# SCREENING FOR POTENTIAL RHIZOSPHERIC SOIL BACTERIA OF OIL PALM AGAINST *Ganoderma boninense*

AU WEN CHYNG



DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR DEGREE OF BACHELOR OF AGRICULTUTR SCIENCE WITH HONOURS

CROP PRODUCTION PROGRAMME
SCHOOL OF SUSTAINABLE AGRICULTURE
UNIVERSITI MALAYSIA SABAH
2012

PUMS 99:1

# PERPUSTAKAAN UNIVERSITI MALAYSIA SABAH

## BORANG PENGESAHAN STATUS TESIS

**JUDUL:** Screening For Potential Rhizopheric Soil Bacteria of Oil Palm Against Ganoderma boninense

**IJAZAH:** Degree of Bacheror of Agriculture Science with Honours.

**SAYA:** AU WEN CHYNG **SESI PENGAJIAN:** 2009/2010

(NAMA PENULIS DALAM HURUF BESAR)

Mengaku membenarkan tesis *(LPSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:-

1. Tesis adalah hakmilik Universiti Malaysia Sabah.
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian, pembelajaran, penyelidikan dan pemeliharaan sahaja.
3. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat pendigitasian
5. Sila tandakan (/)

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di AKTA RAHSIA RASMI 1972)

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana Penyelidikan dijalankan)

☑ TIDAK TERHAD



TANDATANGAN PENULIS

Disahkan oleh:
NURULAIN BINTI ISMAIL
LIBRARIAN
UNIVERSITI MALAYSIA SABAH
(TANDATANGAN PUSTAKAWAN)

Alamat tetap:
32, Kampung Tersusun Kamuning
31100 Sungai Siput (U),
Perak.

(NAMA PENYELIA)

Tarikh: 18 January 2013

Tarikh: _____

Catatan :- *Potong yang tidak berkenaan.
*Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT dan TERHAD.
*Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana Secara penyelidikan atau disertai bagi pengajian secara kerja kursus dan Laporan Projek Sarjana Muda (LPSM)

## DECLARATION

I hereby declare that this dissertation is based on my original work except for citation and quotation which have been duly acknowledged. I also declare that no part of this dissertation has been previously or concurrently submitted for a degree at this or any other university.

AU WEN CHYNG
BR 09110001
13 DECEMBER 2012

**VERIFIED BY**

1. Mr. Clament Chin Fui Seung
   SUPERVISOR

CLAMENT CHIN FUI SEUNG
Lecturer
School Of Sustainable Agriculture
Universiti Malaysia Sabah

2. Prof. Madya Haji Mohd. Dandan
   @ Ame Bin Haji Alidin
   EXAMINER 1

3. Dr. Suzan Benedick
   EXAMINER 2

DR. SUZAN BENEDICK
Pensyarah
Sekolah Pertanian Lestari
Universiti Malaysia Sabah

4. Dr. Siti Raehanah Muhamad Shaleh
   DEAN
   SCHOOL OF SUSTAINABLE AGRICULTURE

DR. SITTI RAEHANAH MUHAMAD SHALEH
DEKAN
SEKOLAH PERTANIAN LESTARI
UMS KAMPUS SANDAKAN

**ACKNOWLEDGEMENT**

I would like to express my sincere appreciation to my lost grandfather, Au Kok Leong and grandmother, Wong Kim Fong who had take care me after my mother, Leong Lai ken past away and my father worked in oversea. They had inspired, supported and encouraged me in my academic life and my entire life. A million thanks to my lovely father, Au Kar Choong who has always encouraged and supported me in my study in School of Sustainable Agriculture (SSA) and entire life. I would also like to thank my brother, Au Mun Hong and my other lovely family members (Au Pooi Keong, Au Yoon Heng, Au Yock Won, Au Yock Leng, Au Mun Wei) who encouraged and supported me in my study in SSA and my entire life.

I would also like to express my sincere gratitude to my supervisor, Mr. Clament Chin Fui Seung who gives guidance, advice, comments and support to me during the preparation of this thesis. I am grateful for his patience to have listened to my problems and gave me his constructive comments.

Appreciation also goes to the lab assistant in SSA, Mr. Panjiman who has assists me to use the laboratory facility and prepared the apparatus and materials to me throughout the period of preparation the experiment.

Thanks to the Ulu Dusun Research Stesen, Sandakan for supplying the low price, high quality and certified oil palm seedling for this experiment. Thanks also to the senior who keep the pure culture of *Ganoderma boninense* and the SSA driver who has taken me to Ulu Dusun Research Stesen, Sandakan to take the oil palm seedling.

Special thanks to my friend, Ngu Wang Hoe who has does the experiment with me. He always helped me and sacrificed some of his effort for my benefit during the preparation of this thesis. Special thanks also to my friend and housemate, Chung Wan Ying who always encouraged and supported me during the preparation of this thesis. She also always take care me throughout the period of my study in SSA, especially when I sick.

Finally, thanks also to SSA, Universiti Malaysia Sabah (UMS), Campus Sandakan for providing a convenience and comfortable study environment for the completion of the experiments and thesis.

## ABSTRACT

Ten culturable rhizospheric soil bacteria were isolated from the rhizosphere soil of oil palm sampled from oil palm plantation located at the School of Sustainable Agriculture, Sandakan campus of University Malaysia Sabah. The bacterial isolates were characterized based on morphological characteristics, including colony colour, colony surface, colony margin, colony elevation and appearance displayed on Potato Dextrose Agar (PDA) plate and Nutrient Agar (NA) plate. The bacterial isolates were Gram's negative and rod shape. Among the ten isolated rhizospheric soil bacteria, only six bacterial isolates (C, D, G, H, I and J) showed inhibition towards the growth of *Ganoderma boninense* in the screening test. The bacterial isolates (C, H and I) showed potential inhibitory effect against *G. boninense* in dual culture test with their percentage inhibition of mycelial growth recorded were more than 50%. There was significant higher in inhibitory effect ($P<0.05$) among the six bacterial isolates in dual culture test. The inhibition zone of *G. boninense* recorded growth by bacterial isolate C was 5.23 cm, while the bacterial isolate H was 4.23 cm and bacterial isolate I was 4.07 cm. The inhibition zone of *G. boninense* growth by bacterial isolates (C and H) was higher than bacterial isolate I. The rhizospheric soil bacteria isolated C and H were further investigated in culture filtrate test, mixture of PDA and bacterial culture test (*in* vitro) and nursery trial. The PI values of bacterial isolate C was 100%, while bacterial isolate H was 17.47% in culture filtrate test. The bacteria C showed 100% inhibition of *G. boninense,* while bacteria H showed 96.78% inhibition mycelial growth in mixture of PDA and bacterial culture test. There was significant different in inhibition of *G. boninense* ($P<0.05$) in both culture filtrate test and mixture of PDA and bacterial culture test. The bacterial isolate H showed 17.47% inhibition of mycelial growth in culture filtrate with absent of bacterial culture, while showed 96.78% inhibition of mycelial growth in mixture of PDA and bacterial culture test with present of bacterial culture. The result showed that antimicrobial metabolites produced during antagonism between bacteria and pathogen. The bacterial isolate C and H caused malformation of hyphae of *G. boninense*. The bacterial isolate C and H were further investigated in nursery trial with three months duration. The disease severity of *G. boninense* infected seedlings treated bacterial isolate C and H was no significant different with non-treated infected seedlings ($P>0.05$). The bacterial isolate C and H showed no effect on growth height of seedlings and plant biomass. There was no significant different between infected seedling treated with bacterial isolate and non-treated infected seedlings ($P>0.05$). The abiotic factor, including soil condition, temperature and humidity affected the inhibitory effect of rhizospheric soil bacteria C and H. Thus, the further field study of effects of abiotic factor on rhizospheric soil bacteria is required. The long study duration of nursery trial also recommended.

