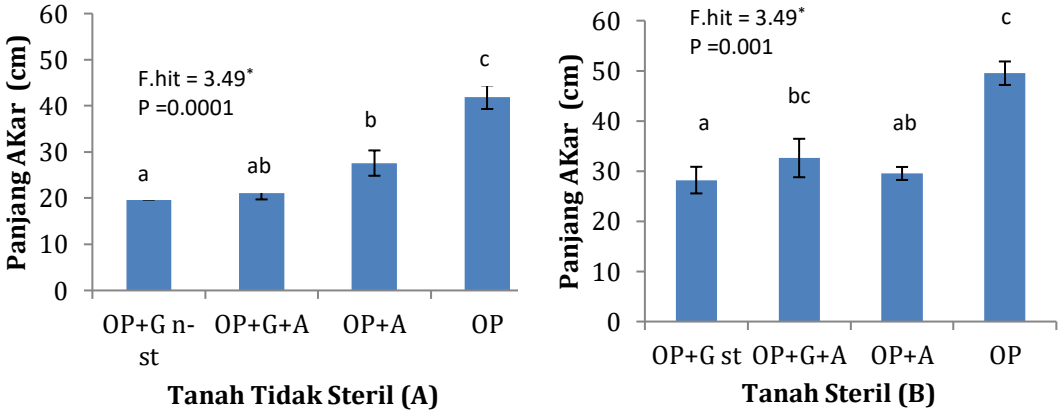

Figure 4.11. Root length of oil palm seedlings planted at unsterile soil (A), and sterile soil (B), bar graphs labeled with the same letter were not significantly different (P<0.05) based on BNJ 5%

4.1.4. Pathogenic Morphological Characteristics

Observation of the morphological characteristics of fungal pathogens that cause oil palm BPB disease in the experiment was carried out macroscopically and microscopically after experiment in the greenhouse and in the laboratory. The results of the observations were compared with the literature. The fungal fruiting body is shaped like a fan without a stalk, red-orange on the picus surface and white on the pore (Figure 4.).

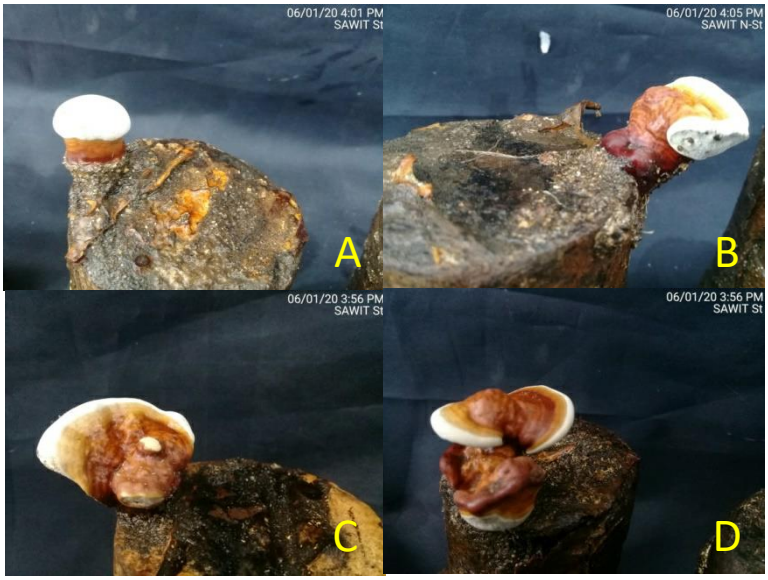

Figure 4.12. The fruiting body of the fungus G. boninense on rubber wood inoculum after field experiment started from initial growth (A), began to form a fan (B), formation of a fan (C), complete fruiting body (D).

Basidiospores are oval in shape with an average size of 9.15 x 4.17 m. The shape of the spores is in accordance with the literature with the description of Moncalvo (2000) (Figure 4.13).