**MENGESAN BAKTERIA TANAH RHIZOSPHERIC DARIPADA KALEPA SAWIT YANG BERKESAN TERHADAP *Ganoderma boninense***

## ABSTRAK

Sepuluh bakteria telah diasingkan daripada tanah rhizosphere kelapa sawit daripada perladangan kelapa sawit yang terletak di Sekolah Pertanian Lestari, Sandakan kampus Universiti Malaysia Sabah. Bakteria digambarkan berdasarkan ciri-ciri morfologi, termasuk warna bakteria, permukaan bakteria, margin koloni bakteria dan penglihatan bakteria yang ditunjukkan atas media PDA dan media NA. Semua bakteria yang diasingkan berbentuk Gram negatif dan rod. Antara sepuluh bakteria tanah rhizospheric terpencil, hanya enam bakteria (C, D, G, H, I dan J) menunjukkan perencatan atas pertumbuhan *Ganoderma boninense* dalam ujian saringan. Bakteria (C, H dan I) menunjukkan kesan potensi perencatan terhadap *G. boninense* dalam ujian dual kultur dengan peratus rencatan pertumbuhan mycelial direkodkan adalah lebih daripada 50%. Terdapat bakteria C, H dan I mempunyai kesan yang lebih tinggi ($P < 0.05$) antara enam bakteria dalam ujian dual kultur. Zon perencatan pertumbuhan *G. boninense* oleh bakteria C adalah 5.23 cm, manakala bakteria H adalah 4.23 cm dan bakteria I adalah 4.07 cm. Zon perencatan pertumbuhan *G. boninense* oleh bakteria (C dan H) adalah lebih tinggi daripada bakteria I. Bakteria tanah rhizospheric C dan H terus dikaji dalam ujian turasan, ujian campuran PDA dan bakteria (*in vitro*) dan di tapak semaian. Nilai PI bakteria C adalah 100%, manakala bakteria H adalah 17.47% dalam ujian turasan. Bakteria C menunjukkan perencatan 100% terhadap *G. boninense*, manakala bakteria H menunjukkan 96.78% perencatan pertumbuhan *G. boninense* dalam ujian campuran PDA dan bakteria. Terdapat perbezaan yang signifikan dalam perencatan *G. boninense* ($P < 0.05$) dalam kedua-dua ujian turasan dan ujian campuran PDA dan bakteria. Bakteria H menunjukkan 17.47% perencatan pertumbuhan *G. boninense* dalam ujian turasan dengan kehadiran bakteria, manakala menunjukkan 96.78% perencatan pertumbuhan *G. boninense* dalam ujian campuran PDA dan bakteria dengan kehadiran bakteria. Ini menunjukkan bahawa metabolit antimikrobial dihasilkan semasa percanggahan antara bakteria dan patogen. Bakteria C dan H menyebabkan kecacatan *G. boninense*. Bakteria C dan H terus dikaji di tapak semaian dengan tempoh tiga bulan. Keterukan jangkitan *G. boninense* atas benih dirawat bakteria C dan H adalah tidak berbeza dengan benih yang tidak dirawat ($P > 0.05$). Bakteria C dan H tidak menunjukkan kesan pada ketinggian pertumbuhan benih dan biojisim tumbuhan. Tiada perbezaan yang ketara antara anak benih yang dijangkiti serta dirawat dengan bakteria dan tidak dirawatkan ($P > 0.05$). Faktor abiotik, termasuk keadaan tanah, suhu tanah dan kelembapan tanah telah menjejas kesan bakteria tanah rhizospheric C dan H. Oleh itu, kajian atas kesan faktor abiotik pada bakteria tanah rhizospheric perlu dilanjutkan dan tempoh kajian di tapak semain juga perlu dipanjangkan.

## TABLE OF CONTENT

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF FORMULAE

## LIST OF SYMBOLS, UNIS AND ABBREVIATIONS

| | |
|---|---|
| ANOVA | Analysis of variance |
| BSR | Basal Stem Rot |
| cm | Centimeter |
| cfu | Colony forming unit |
| °C | Degree Celsius |
| DSI | Disease Severity Index |
| g | Gram |
| ha | Hectare |
| MPOB | Malaysian Palm Oil Board |
| mL | Milliliter |
| mm | Millimeter |
| No. | Number |
| NA | Nutrient Agar |
| OD | Optical Density |
| % | Percentage |
| PI | Percent Inhibition |
| PGPR | Plant Growth Promoting Rhizobacteria |
| PSB | Phosphorus Solubilizing Bacteria |
| PDA | Potato Dextrose Agar |
| *sp.* | Species |
| SPSS | Statistical Package for the Social Science |
| SSA | School of Sustainable Agriculture |
| t | Tonne |
| UMS | Universiti Malaysia Sabah |
| UPM | Universiti Putra Malaysia |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Oil palm is "Golden crop" and main commodities crop of Malaysia. More than four hundred thousand hectare of oil palm was planted in Malaysia. Approximately 4 t $ha^{-1}$ of palm oil produced in Malaysia (Sapak *et al.,* 2008). Oil palm industry produces many profitable products which generates income for Malaysia economy. However, oil palm in Malaysia suffers from serious Basal Stem Rot (BSR) disease which caused by soil borne white rot fungus, *Ganoderma boninense*. The oil palms infected by BSR disease have been reported less about 21% of yield than same age healthy palms (Nazeeb *et al.,* 2000). Peninsular Malaysia has been reported almost 90% of oil palm estate attacked by *G. boninense* (Khairuddin and Chong, 2008). So, any materials that related to *Ganoderma* are strictly prohibited to transfer from Peninsular Malaysia to Sabah and Sarawak.

*Ganoderma boninense* is one of the soil bone pathogen which is difficult to control. Furthermore, *G. boninense* spreading through fungal spores or conducted the root system of oil palm with infected plant residues in the soils (Sanderson, 2005). Present a place on Earth where plants do not suffer from certain disease or infection. The places are known as natural suppressive soil. There have wide range of microorganism in the suppressive soils. The root of crop plants in suppressive soils are protected from infection that caused by soil borne pathogen. So, a lot of researches are done to find the potential biological control agents from soils towards BSR disease. Some of soil microbes have been isolated to control the growth of *G. boninense* through dual culture analysis. However, now still not have satisfactory control on *G. boninense* that caused BSR disease (Susanto *et al.,* 2005).

Many fungicides have presented inhibition characteristic towards the growth of *G. boninense* during *In vitro* studies. Unfortunately, there are failed suppressions in the development of BSR disease in the field (Idris *et al.*, 2002). The negative result in the field may cause by the soil borne characteristic of fungi which undergoes degradation in the soil before they treat their target. Furthermore, the *G. boninense* has various resting stages such as melenised mycelium, basidiospores and pseudosclerotia that resistant to fungicide (Susanto *et al.*, 2005).

There are several mechanism of biological control such as competition for space and nutrients, secretion of chitinolytic enzymes, mycoparasitism and production of an inhibitory compound to control the plant disease (Haram *et al.,* 1996; Zimand *et al.,* 1996). *Trichoderma harzianum* was commercialized as biological control agents towards BSR disease. There has showed good antagonist properties against *G. boninense* growth in plant house trials (Abdullah *et al.,* 1999). However, the result of control or suppress in BSR disease in filed are still not satisfactory. Beside *Trichoderma sp.,* other soil microbes also present antagonistic mechanism towards *G. boninense* in dual culture analysis. There was *Bacillus sp.*, *Pseudomonas sp.* and others.

## 1.2 Justification

According Shamala and Idris (2009), some of the isolation of *Trichorderma sp.* from soils of oil palm plantation in Peninsular Malaysia was proven as potential agents against *G. boninense.* However, there is no satisfactory control method towards *G. boninense*. The unsatisfactory control result of *Trichorderma sp.* towards *G. boninense* due the *Trichoderma sp.* present degradation in the soil before they reach to infect roots of plants (Susanto *et al.*, 2005). So, the negative result was showed in the field.

Rhizosphere soil can be defined as the soil surrounding plant root and influenced by the plant root and plant produced materials. The rhizosphere soil contain plant exudates that rich of energy and nutrient for bacteria growth (Gray and Smith, 2005). The plant growth promotion rhizobacteria from rhizosphere soil can affect the plant growth in directly or indirectly way. The rhizospheric soil bacteria direct stimulate the plant growth by synthesis a compound to increase certain nutrient uptake by the plant for growth (Glick, 1995). On other hand, the plant growth promotion rhizobacteria prevent the harmful effect of pathogen towards plants as indirect

promotion of plant growth. Furthermore, Susanto *et al.* (2005) isolated various soil microbes from oil palm rhizosphere soil for searching bio-control agents towards *G. boninense* growth. *Trichoderma harzianum* and *Gliocladium viride* isolated by Susanto *et al.* (2005) showed inhibition *G. boninense* growth in nursery test with one year of inoculation. However, the *Bacillus sp.* isolated from the same rhizosphere soil had low capacity to prevent the *G. boninense* infection. Thus, the same rhizosphere soils contain various soil microbes that provide different level of antagonism towards the *G. boninense* growth.

The rhizosphere soil of oil palm was collected for bacteria isolation. The efficiency of rhizospheric soil bacterial isolates was investigated. The *in planta* and *in vitro* was done in this investigation for searching a potential rhizospheric soil bacteria to inhibit the growth of *G. boninense* in dual culture and nursery field.

## 1.3 Objectives

I. To evaluate the efficiency of rhizospheric soil bacteria from oil palm in the suppression of *G. boninense* in the culture plate (*in vitro*).

II. To evaluate the efficiency of rhizospheric soil bacteria from oil palm in the suppression of *G. boninense* in the nursery (*in planta*).

## 1.4 Hypothesis

I. H0: There are no significant effects of rhizospheric soil bacteria on *G. boninense* growth in dual culture.
H1: There are significant effects of rhizospheric soil bacteria on *G. boninense* growth in dual culture.

II. H0: There are no significant effects of rhizospheric soil bacteria on *G. boninense* infected oil palm seedling growth.
H1: There are significant effects of rhizospheric soil bacteria on *G. boninense* infected oil palm seedling growth.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Oil Palm (*Elaeis guineensis*)

Oil palm, *Elaeis guineensis* is one of the world's most rapidly increasing crops. Large areas of forest in Southeast Asia have been replaced by oil palm. Oil palm was first planted in Peninsular Malaysia in 1917 (Corley *et al.,* 2003). Oil palm is the most important plantation crop in Malaysia. Malaysia is the second palm oil producer throughout the world. From the Malaysian Palm Oil Board (September 2011), oil palm plated area in Peninsular Malaysia is 2,545,071 hectare and 2,430,703 hectare in Sabah and Sarawak. Malaysia has produced approximately 4 t $ha^{-1}$ of palm oil in a year (Sapak *et al.,* 2008).