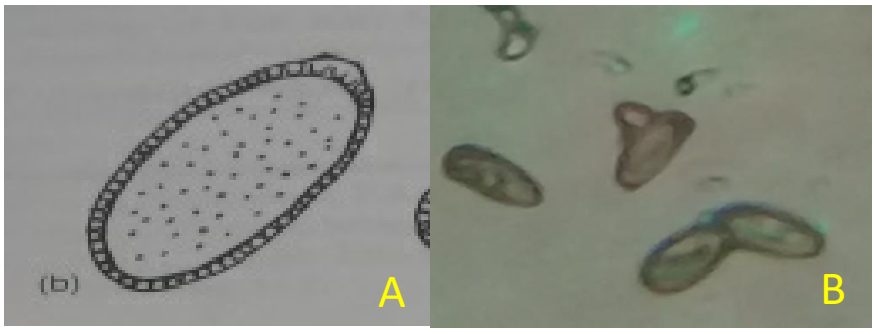

Figure 4.13. Fungal spore morphology from the literature (A) and microscopic observations at 400 x magnification (B).

In addition, tests were carried out on MEA agar (malt extract agar) + RBBR and MEA +Tannins with the results showing the activity of lignin-degrading enzymes by fungi that grew from the inoculation of roots and stem base or the base of the stem of oil palm seedlings after field testing. Signs of enzyme activity including polyphenol oxidase (PPO) can be seen from the yellow-brown color change in both media (Figure 4.14

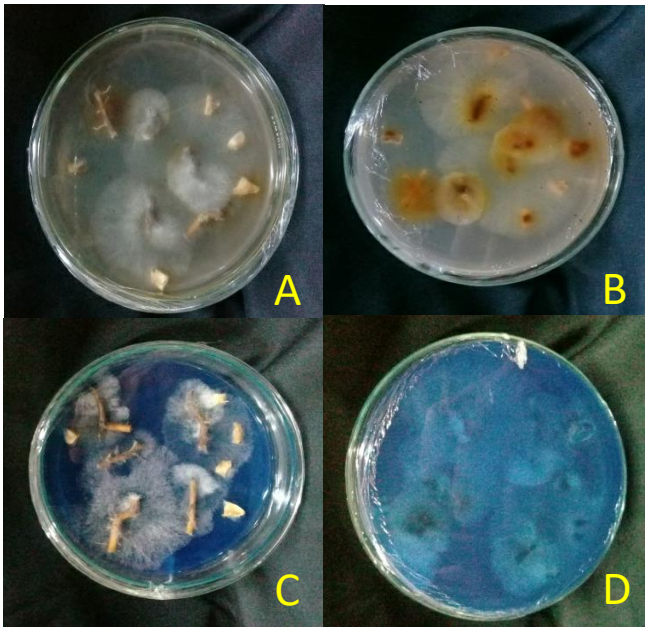

Figure 4.14. Post field test reisolation on MEA tannin media, top view (A), and bottom view (B), as well as reisolation on MEA RBBR media from above (C), and bottom view (D)

4.1.5. Effect of G.boninense on Yam Plants in the Laboratory

Exposure to G. boninense culture for 7 days on water agar in the laboratory planted with yam plants did not cause growth inhibition as indicated by the treatment which was not significantly different for four days of observation (Figure 4.15 and Appendix 8).

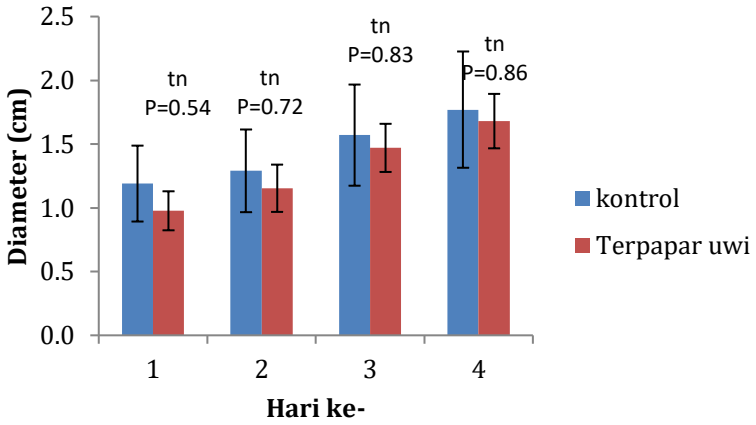

Figure 4.15. The area of inhibition of *G. boninense* inoculum isolated in MEA after being planted on sterile agar with sterile yam plants.