## 2.2 Basal Stem Rot (BSR) Disease

Basal Stem Rot (BSR) caused by white rot fungus, *G. boninense*. Thompson (1931) first reported oil palm Basal Stem Rot (BSR) disease found in Malaysia. Basal Stem Rot (BSR) of oil palm is the most serious plant disease in Malaysia (Turner and Bull, 1967). The losses of oil palm in Malaysian reach up to 80% after repeated plating cycles (Idris *et al.*, 2000; Susanto, 2009). Africa, Papua New Guinea and Thailand has recorded Malaysia and Indonesia has most severe losses that caused by lower BSR incidences (Idris *et al.*, 2004). Peninsular Malaysia showed the higher incidence of BSR compared to Sabah and Sarawak (Ariffin and Idris, 2002).

Decaying, multiple spear and fruit bodies were observed on the bole of BSR infected oil palm. The severe BSR has caused the palm falls over. Initially, BSR was classified as older palms disease. However, the BSR disease symptoms were found on

one to two years old oil palm in replanted area (Singh, 1991). The symptoms appear earlier on younger oil palm are more severe and greater replanting was required (Susanto *et al.*, 2005).

Sanderson (2005) reported BSR spread through contacted adjacent root with debris that remains in the soil after first and second replanting or by spreading the fungal spores. Chemical, cultural, mechanical and biological control was applied to control BSR. However, there are no effective control practices on BSR have been proved acceptable (Susanto *et al.,* 2005). The fungicide treatment is the available disease control, but it often applied ineffectively. According the *In vitro* studies carried out by Idris *et al.* (2002), many fungicides were strongly inhibited the growth of *Ganoderma*. However, the negative result of BSR control was showed in the field. Ineffective of fungicide may caused by the characteristic of fungus which are soil born and undergoes degradation in the soil before they can reach their target (Susanto *et al.*, 2005).

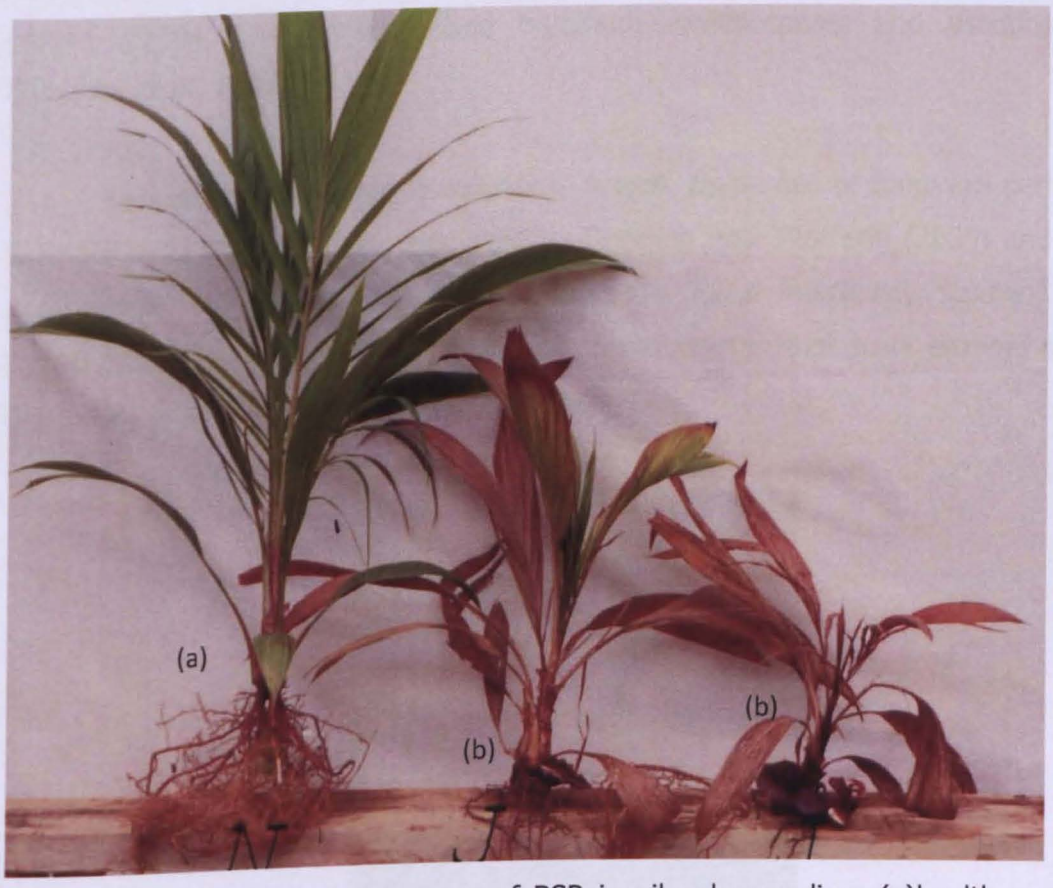


Figure 2.1 Signs and symptoms of BSR in oil palm seeding. (a)healthy seedling; (b)infected seedling.

Source: Mohd Zainudin and Faridah, 2008

## 2.3 *Ganoderma boninense*

Khairuddin and Chong (2008) reported *G. boninense* was found in almost 90% of the estate in Peninsular Malaysia. However, only 4% of oil palm estates in Sabah were reported with the presence of *G. boninense*. Isolates of *G. boninense* from Sabah are less aggressive compared those from Peninsular Malaysia was showed in the Head of Research for Borneo Samudera oil palm that the largest plantation group in Sabah (Hoong, H. W personal communication). Yield of *G. boninense* infected palms less about 21% than same age healthy palms (Nazeeb *et al.,* 2000).

The colonies of *G. boninense* were white in colour on the surface, darkened and undulating basidiomata was found on the reverse surface of the cultures (Idris *et al.*, 2000). After one to three weeks of incubation *G. boninense* on rubber wood blocks, the white mycelium was appeared. The length and width *G. boninense* increased rapidly and various yellowish brown colour with concentric was found on the developed upper surface (Idris, 2009). *Ganoderma* resistant to fungicide due to consists of various resting stages such as melenised mycelium, basidiospores and pseudosclerotia (Susanta *et al.*, 2005).

*Ganoderma boninense* is soil borne fungal. Numerous of fungi are particularly susceptible to microorganism lytic activity. Downing and Thomson (2000) and Anitha and Rabeeth (2010) stated chitinase are the most intensively studied in the investigation on lytic activity of biological control agents that have enzyme systems capable of degrading fungal cell wall components.

Figure 2.2 Pure culture of *Ganoderma boninense*
Source: Bivi *et al.,* 2010

### 2.3.1 Mycelial growth of *Ganoderma boninense*

The study of Bivi *et al.* (2010) showed the abnormal mycelial growth of *G. boninense* when treated with *Pseudomonas aeruginosa*. Malformation of hyphae by *Pseudomonas aeruginosa* was observed. The shrinkage of hyphae by other bacterial isolate also was observed.

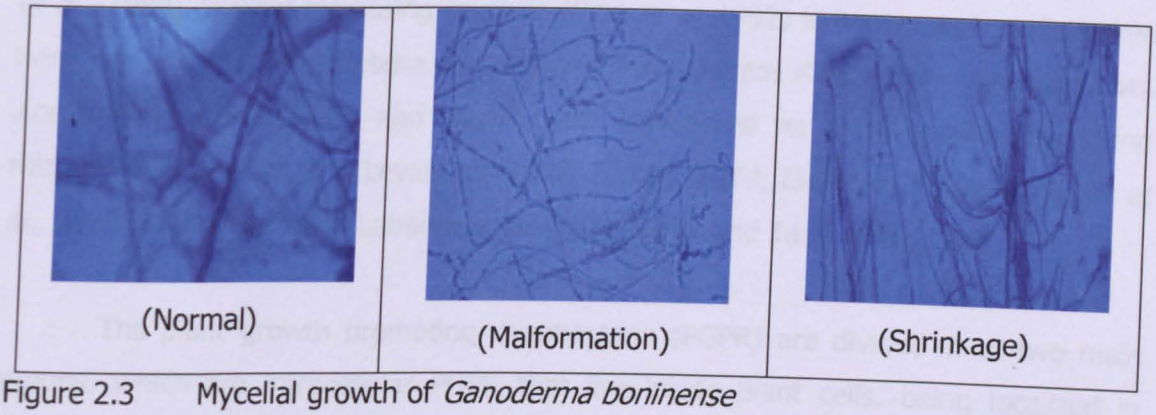


Figure 2.3 Mycelial growth of *Ganoderma boninense*
Source: Bivi *et al.*, 2010

## 2.4 Rhizosphere Soil Microbes

The soil provides habitat for variety of microorganism such as fungi, bacteria, virus and others which have an important role on nutritional chain for other macro-organisms. Rhizosphere soil is the layer of soil that surrounds the roots and supported greater microbial activity than bulk soil (Hiltner, 1904). Microbial population lives at rhizosphere soil capable of exerting beneficial, neutral and detrimental effects on plants (Ajay *et al.*, 2012). Thus, the isolation of beneficial microorganism in rhizosphere soil region higher than the bulk soil (Curl *et al.*, 1986; Lynch, 1990). Rhizpsphere soil layer high in fertility and biological activity have microbial densities about five to fifty times than in bulk soil (Brian *et al.*, 1999). The higher bacterial population in rhizosphere soil is the result of rich source of plant exudates, including amino acids and sugar that provides rich source of energy and nutrients for bacteria (Gray and Smith, 2005). Rhizospheric fungi produced ethylene that potentially influencing root morphological changes such as lateral root initiation (Brian *et al.*, 1999). Shahida and Naghman (1989) reported bacteria Gram's negative rod that present in rhizosphere had an adaptability of stress environment.