4.2 Discussion

Oil palm stem rot disease is one of the most feared pests in the world for the oil palm plantation sector. The disease causes very severe losses. Palm oil is an important commodity in Southeast Asia, especially Indonesia as the world's largest producer of palm oil (Ditjenbun, 2017**).** Root rot disease of oil palm which is also known by local people as red fungus disease is one of the diseases that has not been able to be overcome until now, so that many farmers on an individual or company scale suffer losses due to the severity of this red root fungus disease. According to Rahman and Othman (2019), basal stem rot disease in Southeast Asia is dominated by the fungus *G. boninense* species..

This disease that attacks oil palm has symptoms that are quite difficult to detect because there is no obvious symptoms or signs of attack when the pathogen has attacked with moderate to severe severity. The symptoms include the leaves starting to turn yellow at the same time, the leaf sheath sticking downwards including the newly developed leaf crown, in addition to other symptoms, the growth of the fungal fruiting body at the base of the stem, and followed by a tilted plant due to porousness on the stem. Microscopic symptoms can be seen from the root tissue of oil palm, where generally the roots of oil palm seedlings will produce white hyphae. These hyphae are thickened and attached to the roots which are indicated to enter the network so that if the basal stem of the seedling is split it wil appear blackish brown

necrosis. This is also supported by Fitriani et al., (2017), which states that roots that are attacked by the fungus *G. boninense* will enter the tissue until the plant is porous and dies.

The magnitude of the loss and the difficulty of controlling this disease make scientists continue to look for solutions. However, the tropical regions of Indonesia, especially the South Sumatra region, Ogan Ilir Regency, has a lot of floral diversity that is thought to be able to control or inhibit the growth of the red root disease. People generally know this plant as purple yam with the species *D. alata* (Ministry of Agriculture, 2015). According to existing research, purple yam plants contain root exudates resulting from metabolic processes (Winarti et al., 2011). The content of root exudates in the form of phenolics, antioxidants (Pelima, 2012) and various metabolic products is believed to be able to reduce the level of fungal attack that causes stem rot (Yulianti et al., 2017). The symptoms shown do have similarities with various other diseases, especially in leaf symptoms, therefore it is necessary to observe other parts until being isolated on a specific medium, then purification of the fungus and identification of the spores to be matched with the existing literature.

Based on the results of the study, it can be seen from the severity of the disease, in the treatment of oil palm seedlings planted with pathogenic inoculum on sterile soil, the percentage of attack was greater than other treatments. However, when compared to the treatment of oil palm seedlings planted with pathogenic inoculum and also yam plants, the disease intensity was lower even on unsterilized soil. These differences are caused by soil microorganisms that naturally play a role in the growth and development of living things (Prayudyaningsih, 2015).

Differences in aggressiveness from the experiments carried out can occur due to various factors such as according to Rakib et al (2015), aggressiveness can be caused by many factors, but the main factors of pathogen aggressiveness in oil palm nurseries are stem diameter, root length, and plant biomass weight. . The influence of stems and roots is because the pathogenic fungi*G. boninense* requires metabolic products from oil palm during the vegetative phase which are very much needed by the fungus that causes the disease for growth and development starting from forming fruit bodies and producing spores (Goh et al., 2014) The fungus *G. boninense* is lignolytic which is able to penetrate the lignin layer through enzymes produced by

the fungus, so that pathogenic fungi are able to penetrate the hard epidermal layer of the host plant and then enter the plant tissue, thereby exacerbating the aggressiveness of the disease (Widyati, 2013)4)..