Lynch (1990) stated that the interaction between bacteria and plant roots may be beneficial, harmful or neutral for the plant, further the soil condition also be a factor on the effects to plant. The fixing nitrogen bacteria not facilities the plant growth when the soil is added with exogenous fixed nitrogen (Glick, 1995). Kloepper *et al.* (1988) stated that the bacteria establish a symbiotic relationship with the plant and those bacteria are free living in the soil but are found near on or within plant roots are the bacteria that provide benefit to plant. Plant growth promoting rhizobacteria (Kloerpper *et al.,* 1989) or yield increasing bacteria (Piao *et al.,*1992) is known as beneficial free living soil bacteria. The bacteria of the genera *Azotobacter, Azospirillum, Pseudomonas, Acetobacter, Burkholderia* and *Bacillus* are considered as plant growth promoting rhizobacteria (Bashan and Levanony, 1990; Brown, 1974; Elmerich, 1984; Kloepper *et al.,* 1988, 1989; Okon and Labandera-Gonzalez, 1994 and Tang *et al.,* 1994).

The plant growth promoting rhizobacteria (PGPR) are divided in to two main groups, which are intracellular PGPR that live inside plant cells, being localized in nodules and extracellular PGPR that live outside of plant, being able to enhance plant growth through the production of signal compounds that directly stimulate plant growth, improvement of plant disease and mobilization of soil nutrients to the plant (Analise and Luciane, 2011). Gray and Smith (2005) stated that extracellular PGPR are subdivided into three groups based on the degree of association with plant roots. There are living near but not contact with the roots, colonizing the root surface and living in the space between cells of the root cortex. The plant growth promoting rhizobacteria can affects the plant growth by indirectly or directly way. The PGPR promotes the plant growth by producing a compound that facilitating the uptake of certain nutrient from the environment (Glick, 1995). The phosphorus solubilizing bacteria (PSB) is known as PGPR that promote the plant growth with directly way. The phosphorus solubilizing bacteria able to solubilize insoluble mineral phosphate by producing various organic acids that promote plant growth (Anelise and Luciane, 2011). The indirect promotion of plant growth is preventing the deleterious effects of pathogenic organism.

A large number of PSB have been isolated from rhizosphere of several crops. Chabot *et al.* (1993) reported that 20% to 40% of PSB are isolated from rhizosphere soil. The phosphate solubilizing bacteria found in rhizosphere soil higher than nonrhizosphere soil (Rodriguez and Fraga, 1999). The bacteria group that known as

phosphate solubilizing bacteria in soil rhizosphere is *Pseudomonas, Bacillus, Rhizobium, Burkholderia, Achromobacter, Agrobacterium, Micrococcus, Aerobactor, Flavobacterium* and *Erwinia* (Anelise and Luciane, 2011). According Chet*et al.* (1990) and Handelsman and Stabb (1996), many bacteria and fungi have been isolated from soil and the rhizosphere used as bio-control agaist soil borne pathogen. *Pseudomonas fluorescens* isolated form rhizosphere soils are capable to suppress a major root disease of wheat caused by *Gaeumannomyces graminis* variety *tritici.* (Thomashow and Weller, 1988).

Due the study of (Dikin *et al.,* 2006), more dominant bacteria be isolated from rhizosphere region compared with seed and fruits. The complex interaction between microorganism and plant part in rhizosphere dominated bacteria. Plant health and soil fertility are increasing due to the interaction of plant with microbe in the rhizosphere (Khan, 2006). The rhizosphere soil bacteria introduced beneficial effect on plant, which promoting plant growth or exercising biological control of pathogen with its root colonization capacity (Benizri *et al.,* 2001). Due to availability of organic matter and oxygen, the number of microbes is less in 15 cm to 30 cm depth of soil compare to 0 cm to 15 cm depth of soil (Udotong *et al.,* 2008).

Gram's negative rod bacteria, including *Pseudomonas sp., Agrobacterium sp., Burkholderia* and *Stenotrophomonas* was commonly isolated from rhizosphere soil (Dekin *et al.,* 2006). The Gram's positive bacteria comparatively rare be isolated. The Gram's positive bacteria included *Bacillus sp., Azotobacter, Mycobacterium, Cellulomonas* and *Clostridium sp.. Pseudomonas sp., Burkhoderia sp., Seratia sp., Bacillus* and actinomycetes from the genera *Streptosporangium* and *Nacardiopsis* shown the antibiotic activity and lysis and able to induce systemic resistance in plants (Kloepper *et al.,*1992). As a biological control agent to limit the growth of pathogen by direct parasitism, cell wall lytic enzyme including chitinases, glucanases and proteases are capable produced (Jayaprakashel and Mathivanam, 2011).

Places where disease severity is reduced or the plants do not suffer from certain disease are known as natural suppressive soil. Bivi *et al.* (2010) suggested BSR in most likely kept under control by some biological means when the low BSR incidence was observed in some natural stand. This observation was leading the use of biological control agents were focused in control of *Ganoderma* infection (Bivi *et al.,* 2010; Susanta *et al.*, 2005). Microorganism that commonly found in the rhizosphere was

bacteria, actinomycetes, fungi, algae and protozoa. The fungi, bacteria and actinomycetes are able used as biological control agent. There are two types of biological control agent which are the microbes that able lyse fungal cell by produced mycolytic enzymes such as chitinase and ß-1, 3-glucanase (Patel *et al.,* 2007; Gohel *et al.,* 2006; Kucuk and Kivanc, 2004; El-Katatny *et al.*, 2000) and enter the hyphae of pathogen by parasitic mechanism (Alabouvette *at al.*, 2006; Ozbay and Newman, 2004).

### 2.4.1 Chitinolytic bacterial

Chitinolytic bacteria play an important role in plant pathogenic fungi biological control and can be isolated from soil (Gohel *et al.,* 2006). The chitinolytic bacteria included *Aeromonas hydrophila*, *Aeromonas caviae*, *Pseudomonas maltophila, Bacillus licheniformis*, *Bacillus circulans*, *Vibrio furnissi*, *Xanthomonas sp.*, and *Serratia marcescens* (Gohel *et al.,* 2006). Suryanto *et al.* (2010) reported chitinolytic bacteria reduced the incidence of red pepper seedling wiit caused by *Fusarium oxysporum*. The growth of *Phytium capsici*, *Rhizoctonia solani* and *Fusarium sp.* was inhibited by combined chitinolytic bacteria of *Serratia plymuthica*, *Chromobacterium* and *Lysobacter enzymogenes* (Kim *et al.,* 2008). Furthermore, the growth of *Fusarium oxysporum*, *Ganoderma boninense* and *Penicillium semitectum* was inhibited by chitinolytic bacterial isolates (Suryanto *et al.,* 2011).

*Aeromonas caviae* induce chitinase with the chitin colloidal (Inbar and Chet, 1991). Chitin is second abundant biopolymer that mostly found in fungi and arthropods (Tsujibo *et al.,* 2002; Singh *et al.,* 2008). The source of chitin were available in soil, so the chitinolytic bacterial were capable survived in the grow media of oil palm seedling. After chitin colloidal incubated as C-source within 24 to 72 hours, the chitin hydrolysis was occurred (Watanabe *et al.,* 1997). Furthermore, the maximum level of chitinase activity of bacterial was stated after 10 to 20 days of bacterial inoculation (Kim *et al.*, 2008). The chitinase activity indicated through the degradation of fungal hyphae with chitinase production. Necrotic of hyphal tip and hyphal lytic were caused by endochitinase (Harjono and Widyastui, 2001). According Alabouvette *et al.* (2006), the lytic activity of bacterial have been conducted in biocontrol for several years.

## REFERENCES


Abdullah, F., Ilias, G.N.M., Vijaya, S.K., Leong, T.T. 1999. Diversity of *Trichoderma* and its *in vivo* Efficacy Against *Ganoderma boninense*. In: Sidek Z., Bong S.K., Ong C.A., Husan A.K. (eds): Sustainable Crop Protection Practices in the Next Millenium. MCB-MAPPS Plant Protection Conference '99, 2–3 November 1999, Kota Kinabalu, Sabah: 137–140

Abdullah, F., Ilias, G.N.M., Nelson, M., Nur Ain Izzati, M.Z. and Umi Kalsom, Y. 2003. Disease Assessment and The Efficacy of *Trichoderma* as a Biocontrol Agent of Basal Stem Rot of Oil Palms. Research Bulletin Science Putra, **11**: 31–33

Abdullah, H., Saud, H.M. and Fong, C.E.. 2003. Evalaution of the Comnined Effect of *Pseudomonas aeruginosa* and *Penicillium sp.* on the Development of Bacterial Wilt Caused by *Ralstonia solonacearum* on Tomato.Third Federal of Asia Pacific Microbiology Societies Conferences, Kuala Lumpur.

Adebola, M.O. and Amadi, J.E. 2010. Screening Three *Aspergillus* species for Antagonistic Activity Against the Cocoa Black Pod Organism (*Phytophthora palmivora*). *Agriculture and Biology Journal of Nortic America,***1**(3):362-365

Ajay, K., Amit, K., Shikha, D., Sandip, P., Chandani, P. and Sushila, N. 2012. Isolation, Screening and Characterization of Bacteria from Rhizospheric Soil for Different Plant Growth Promotion (PGP) Activities: an *In vitro* Study. *Recent Research in science and Technology 2012,* **4**(1): 1-5

Alabouvette, C., Olivain, C. and Steinberg, C. 2006. Biological Control of Plant Disease: The Review. *Eur. J. Plant Pathol.,* **114**:329-341

Anelise, B. and Luciane, M.P.P. 2011. Genetic and Phenotypic Diversity of Plant Growth Promoting Bacilli. Dinesh, K.M. (Eds.). *Bacteria in Agrobiology: Plant Growth responses.*Berlin: Springer

Anitha, A. and Rabeeth, M. 2010. Degradation of Fungal Cell Wall of Phytopathogenic Fungi by Lytic enzyme of *Streptomyces griseus. Afr. J. Plant Sci.,* **4**:61-66

Ariffin, D. and Idris, A.S. 2002. Progress and Research on *ganoderma* basal stem rot of oil palm. Proc. Seminar on Recent Progress in the Manage. Peat and *Ganoderma* May 2002. Bangi, MaLaysia, **50**

Arnesen, L.P., Fagerlund, A. and Granum, P.E. 2008. From Soil to Gut: *Bacillus cereus* and Its Food Poisoning Toxins.*Toxicon* **49**:423-435

Azadeh, B. F., Sariah, M. and Wong, M.Y. 2010. Characterization of *Burkholderia cepacia* genomover I as a Potetntial Biocontrol Agent of *Ganoderma boninense* in oil palm. *Afr. J. Biotechnol.,***9**: 3542-3548

Bargabus, R.L., Zidack, N.K., Sherwood, J.W. and Jacobsen, B.J. 2002. Characterization of Systemic Resistance in Sugar Beet Elicited by a Nonpathogenic Phyllosphere-colonizing *Bacillus mycoides,* Biological Control Agent. *Physiological and Molecular Plant Pathology* **61**:289-298

Bashan, Y. and Levony, H. 1990. Current Status of *Azospirillum* inoculation Technology: *Azospirillum* as a Challenge for Agriculture.*Can J Microbiol,* **36**:591-608

Benizri, E., Baudoin, E. and Guckert, A. 2001. Root Colonization ny Inoculated Plant Growth Promoting Rhizobacteria. *Biocontr Sci Technol,* **11**:557-574

Bivi, M.R., M.S.N. Farhana, A. Khairulmazmi and A. Idris. 2010. Control of Ganoderma boninense: A Causal Agent of Basal Stem Rot Disease in Oil Palm with Endophyte Bacteria *In Vitro.International Journal of Agriculture and Biology,* **12**(6): 833-839

Bravo, A., Gill, S.S, and Soberon, M. 2007. Mode of Action of *Bacillus thuringiensis* Cry and Cry toxin and Their Potential for Insect Control. *Toxicon* **49**:432-435

Brian, J.A., Paul,E.K. and Colin, G.N. 1999. Plant in Action. Adaption in Nature, Performance in Cultivation. *Macmillan Education Australia Pty Ltd, Melbourne, Australia.*

Brown, M.E.1974.Seed and Root Bacterization. *Annu Rev Phytopathol,***12**:181-197

Chatbot, R., Antou, H. and Cescas, M.P.1993. Stimulation de la croissance du mais et la laitue romaine par desmicroorganism dissolvent le phosphore inorganique.*Can J Microbiol,* **39**:941-947

Chen, C., Belarger, R.R., Benhamou, N. and Paulitz, T.C. 2000. Defence Enzyme Induced in Cucumber Roots by Treatmnet With Plant Growth Promoting Rhizobacteria (PGPR) and *Pythium aphanidermatum. J. Physiol. Mol. Plant Pathol.,* **56**:13-23

Chet, I., Ordentlich, A., Shapira, R. and Oppenhime, A. 1990. Mechanisms of Biocontrol of Soil Borne Plant Pathogen by nRhizobactria. *Plant Soil,***129**:85-92

Chin-A-Woeng TFC, Bloemberg, G.V., Mulders, I.H.M., Dekkers, L.C. and Lugtenberg, B.J.J. 2000. Root Colonization by Phenazine-1-carboximide Producing Bacterium *Pseudomonas chlororaphis* PLC 1931 is Essential for Biocontrol of Tomato Foot and Root Rot . *Mal Plant Microbe Interact,***10**:79-86

Compant, S., Duffy, B., Nowak, J., Clement, C. and Barka, E.A. 2005. Use of Plant Growth Promoting Bacteria for Biocontrol of Plant Disease;Priciples , Mechanism of Action and Future Prospects. *Appl Environ Microbiol,***71**:4951-4959

Cook, R.J. and Beaker, C.F.1983. The Nature Pratice of Biological Control and Plant Pathogens.*American Phytopathological Society,St.Paul.*

Coombs, J.T., Michelsen, P.P. and Franco, C.M.M. 2004. Eval;uation of Endophytic Actinibacteria as Antagonists of *Gaeumannomyces graminis* var *tritici* in Wheat. *Biol Control,***29**:359-366

Corley, R.H.V. and Tinker, P.B., 2003. The Oil Palm. *Blackwell Publishing,Oxford.*

Curl, E.A. and Truelove, B. 1986. The Rhizosphere. *Springer-Verlag,New York.*

De Marco, J.L. and Felix ,C.R. 2002. Characterization of A Protease Produced by A Trichoderma harzianum Isolate Which Controls Cocoa Plant Witches' Broom Disease. *BMC Biochemistry*, **3**: 3–10.

De Oliveira, M.F., Da Silva, M.G. and Van Der Sand S.T. 2010. Anti-phytophatogen Potential of Endophytic Actinobacteria Isolated from Tomato Plant (*Lycopersicon esculentum*) in Southen Brazil and Characterization of *Streptomyces sp.* R18(6), a Potential Biocontrol Agent. *Res Microbial,***161**:565-572

De Salamone, I.E.G, Hynes, R.K. and Nelson, L.M. 2005. Role of Cytokinin in Plant Growth Promotion by Rhizosphere Bacteria. In: Siddiqui Z.A. (ed) PGPR: Biocontrol and Biofertilization. Springer, The Netherlands, 173-195

Dharmaputra, O. and Soetarmitjirosomo, H.S. 1999. Antagonistic Effect of Four Fungal Isolates to *Gonoderma boninense,* The Causal Agent of Basal Stem Rot of Oil Palm. *Biotropia* **3**:41-49

Dikin, A., Sijam, K., Kadir, J. and Idris, A.S.2005. Extraction of Antimicrobial Substances from Antagonistic Bacteria against *Schyzophyllum commune. Malaysian Micribiology Symposium.*Inovar=tion through Microbes. Grand Plaza Parkoyal Penang, Malaysia (2005), 24-27

Dikin, A., Kamaruzamansiiam, Jugahkadir and Idrisabuseman. 2006. Antagonistic Bacteria against *Schizophyllum communer* in Penisular Malaysia. *Biotropia,* **13**(2): 111-121

Di Simine, C.D., Sayer, J.A. and Gadd, G.M.1998. Solibilization of Zinc Phosphate by a Strain of *Pseudomonas fluoscences* isolated from a Forest Soil.*Biol Fert Soils,***28**:87-94

Downing, K.J. and Thomson, J.A. 2000. Introduction of The *Serratia marcescens* chiA gene into An Endophytic *Pseudomonas fluorescens* for Biocontrol of phytopathogenic Fungi. *Can J. Microbiol.* ,**48**: 363-369

Dwivedi, D., and Johri, B.N. 2003. Antifungals fro Fluorescent Pseudomonads: Biosyntheis and Regualtion. *Curr Sci,***12**:1693-1703

Elad, Y., Chet, I. and Henis Y. 1983. Parasitism of *Trichoderma* spp. on *Rhizoctonia solani* and *Sclerotium rolfsii*. Scanning Electron Microscopy and Fluorescence Microcopy. *Phytopathology*, **73**: 85–88.