The fruiting bodies of the mushrooms were observed to have started to grow at the 8th week, although not yet perfect. The fruiting bodies grew from the inoculum of the pathogen planted in the inoculation treatment of *G. boninense* and/or yam plants. In the initial phase, the fruiting body appears as a white ball which gradually forms like a comb with a red upper surface. The appearance of the fruiting body indicates the weathering of the wood media during infection, so that it will form a fruiting body before it dies. Tubuh buah jamur pada pengamatan sudah mulai tumbuh pada minggu ke-8 walaupun belum sempurna. Tubuh buah tersebut tumbuh dari inokulum patogen yang di tanam pada perlakuan inokulasi *G. boninense* dan/ atau tanaman uwi. Pada fase awal tubuh buah muncul terlihat seperti bola berwarna putih yang lama kelamaan membentuk seperti sisir dengan permukaan atas berwarna merah. Munculnya tubuh buah menandakan adanya pelapukan media kayu saat infeksi, sehingga akan membentuk tubuh buah sebelum mati to maintain its survival through the spores produced (Hidayati et al., 2015; Huda et al., 2016).

For the growth of leaf area that grows from each oil palm seedling on non-sterile soil and sterile soil, the treatment of oil palm, yam, and inoculum was the lowest compared to control oil palm alone. This is due to the competition that occurs and also the influence of pathogens that begin to infect oil palm although there are no severe symptoms that indicate the death of oil palm seedlings will occur in the near future. According to Goh et al., (2014), the aggressiveness and malignancy of the stem rot disease of oil palms are not visible when the oil palms are still young but are clearly visible when the attack rate is high and the age reaches 10 to 20 years and above, where at the age of decades oil palms will show severe symptoms ranging from withering all the leaves, productivity stops, until the death and breaking of oil palm stems due to rot or porousness at the base. According to available data from oil palm plantations in Indonesia, the incidence of disease by *G. boninense* was initially low in nurseries up to 12 years, but the older the plant the more damage it caused to more than 95% (Boulord et al., 2017).

CHAPTER 5
CLOSING

5.1 Conclusion

The conclusions from the research conducted are as follows:

1. Treatment of yam plants on unsterile soil can suppress aggressiveness, but does not affect weathering and plant growth.
2. The suppression of the aggressiveness of stem rot disease in oil palm has no impact on sterile soil.
3. The root exudate of the yam plant did not affect the growth of the fungus.
4. Oil palm seedlings inoculated with *G. boninense* and/or in yam plants caused growth inhibition.
2. *G. boninense* inoculation and/or yam planting did not affect the growth of oil palm seedlings.

5.2 Suggestion

Further research is needed on the effect of unsterilized soil on suppressing stem rot disease of oil palms and further research other than yam plants to obtain allelopathy-producing plant species that can suppress stem rot disease of oil palm.

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APPENDICES

Lampiran 1. Persentase Jumlah Akar Nekrosis

Jenis Tanah	Perlakuan	Jumlah Akar Terinfeksi	Jumlah Akar	Persentase (%)
Tanah Tidak Steril	OP+G	5	6	83.33
		6	8	75.00
		2	4	50.00
		4	5	80.00
		4	6	66.67
	OP+G+A	2	3	66.67
		3	4	75.00
		2	4	50.00
		2	3	66.67
		3	5	60.00

	OP+G	4	5	80.00
		3	4	75.00
		4	6	66.67
		3	4	75.00
Tanah Steril		3	4	75.00
	OP+G+A	2	3	66.67
		5	6	83.33
		3	10	30.00
		3	6	50.00
		2	3	66.67

Sidik Ragam Persentase Jumlah Akar Nekrosis Tanah Tidak Steril

	Levene's test	t-Test			
	F.hit	db	md	T.hit	T. tab
Homogen	0.035*	8	15.00	0.145	2.31
Tidak Homeogen		4.451	15.00	0.174	2.78

Sidik Ragam Persentase Jumlah Akar Nekrosis Tanah Steril

	Levene's test	t-Test			
	F.hit	db	md	T.hit	T. tab
Homogen	0.434^{tn}	8	7.33	0.342	2.31
Tidak Homeogen		7.158	7.33	0.346	2.36

Lampiran 2. Agresivitas Patogen

Jenis Tanah	Perlakuan	Nekrosis (cm)	Panjang Akar di amati (cm)	Persentase (%)
	OP+G	3.00	3.26	92.02
		2.50	2.87	87.11
		2.00	4.87	41.07
		2.50	3.80	65.79
Tanah Tidak Steril		2.00	3.50	57.14
	OP+G+A	2.00	6.37	31.40
		2.00	5.34	37.45
		1.50	5.25	28.57