Elisa, G. and Bernard, R.G. 2011. Mechanisms Used by Plant Growth Promoting Bacteria. Dinesh, K.M. (Eds.). *Bacteria in Agrobiology: Plant Nutrient Management.*Berlin: Springer

El-Katatny, M.H., Somitsh, W., Robra, K.H., El-Katatny, M.S. and Gubitz, G.M. 2000. Production of Chitinase and ß-1, 3-glucanase by*Trichoderma harzianum* for Control of The phytopathogenuc fungus *Scerotium roifsii. Food Technol. Biotechnol.,* **38**:173-180

Elmirich, C. 1984. Molecular Biology and Ecology of Diazotroph Associated with Non-Leguminous Plants. Biotechnology,**2**:967-978

El-Mougith, A. 2009. *The Antagonistic Activities of Some Metabolites Produce by Pseudomonas aeruginoca Sha8.* Dapartment of Botany , Faculty of Science, Zagazig University, Egypt.

El-Tarabily, K.A., Hardy, G.E.S.J., Sivasithamparam, K., Hussein, A.M. and Kurtboke,D.I. 1997. The Potential for the Biological Control of Cavity-spot Diseas of Carrots, Caused by *Pythium coloratum,* by the Streptomycete and Non-streptomycete Actinomycetes.*New Phytol,***137**:495-507

El-Tarabily, K.A. and Sivasithamparam,K. 2006. Non-streptomycete Actinomycetes as Biocontrol Agents of Soil Borne Fungal Plant Pathogen and as Plant Growth Promoters. *Soil Biol Biochem,***38**:1505-1520

El-Tarabily, K.A.,Nassar, A.H. and Sivasithamparam, K. 2008. Promotion of Growth of Bean (*Phaseolus vulgaris* L.)in a Calcareous Soil by a Phosphate Solubilizing, Rhizosphere Component Isolate of *Micromonospora endolithica.Appl Soil Ecol,***39**: 161-171

Fravel.D. 1988. Role of Antibiosis in the Biocontrol of Plant Disease. *Annu Rev Phytopathol,* **26**:75-91

Ghodhbane-Gtari, F., essoussi, I., Chattaoui, M., Chouaia, B., Joaunani, A., Daffonchio, D., Boudabous, A. and Gtari, M. 2010. Isolation and Characterization of Non-Frankia Actinobacteria from Root Nodules of *Alnus glutinosa, Casuarina glauca* and *Elaeagnus angustifolia.Symbiosis.***50**:51-57

Glick,B.R. 1995. The Enhancement of Plant Growth by Free Living Bacteria. *Can J Microbiol,* **41**:109-117

Gohel, V., Singh, A., Vimal,M., Ashwini, D. and Chhatpar, H.S. 2006. Bioprospecting and Antifungal Potential of Chitinolytic Microorganism. *Afr. J. Biotechnol.,* **5**:54-72

Gray, E.J. and Smith, D.L.2005. Intracellular and Extracellular PGPR: Commonalities and Distinction in the Plant bacterium Signaling Processes. *Soil Biol Biochem,* **37**:395-412

Gualti, A., Rahi, P. and Vyas, P. 2008. Characterization of Phosphate Solubilizing Fluorescent Pseudomonads from the Rhizosphere of Seabuckthorn Growing in the Cold Deserts of Himalayas.*Curr Microbial,***56**:73-79

Haas, K., Keel, C., Laville, J., Maurhofer, M., Orbenhan-sli, T., Schnidder, U., Voisard, C., Wuthrich, B. and Defago, G. 1991. Secondary Metabolites of *Pseudomonas fluorescences* Strain CHAD Involved in the Suppression of Root Disease. *In Advances in Molecular Genetics of Plant Microbe Interaction,* **1**

Halder, A.K., Misra, A.K. and Chakrabarty, P.K.1991. Solubilization of Inorganic Phosphate by *Bradyrhizobium.Indian J.Exp Biol,***29**:28-31

Hallmann, J., Quadt-Hallmann, A., Mahaffe, W.F. and Kloepper, J.W. 1997. Bacterial Endophytes in Agricultural Crops. *Can J Microbial,***43**:895-914

Handelsman, J. and Stabb, E.V. 1996. Biocontrol of Soilborne Plant Pathogens. *Plant Cell,***8**:1855-1869

Haram, S., Schickler, H., Oppenheim, A. and Chet, I. 1996. Differential Expression of *Trichoderma harzianum* Chitinases During Mycoparasitism. *Phytopathology*, **86**: 980–985

Harjono, S. and Widyastuti, S.M. 2001. Antifungal Activity of Puriefied Endochitinase Produced by Biological Agent *Trichoderma reesei* against *Ganoderma philippi. Pakistan J. Biol. Sci.,* **4**:1232-1234

Hayward, A.C.1983.Primary Differention of the Genera of Plant Pathogenic Bacteria.In Plant Bacteria Disease A Diagnostic Guide, ed. P.C.Fathy and G.J.Persley: Academic Prees:13-26

Hill, D.S., Stein, R.I., Torkewitz, N.R., Morse, A.M., Howell, C.R., Pachlatko, J.P., Becker,J.O. and Ligon,J.M. 1994. Cloning of Genes Involved in the synthesis of Pyrrolnitrin form *Pseudomonas fluorescences* and role of Pyrolnitrin Synthesis in Biological Control of Plant Disease. *Appl Environ Microbiol,* **60**:78-85

Hiltner L. 1904. Uber neue erfahrungen und probleme auf dem gebiete der bodenbakteriologie. *Arbeiten der Deutschen Landwirtschaft Gesellschaft* **98**: 59–78.

Hofte, M., Buysens, S., Koedan, N. and Cornelis, P. 1993. Zinc Affects Siderophores-mediated High Affinity Iron Uptake System in the Rhizosphere *Pseudomonas aeruginosa* 7NSK2. *Biometals,* **6**:85-91

Idris, A.S., Arifin, D., Swinburne, T. R. and Watt, T. A. 2000.The Identified of *Ganoderma* species responsible for BSR diseaseof oil palm in Malaysia-Mophological characteristics. Malaysia Palm Oil Board **102**: 77a

Idris, A.S., Ismail, S., Arrifin, D. and Ahmad, H. 2002. Control of *Ganoderma* infected palm development of pressure injection and field application. *MPOB Information Series.*

Idris, A.S., Kushairi, A., Ismail, S. and Ariffin, D. 2004. Selection for partial resistance in oil palm progenies to *Ganoderma* basal stem rot. *Journal of Oil Palm Research* **16**: 12-8.

Idris, A.S., Zaiton, S. and Noorhaida,S. 2008. *In vitro* Methods for Evaluation of Antagonistic Bacteria and Actinomycetes against Pathogenic *Ganorderma. MPOB Information Series,* **54**.

Ilias, G.N.M. 2000. *Trichoderma and its efficacy as a bio-control agent of basal stem rot of oil palm (Elaeis guineensis Jacq.).* Ph.D. Thesis. Universiti Putra Malaysia, Selangor, Malaysia

Inbar, J. and Chet. 1991. Evidence that Chitinase Produced by *Aeromonas caviae* is Involved in The Biological Control of Soil Borne Plant Pathogen by This Bacterium. *Soil Boil. Biochem.,* **23**: 973-978

Jason, W. 2004.Bacteriology. *NWFHS Laboratory Procedures Manual,* 2nd edition. USFWS: Pinetop Fish Health Center

Javier, A.A., Marisa, R., Lorena, B.G. and Nicolas, A.P. 2011. Role of *Pseudomonas aurantiaca* in Crop Tmprovement, Dinesh, K.M. (Eds.). *Bacteria in Agrobiology: Plant Responses.*Berlin:Springer

Jayaprakashevel,M. and Mathivanan,N. 2011. Management of Plant Disease by Microbial Metabolites. Dinesh, K.M. (Eds.). *Bacteria in Agrobiology: Plant Nutreint Management.*Springer

Jeffrey, D. P., Teresa, L. O. and Hamed, K. A. 2007. Isolation of Maize Soil and Rhizosphere Bacteria with Antagonistic Activity against *Aspergillus flavus* and *Fusarium verticillioides. Journal of Food Protestion,* **70**(7): 1615-1621

Jiang, C.Y., Sheng, X.F., Qiang, M. and Wang, Q.Y. 2008. Isolation and Characterization of a Heavy Metal Resistant *Burkholderia sp.* from Heavy metal Contaminated Paddy Field Soil and its Potential in Promoting Plant Growth and Heavy Metal Accumulation in Metal-polluted Soil. *Chemosphere,***72**: 157-164

Joseph, B., Patra, R.R. and Lawrence, R. 2007. Characterization of Plant Growth Promoting Rhizobacteria Associated with Chickpea (*Cicer arietinum* L.).*Int J Plant Prod,* **2**:141-152

Kaewchai, S. and Soytong, K. 2010. Application of biofungicides against *Rigidoporus microporus* causing white root disease of rubber trees. *Journal of Agricultural Technology* **6**(2): 349-363

Kamaruzaman, S. and Dikin, A. 2005. Biochemical and Physiological Characterization of *Burkholderia cepacia* as Biological Control Agent. *International Journal of agricultura and Biology,* **7** (3):385-388

Keel, C., Wirthner, P.H., Oberhansii, T.H., Voisard, C., Burger, P., Has, D. and Defago, G. 1990. *Pseudomonas* as Antagonists of Plant Pathogen in the Rhizosphere Role of the Antibiotic 2,4-diacetylpholoroglucinol in the Suppression of Black Root Rot of Tabacco. *Symbiosis,* **9**:327-341