		1.50	6.00	25.00
		2.00	5.20	38.46
	OP+G	3.00	6.40	46.88
		2.00	6.00	33.33
		2.73	5.67	48.15
		2.00	5.00	40.00
Tanah Steril		3.00	7.75	38.71
	OP+G+A	4.33	9.67	44.78
		1.80	5.17	34.82
		1.73	4.20	41.19
		2.21	6.67	33.13
		1.00	7.00	14.29

Sidik Ragam Agresivitas Patogen Tanah Tidak Steril

	Levene's test	t-Test			
	F.hit	db	md	T.hit	T. tab
Homogen	0.430^{tn}	8	7.77	0.227	2.31
Tidak Homeogen		6.007	7.77	0.239	2.45

Sidik Ragam Agresivitas Patogen Tanah Steril Steril

	Levene's test	t-Test			
	F.hit	db	md	T.hit	T. tab
Homogen	0.028*	8	36.45	0.006	2.31
Tidak Homeogen		4.589	36.45	0.016	2.78

Lampiran 3. Pelapukan Inokulum

Jenis Tanah	Perlakuan	Rerata Berat kering Awal (g)	Berat kering Akhir (g)	Pelapukan (%)
	OP+G	90.28	80.82	10.48
		90.28	77.92	13.69
		90.28	77.82	13.80
		90.28	72.62	19.56
		90.28	76.42	15.35
	OP+G+A	90.28	64.92	28.09
		90.28	73.22	18.90

Tanah Tidak Steril		90.28	64.72	28.31
		90.28	76.62	15.13
		90.28	77.12	14.58
	G	90.28	69.42	23.11
		90.28	72.62	19.56
		90.28	79.72	11.70
		90.28	60.62	32.85
		90.28	51.52	42.93
	G+A	90.28	73.32	18.79
		90.28	69.52	23.00
		90.28	53.62	40.61
		90.28	63.12	30.08
		90.28	81.12	10.15
	OP+G	90.28	70.02	22.44
		90.28	78.42	13.14
		90.28	73.52	18.56
		90.28	65.42	27.54
		90.28	66.72	26.10
	OP+G+A	90.28	76.02	15.80
		90.28	79.62	11.81
Tanah Steril		90.28	72.52	19.67
		90.28	60.12	33.41
		90.28	80.62	10.70
	G	90.28	71.22	21.11
		90.28	80.42	10.92
		90.28	74.62	17.35
		90.28	75.32	16.57
		90.28	69.92	22.55
	G+A	90.28	73.52	18.56
		90.28	56.92	36.95
		90.28	55.42	38.61
		90.28	70.72	21.67
		90.28	63.52	29.64

Sidik Ragam Pelapukan Inokulum Tanah Tidak Steril

Sumber keragaman	Derajat Bebas	Jumlah Kuadrat	Kuadrat Tengah	F Value	Pr > F
Perlakuan	3	389.31	129.77	0.338	3.49
Ulangan	4	90.77	22.692	0.924	
Error	12	1255.92	104.66		
Corrected Total	19	1736.01			

Sidik Ragam Pelapukan Inokulum Tanah Steril

Sumber keragaman	Derajat Bebas	Jumlah Kuadrat	Kuadrat Tengah	F Value	Pr > F
Perlakuan	3	411.38	137.13	0.143	3.49

Ulangan	4	121.81	30.45	0.746	
Error	12	752.72	62.72		
Corrected Total	19	1285.91			

Lampiran 4. Bobot Kering Tanaman

Perlakuan	Berat massa (g)	
	Tanah Tidak Steril	Tanh Steril
OP+G	2.1	3.5
	3.9	3.2
	2.5	3.7
	2.8	3.8
	2.5	1.9
OP+G+A	5.2	3.1
	2.6	3.6
	1.0	2.7
	1.8	4.0
	2.8	1.8
G	3.8	2.9
	3.5	3.1
	1.7	4.9
	1.6	6.2
	2.6	1.4
A	3.0	4.7
	4.6	6.2
	2.1	4.5
	4.8	3.5
	5.8	3.4

Sidik Ragam Bobot Kering Tanaman Tanah Tidak Steril

Sumber keragaman	Derajat Bebas	Jumlah Kuadrat	Kuadrat Tengah	F Value	Pr > F
Perlakuan	3	6.04	2.01	0.168	3.49
Ulangan	4	12.33	3.08	0.059	
Error	12	12.06	1.00		
Corrected Total	19	30.43			

Sidik Ragam Bobot Kering Tanaman Tanah Steril

Sumber keragaman	Derajat Bebas	Jumlah Kuadrat	Kuadrat Tengah	F Value	Pr > F

Perlakuan	3	7.04	2.35	0.197	3.49
Ulangan	4	9.26	2.32	0.194	
Error	12	15.46	1.29		
Corrected Total	19	31.77			

Lampiran 5. Panjang Akar

Perlakuan	Panjang Akar (cm)	
	Tanah Tidak Steril	Tanh Steril
OP+G	19.56	32.00
	22.96	24.00
	19.48	34.02
	19.00	20.00
	21.00	31.00
OP+G+A	19.11	29.01
	21.36	31.02
	21.00	42.00
	18.00	40.02
	26.00	21.00
OP+A	34.98	28.68
	23.00	31.98
	21.00	26.01
	26.01	33.00
	33.00	27.99
OP	43.15	56.10
	36.90	53.06
	35.01	49.60
	48.00	43.48
	46.35	45.36

Sidik Ragam Panjang Akar Tanah Tidak Steril

Sumber keragaman	Derajat Bebas	Jumlah Kuadrat	Kuadrat Tengah	F Value	Pr > F
Perlakuan	3	1490.31	496.78	0.0001	3.49
Ulangan	4	131.44	32.86	0.161	
Error	12	198.55	16.55		
Corrected Total	19	1820.31			

Sidik Ragam Panjang Akar Tanah Steril

Sumber keragaman	Derajat	Jumlah	Kuadrat	F Value	Pr > F

	Bebas	Kuadrat	Tengah		
Perlakuan	3	1463.11	487.70	0.001	3.49
Ulangan	4	98.89	24.72	0.657	
Error	12	478.65	39.89		
Corrected Total	19	2040.65			

Lampiran 6. Luas Daun Kelapa Sawit pada Tanah Tidak Steril

Pelakuan	Hari ke-									
	7	14	21	28	35	42	49	56	63	70
OP	10.49	11.36	17.33	19.94	23.95	28.82	35.27	40.79	51.93	58
OP+G	9.46	9.32	11.68	15.65	18.52	19.64	24.30	30.98	38.07	42
OP+A	10.26	9.53	15.53	17.60	19.41	22.61	26.24	31.39	37.19	41
OP+G+A	10.25	11.41	17.18	18.21	24.54	24.92	30.86	37.90	39.22	45

Sidik Ragam Luas Daun Kelapa Sawit pada Tanah Tidak Steril Pengamatan 84 hst

Sumber keragaman	Derajat Bebas	Jumlah Kuadrat	Kuadrat Tengah	F Value	Pr > F
Perlakuan	3	1558.74	519.58	0.132	3.49
Ulangan	4	1359.96	339.99	0.266	
Error	12	2736.21	228.02		
Corrected Total	19	5654.91			

Lampiran 7. Luas Daun Kelapa Sawit pada Tanah Tidak Steril

Pelakuan	Hari ke-									
	7	14	21	28	35	42	49	56	63	7
OP	10.38	11.80	15.52	19.81	23.98	26.43	31.86	37.21	46.35	4
OP+G	11.52	11.92	16.18	17.94	23.46	26.85	30.49	37.35	45.00	4
OP+A	9.78	11.68	14.61	18.88	25.03	23.75	28.71	33.20	37.27	3
OP+G+A	10.52	13.20	17.77	20.69	24.81	24.87	27.95	34.01	41.42	4

Sidik Ragam Luas Daun Kelapa Sawit Tanah Steril 84 Hst

Sumber keragaman	Derajat Bebas	Jumlah Kuadrat	Kuadrat Tengah	F Value	Pr > F
Perlakuan	3	471.17	157.06	0.279	3.49
Ulangan	4	794.07	198.52	0.189	
Error	12	1304.57	108.71		
Corrected Total	19	2569.82			