Kexiang Xiaoguang, L., Yonghong, L., Tianbo, Z. and Shuliang, W. 2002. Potential of *Trichoderma harzianum* and *T. atroviride* to control *Botryosphaeria berengeriana* f.sp. *piricola*, the cause of apple ring rot. *Journal of Phytopathology*, **150**: 271–276

Khairuddin, H. and Chong, T.C. 2008. An Overview of The Current Status of *Ganoderma* Basal Stem Rot Disease and Its Management in A Large Plantation Group in Malaysia. *The Planter,* **84**:147-152

Khan, M. S. 2006. Screening of Free-living Rhizospheric Bacteria for Their Multipla Plant Growth Promoting activities. *Microbial,***163**:173-181

Kim, Y.C., Jung, H., Kim, K.Y. and Park, S.K. 2008. An Effective Biocontrol Biofomulation Against Phytophthora Blight of Pepper Using Growth Mixtures of Combined Chitinolytic Bacteria Under Different Field Condition. *Eur. J. Plant Patyhol.,* **120**:373-382

Kloepper, J.W., Lifshiyz, R. and Schroth, M.N. 1988. *Pseudomonas* Inoculants to Benefit Plant Production. *ISI Atlas Sci Anim Plant Sci,* **1**:60-64

Kloepper, J.W., Lifshiyz, R. and Zablotowicz, R.M. 1989. Free Living Bacterial Inoculas for Enhancing Crop Productivity. *Trends Biotechnol,* **7**:39-43

Kloepper, J.W. 1992. Plant Growth Promoting Rhizobacteria as Biological Control agents. *Soil Microbial ecology: Application in Agriculture and Environment Management,:* 255-274

Kucuk, C. and Kivanc, M. 2004. *In Vitro* Antifungal Activity of Strains of *Trichoderma harzianum. Turk. J. Biol.,* **28**:111-115

Lee, S.O., Choi, G.J., Choi, Y.H., Jang, K.S., Park, D.J.,Kim, C.J. and Kim, J.C. 2008. Isolation and Characteriization of Endophytic Actinomycetes from Chinese Cabbage Root as Antagonists to *Plasmodiophora brassicae.J Microbial Biotechnol,* **18**:1741-1746

Liu, L., Kloepper, W. and Tuzun, S. 1995. Introduction of Systemic Resistance in Cucumber against Bacterial Angular Leaf Spot by Plant Growth Promoting Rhizobacteria. *J. Phytopathol.,***85**:843-847

Lo, C.T., Nelson, E.B. and Harman, G.E. 1997. Improved biocontrol efficacy of Trichoderma harzianum 1295-22 for Foliar Phases of Turf Diseases by Use of Spray Applications. *Plant Disease*, **81**: 1132–1138

Lynch, J.M.1990. The Rhizisphere. Wiley, Chichester

Malboodi, M.A., Behbahani, M., Madani, H.,Owlia, P., Deljou, A., Yakhchali, B., Moradi, M. and Hassanabadi, H. 2009. Performance Evaluation of Potent Phosphate Solubilizing Bacteria in Potato Rhizosphere. *World J Microbial Biotechnol,* **25**:1479-1484

Mansion, M., Cocolin, L., Cantoni, C. and Comi, G. 2003. *Bacillus thuringiensis* and *Bacillus mycoides* Differentiation Using a PCR-RE Technique. *International Journal of Food Microbiology* **81**:249-254

Masafumi, S. 2011. Endophytic Actinomycetes: Biocontrol Agents and Growth Promoters. Dinesh, K.M. (Eds.), *Bacteria in Agrobiology: Plant Growth Responses.*Berlin:Springer

Mathivanan, N. and Manibhushanrao, K. 2004. An Overview of Current Strategies on Biological Control of Soil Borne Pathogen. Prakash, H.S. and Niranjana, R.S. (Eds.). *Vistas in Applied Botany Department of Applied Botany Technology,* University od Mysore, Mysore, India: 119-148

Mathivanan, N., Prabavanthy, V.R. and Vijayanandraj, V.R. 2008. The Effect of Fungal Second Metaolites on Bacterial and Fungal Pathogen. In: KarlovskyP. (Eds.) *Secondary Metabolites in Soil Ecology.* Berlin :Springer

Maurhofer, M., Keel, C., Schnier, U., Voisard, C., Haas, D. and Defago, G. 1991. Influence of Enhanced Antibiotic Production in *Pseudomonas fluorescens* CHAO on its Disease Suppressive Capacity. *Pthytopathology* ,**82**:190-195

MPOB. 2008. Control of *Ganoderma* Infected Palm Development of Pressure Injection and Field Applications. Idris, A.S., Ismail, S., Arrifin, D. and Ahmad, H. Information Series

Mejia, L.C., Rojas, El., Maynard, Z., Van Bael S., Arnold A.E., Hebbar, P., Samuels, G.J., Robbins, N. and Herre, E.A. 2008. Endophytic Fungi as Biocontrol Agents of *Theobroma cacao* Pathogen. *Boil. Control* **46**:4-14

Mohd Zainudin, N. A. I. and Faridah, A. 2008. Disease Suppression in *Gonoderma* Infected Oil Palm Seedling Treated with *Trichoderma harzianum. Plant Protect. Sci.,* **44**(3):101-107

Nazeeb, M., Barakabah, S.S. and Loong, S.G. 2000. Potential of High Intensity Oil Palm Plantings in Diseased Environments. *The Planter,* **76**: 699-710.

Ndubuisi-Nnaji, U.U, Adegoke, A.A, Ogbu, H.I, Ezenobi, N.O and Okoh A.I. 2011. Effect of long-term organic fertilizer application on soil microbial dynamics. *African Journal of Biotechnology* **10** (4) : 556-559

Nimnoi, P., Pongsilp, N. and Lumyong,S. 2010. Endophytic Actinomycetes Isolated rom *Aquilaria crassna* Pierre ax Lec and Screening of Plant Growth Promoters Production. *World J Microbial Biotechnol,***26**:193-203

Nur Masirah, M.Z, Rosli, M. and Kamuruzaman, S., 2011. Bacterial population in soil of a young oil palm plantation. *International Congress of the Malaysian Society for Microbiology 2011,Penang, Malaysia* **8**(1): 233-235

Nurulnisa binti Nor Azman. 2009. *Isolation and Characterization of Potential Cellulolytic Bacteria from Masterfeed Using 16S RNA Analysis and Biochemical Method,* Bachelor of Science (Biology). Universiti Teknologi Malaysia

Okon, Y. and Labandera-Gonzalez, C.A.1994. Improving Plant Productivity with Bacteria. Ryders,M.H., Stephens,P.M. and Bowen,G.D. (Eds.).Commonwealth Scientific and Industrial Research Organization

Oregon State University Plant Clinic. 2006. Protocol for Isolation of *Agrobacterium* from Herbaceous Plant Material.

Ozbay, N. and Newman, S.E. 2004. Biological Control with *Trichoderma* spp. with Emphasis On *T. harzianum. Pakistan J. Biol. Sci.,* **7**: 478-484

Pan, M.J., Redeman, S., Kunert, K and Hastings, J.M. 1997. Ultrastructural Studies on the Colonization of Banana tissue and *Fusarium oxysporum f.sp. cubense* race 4 by the Endophytic Bacterium *Burkholderia cepacia. J. Phytopathol,* **145**: 479-489

Park,K.H., Lee, C.Y.and Son,H.J. 2009. Mechanism of Insoluble Phosphate Solubilizing by *Pseudomonas fluorescens* RAF!% Isolated from Ginseng Rhizosphere and its Plant Growth Promoting Activities. *Lett Appl Micribiol,* **49**:222-228

Patel, B., Gohel, V. and Raol, B. 2007. Statistical Optimization of Medium Components for Chitinase Production by *Paenibacillus Sabina* strain JD2. *Ann. Microbiol. ,* **57**:589-597

Pausey, P.L. and Wilson, C.L. 1984. Postharvest Biological Control of Stone Fruit Brown Rot by *Bacillus subtilis. Plant Disease* **68**:753-756

Phillips-Laing, E., Staines, H.J. and Palfreyman J.W. 2003. The isolation of specific bio-control agents for the dry rot fungus *Serpula lacrymans. Holzforschung,* **57**: 574–578

Piao, C.G., Tang, W.H. and Chen, Y.X. 1992. Study on the Biological Activity of Yiled Increasing Bacteria.*Chin J Micrecol,* **4**: 55-62

Preeti, T., Swati, R.E. and Jaya, T. 2011. *In vitro* Study of *Pseudomonas sp.* Isolated from Soil. *Journal of Phytology,* **3**(4):21-23

Rathnayake, I. V. N., Mallavarapu Megharaj, Nanthi Bolan, and Ravi Naidu. 2009. Tolerance of Heavy Metals by Gram Positive Soil Bacteria. *World Academy of Science, Engineering and Technology* **53**: 1185-1189

Roco, A. and Maria Pèrez L. 2001. *In vitro* biocontrol activity of *Trichoderma harzianum* on *Alternaria alternata* in the presence of growth regulators. *EJB Electronic J ournal of Biotechnology,* **4**: 68–73

Rodrigues, H. and Fraga, R. 1999. Phosphate Solubilizing Bacteria and Their Role in Plant Growth Promotion. *Biotechnol Adv,* **17**;319-339

Rojas, A., Holguin, G., Glick, B.R. and Bashan,Y. 2001. Syergism Between *Phyllobacterium sp.*(Nitogen Fixer) and *Bacillus licheniformis* (P-solubilizer), both from a Semiarid Mangrove Rhizosphere. *FEMS Microbiol Ecol,***35**:181-187

Rothrock, C.S. and Gottlied, D. 1984.Role of Antibiosis in an Antagonism of *Streptomyces hygroscopicus* var. *geldanus* to *Rhizoctonia solani* in Soil. *Can J Microbial,* **30**:1440-1447

Sahin, F., Cakmakci, R. and Kantar, F. 2004. Suagr Beet and Barley Yields in Relation to Inoculation with Nitrogen Fixing and Phosphate Solubilizing Bacteria. *Plant Soil,* **265**: 181-187

Samuel, S.G. 2007. *Burkholderia. Plant Associated Bacteria.* Springer.

Sanderson, F.R. 2005. An Insight into Dispersal of *Ganoderma boninense* on Oil Palm. *Mycopathologia,* **159**, 139–141

Sapak, Z., Meon, S. and Ahmad, Z. A. M., 2008. Effect of Endophytic Bacteria on Growth and Suppression of *Garnoderma* Infection in Oil Palm.*Int. J. Agri. Biol.,* **10** (2): 127-132

Sariah, M., Cho,o C.W., Zakaria, H. and Norihan, M.S. 2005. Quantification and Characterization of *Trichoderma* spp. from Different Ecosystems. *Mycopathologia,* **159**: 113–117

Shahida, H. and Naghma, T. 1989. Characterization of Salt Tolerant Bacteria Isolated from the Rhizosphere of *Leptochiloa fusca* and *Atritplex rhocodoidaes.Pakistan J. Pham. Sci.* **2**(2):47-53

Shamala, S., Abdullah, F., Ahmad, Z. A. M. and Yusuf, U. K. 2008. Efficacy of Single and Mixed Treatment of *Trichoderma harzianum* as Biocontrol Agents of *Ganoderma* Basal Stem Rot in Oil Palm. *Journal of Oil Palm Research,* **20**: 470-483

Shamala, S. and Idris, A.S. 2009. *Trichoderma* as A Biocontrol Agent Against *Ganoderma* in Oil Palm. *MPOB Information Series.*

Sharon, E., Bar-Eyal, M., Chet, I., Herrera-Estrella, A., Kleifeld, O. and Spiegel, Y. 2001. Biological Control of The Root-knot Nematode *Meloidogyne javanica* by *Trichoderma harzianum. Phytopathology*, **91**: 687–693

Sharoni, S., Arnon, D., Alon, B., Mohamad, A.D. and Yigal, E. 2006. Honey Bee Dispersal of The Biocontrol Agent *Trichoderma harzianum* T39: Effectiveness in Suppressing *Botrytis cinerea* on Strawberry Under Field Conditions. *European Journal of Plant Pathology*, **116**: 119–128

Siloh-suh. 1994. Biological Activities of Two Fungistatic Antibiotics Produced by *Bacillus cereus* UW85. *Applied Environmental Microbiology* **60**: 330-339

Singh, G, 1991. *Ganoderma*- the scourge of oil palm in the coastal areas. *The Planter* **67**, 421-44.

Singh, G., Sharma, J.R. and Hoondal, G.S. 2008. Chitinase Production by *Serratia marcescens* GG5.*Turk. J. Biol.*,**32**: 231-236

Sonil, N., Smiti, S.S. and Jayanthi, A. 2010. Studies on the Biodegradation of Natural and Synthetic Polythylene by *Pseudomonas spp. J. Appl. Sci. Environ. Manage,* **14**(2):57-60

Suryanto, D., Irawati, N. and Muhir, E. 2011. Isolation and Characterization of Chitinolytic Bacteria and Their Potential to Inhibit Plant Pathogenic Fungi. *Microbiol. Indones.,* **5**:118-122

Suryanto, D., Patonah, S. and Muhir, E. 2010. Control of *Fusurium* Wilt if Chili with Chitinolytic Bacteria. *Hayati J. Bioscie.,* **17**:5-8

Suryanto, D., Wibowo, R.H.,Siregar, E.B.M. and Munir, E. 2012. A Possibility of Chitinolytic Bacteria Utilization to Control Basal Stem Disease by *Ganoderma boninense* in Oil Palm Seedling. *African Journal of Microbiology Research* **6**(9):2053-2059

Susanto, A. 2009. Basal stem rot in Indonesia. Biology, economic importance, epidemiology, detedtion and control. Proceedings of International Workshop on Awareness, Detection and Control of Oil Palm Devastating Disease November 2009. Kuala Lumpur Convention Centre, Malaysia. *University Putra Malaysia Press.*

Susanto, A., Sudharto, P.S and Purba, R.Y. 2005. Enhancing Biological Control of Basal Stem Rot Disease (*Ganoderma boninese)* in Oil Palm Plantation.*Mycopathologia,* **159**:153-157

Tahtamouni, N.E.W., Hameed, K.M. and Saadoun, I.M. 2006. Biological Control of *Sclerotinia sclerotiorum* Using Indigeous Chitinolytioc Actinomycetesin Jordan. *Plant Pathol J,* **22**:107-114

Tang, W.K., Pasternak, J.J. and Glick, B.B. 1994. Stimulation of Canola Root Growth by *Pseudomonas putida* GR 12-2 and its Genetically Engineered Derivatives. *Life Sci Adv,* **13**:89-95

Tao, G.C., Tian, S.J., Cai, M.Y. and Xie, G.H.2008. Phosphate Solubilizing and Mineralizing Abilities of Bacteria Isolated from Soils. *Pedosphere,***18**:515-523

Thomashow, L.S. and Weller, D.M.1988. Role of a Phenazine Antibiotic from *Pseudomonas flousence* in Biocontrol of *Gaeumannomyces graminis* var. *tritici. J. Bacteriol,***170**:3499-3500

Thompson, A. 1931. Stem Rot of The Oil Palm in Malaysia. *Bull Department Agric., Straits Settlements and FMS. Sci. Series 6.*

Tiwari, B.K., Valdramidis,V.P.,O'Donnel, C.P.,Muthukumarappan, P.,Bourke,P. and Culle, P.J. 2009. Application of Natural Antimicrobials for Food Preservation. *J. Agric. Food Chem.,* **57**:5897-6000

Toro,M., Azcon, R. and Barea, J. 1997. Improvement of Arbuscular Mycorrhiza Development ny Inoculation of Soil with Phosphate Solubilizing Rhizosphere to Improve Rock Phosphate Bioavailability and Nutrient Cycling.*Appl Environ Microbiol,***63**:4408-4412

Tsujibo, H., Orikoshi, H., Baba, N., Miyahara, M., Miyamoto, K., Yasuda, M. and Inamori, Y. 2002. Identification and Characterization of The Gena Cluster Involved In Chitin Degradation In A Marina Bacterium *Alteromonas* sp. strain 0-7.*Appl. Environ. Microbiol.,***68** :263-270

Turner, P.D. and Bull, R.A. 1967. Disease and Disorders of the Oil Palm in Malaysia. Incorporated Society of Planters. Kuala Lumpur.

Uchida, J.Y. and Kadooka, C.Y. 1997. Colletotrichum leaf spot of red sealing wax palm. *Plant Disease.* University of Hawaii Manoa: 1-4

Udotong, I.R., Ofanime, U.M. and Udotong, J.I.R. 2008. Microbiological and Physiological Studies of Wetland Soils in Eket, Nigeria. *World Academy of Science, Engineering and Technology* **44**:837-842

Van Loon, K.C., Bakker P.A.H.M. and Pertrse, C.M.J. 1998. Systemic Resistance Induced by Rhizospheric Bacteria. *Annu Rev Phytopathol* **36**: 453-483

Watanable, T., Kimura, K., Sumiya, T., Nikaidou, N.,Suzuki, K., Suxuki, M., Taiyoji, M., Ferrer, S. and Regue, M. 1997. Genetic Analysis of The Chitinase System of *Serratia marcescens* 2170. *J. Bacteriol.,* **179**: 7111-7117

Winding, A., Binnerup, S.J. and Pritchard, H. 2004. Non-target of Effect of Bacterial Biological Control Agent Suppressimg Root Pathogenic Fungi.*FEMS Mirobial Ecol,***47**:129-141

Yamaguchi, I. 1996. Pesticides of Microbial Origin and Application of Molecular Biology. Copping, L.G. (Eds). *Crop Protection Agents from Nature:Natural Products and Analogues.* The Royal Society of Chemistry , Cambridge

Yanti, Y., Umi Marshida, A.H. and Zainon, M.N. 2011. Biocontrol of Plant Pathogen *Phellinus noxius* by Selected Actinomycetes, Bacteria and Fungi. *International Cingress of The Malaysian Society for Microbiology 2011.*

Zimand, G., Elad Y., Chet, I. 1996. Effect of *Trichoderma harzianum* on *Botrytis cinerea* Pathogenicity. *Phytopathology,* **86**: 1255–1260