Lampiran 8. Tinggi Kelapa Sawit pada Tanah Tidak Steril

Pelakuan	Hari ke-								
	7	14	21	28	35	42	49	56	63
OP	12.58	14.50	17.3	20.5	23.0	24.8	26.5	28.5	31.6
OP+G	11.15	13.20	15.7	16.4	19.1	20.7	22.4	24.7	28.3
OP+A	11.10	13.50	15.6	16.8	20.5	21.6	23.3	27.4	29.4
OP+G+	13.00	14.40	16.7	20.1	20.9	22.8	25.4	28.1	29.7

A

Sidik Ragam Tinggi Kelapa Sawit pada Tanah Tidak Steril 84 Hst

Sumber keragaman	Derajat Bebas	Jumlah Kuadrat	Kuadrat Tengah	F Value	Pr > F
Perlakuan	3	113.30	37.77	0.121	3.49
Ulangan	4	35.58	8.89	0.697	
Error	12	190.82	15.90		
Corrected Total	19	339.70			

Lampiran 9. Tinggi Kelapa Sawit pada Tanah Steril

Pelakuan	Hari ke-									
	7	14	21	28	35	42	49	56	63	7
OP	13.1	14.1	16.9	19.2	21.3	23.3	25.5	27.2	30.7	
OP+G	12.7	14.5	16.1	17.6	21.3	23.1	25.2	27.5	29.5	
OP+A	12.4	13.9	16.2	18.2	19.4	22.0	24.8	26.0	27.4	
OP+G+A	14.2	15.5	18.1	19.7	20.9	22.6	24.4	26.0	27.3	

Sidik Ragam Tinggi Kelapa Sawit Tanah Steril

Sumber keragaman	Derajat Bebas	Jumlah Kuadrat	Kuadrat Tengah	F Value	Pr > F
Perlakuan	3	93.14	31.05	0.446	3.49
Ulangan	4	140.25	35.06	0.411	
Error	12	391.05	32.59		
Corrected Total	19	624.44			

Lampiran 10. Pengaruh *G.boninense* pada Tanaman Uwi di Laboratorium

Ulangan	Hari ke-						
	1		2		3		
	Kontrol	Pemaparan Uwi	Kontrol	Pemaparan Uwi	Kontrol	Pemaparan Uwi	Kontrol
1	1.50	1.08	1.70	1.20	1.80	1.28	2.00
2	1.50	0.97	1.65	1.15	2.00	1.25	2.25
3	1.45	0.40	1.50	0.47	1.90	1.00	2.00
4	1.50	1.15	1.60	1.53	2.15	2.02	2.60
5	0.00	1.28	0.00	1.42	0.00	1.80	0.00

Sidik Ragam Pengaruh *G.boninense* pada Tanaman Uwi di Laboratorium hari ke-1

Levene's test	t-Test

	F.hit	db	md	T.hit	T. tab
Homogen	0.268^{tn}	8	0.21	0.540	2.31
Tidak Homeogen		5.965	0.21	0.546	2.57

Sidik Ragam Pengaruh *G.boninense* pada Tanaman Uwi di Laboratorium hari ke-2

	Levene's test	t-Test			
	F.hit	db	md	T.hit	T. tab
Homogen	0.329^{tn}	8	0.14	0.725	2.31
Tidak Homeogen		6.349	0.14	0.727	2.45

Sidik Ragam Pengaruh *G.boninense* pada Tanaman Uwi di Laboratorium hari ke-3

	Levene's test	t-Test			
	F.hit	db	md	T.hit	T. tab
Homogen	0.306^{tn}	8	0.10	0.826	2.31
Tidak Homeogen		5.732	0.10	0.828	2.57

Sidik Ragam Pengaruh *G.boninense* pada Tanaman Uwi di Laboratorium hari ke-4

	Levene's test	t-Test			
	F.hit	db	md	T.hit	T. tab
Homogen	0.335^{tn}	8	0.09	0.863	2.31
Tidak Homeogen		5.684	0.09	0.864	2.57