RESPONSE OF OIL PALM TO GANODERMA BONINENSE, TRICHODERMA HARZIANUM AND GLOMUS ETUNICATUM INTERACTIONS

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

April 2012

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

RESPONSE OF OIL PALM TO *Ganoderma boninense*, *Trichoderma harzianum* AND *Glomus etunicatum* INTERACTIONS

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April 2012

Chairman: Datin Siti Nor Akmar Abdullah, PhD

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Knowledge on the microbial relationship and molecular mechanism during oil palm-fungi interactions is of primary importance for the development of diagnostic tools for early detection of basal stem rot disease caused by *Ganoderma* species. Mycelial growth rate of different *Ganoderma* species were examined on various culture media to develop a medium for rapid growth of *Ganoderma* species. Rubber or oil palm wood waste was sufficient to improve growth of *Ganoderma* species; hence could be a useful renewable source for the early detection of *Ganoderma* disease. The density of soil microfungal community and growth profile of oil palm seedlings were investigated in oil palm artificially inoculated with pathogenic fungus *Ganoderma boninense* and the symbiotic fungi *Trichoderma harzianum and Glomus etunicatum.* Densities of the soil microfungal community increased significantly in oil palm inoculated with *T. harzianum* and *G. etunicatum*, while oil palm inoculated with *G. boninense* showed a

significant decrease in the density of the soil microfungal community. Thus, the density of soil microfungal community could be useful for early detection and control of *Ganoderma* disease in oil palm. Fatty acid (FA) signaling is emerging as an important mechanism in plant response during interaction with microbial organisms. Furthermore plants have several antioxidant scavenging mechanisms which are induced in response to biotic and abiotic stresses. For a comprehensive evaluation of key genes involved in FA pathway and antioxidant reactive oxygen species (ROS) scavenger genes during oil palm-*G boninense* and -*T. harzianum* interactions, a lane-based array analysis of gene expression in artificially inoculated oil palm seedlings was performed. The results obtained demonstrated that acetyl-CoA carboxylase, β-ketoacyl-ACP synthases II and III, Δ^9-stearoyl-acyl carrier protein desaturase, palmitoyl-ACP thioesterase, oleoyl-ACP thioesterase and glycerol-3-phosphate acyltransferase showed identical response in root and leaf tissues for the same fungi. Oil palm-*G. boninense* interaction up-regulated the expression of these genes in both root and leaf tissues and induced plant defense responses at 21 days postinoculation (dpi). Thereafter the production of physical symptoms occurred at 42 and 63 dpi concomitantly with suppression of expression of these genes. In oil palm-*T. harzianium* interaction increase in the expression level of these genes was observed in both tissues which correlated with the colonization of roots and promotion of plant growth at 3-63 dpi. The results from transcript level analysis of antioxidant ROS scavenger genes, metallothionein type 3 (*MT3-A* and *MT3-B*) revealed a different pattern of gene expression. Expression of *MT3-A* in roots was significantly up-regulated in *G. boninense* inoculated seedlings at 21 dpi. While the transcripts of *MT3-A* and *MT3-B* genes were synthesized in *G. boninense* inoculated leaves at 42 dpi,

and the analyses did not show detectable expression of these genes before 42 dpi. In *T. harzianum* inoculated seedlings, the *MT3-A* expression was significantly up-regulated in roots at 3 dpi and thereafter were maintained at this level. The expression levels of *MT3-A* and *MT3-B* were induced in leaves at 3 dpi and subsequently maintained at same levels until 63 dpi. Differences in the expression profiles of the FA biosynthetic pathway genes during pathogenic and symbiotic interaction demonstrated their role in plant resistance mechanism and growth promotion by *T. harzianum* and could be the basis for molecular marker development for early detection of infection. The antioxidant ROS scavenger genes expressed in leaves and root tissues during oil palm-fungi interactions led to the discovery of their potential use as marker for the detection of oxidative stress.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENYELIDIKAN MENGENAI TINDAK BALAS KELAPA SAWIT TERHADAP INTERAKSI DENGAN *Ganoderma boninense*, *Trichoderma harzianum* AND *Glomus etunicatum*

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Pengetahuan mengenai hubungan mikrob dan mekanisme molekul semasa interaksi kelapa sawit dengan kulat adalah sangat penting bagi tujuan penghasilan alat diagnostik untuk pengesanan awal penyakit reput pangkal batang yang disebabkan oleh spesies *Ganoderma*. Kadar pertumbuhan miselium spesies *Ganoderma* yang berlainan telah diuji di atas pelbagai kultur media bagi tujuan penghasilan satu media yang mampu menggalakkan pertumbuhan pesat spesies *Ganoderma*. Bagi meningkatkan pertumbuhan spesis *Ganoderma*, penggunaan sisa kayu getah dan kelapa sawit adalah mencukupi, dengan itu sisa-sisa kayu tersebut boleh digunakan sebagai sumber yang boleh diperbaharui untuk pengesanan awal penyakit yang disebabkan oleh *Ganoderma.* Ketumpatan komuniti kulat mikro tanah dan profil pertumbuhan anak pokok kelapa sawit dikaji dalam kelapa sawit yang diinokulat secara artifisial dengan patogen kulat *Ganoderma boninense* dan kulat simbiotik; *Trichoderma harzianum* dan *Glomus*

etunicatum. Ketumpatan komuniti kulat mikro tanah meningkat dengan ketara pada anak pokok kelapa sawit yang diinokulat dengan *T. harzianum* dan *G. etunicatum*, manakala anak pokok kelapa sawit yang diinokulat dengan *G. boninense* menunjukkan penurunan yang signifikan dalam ketumpatan komuniti kulat mikro tanah. Oleh itu, ketumpatan komuniti kulat mikro tanah boleh menjadi penanda bagi tujuan pengesanan awal dan kawalan penyakit *Ganoderma* dalam kelapa sawit. Pengisyaratan asid lemak sebagai mekanisme penting dalam tindakbalas tumbuhan semasa berinteraksi dengan mikrob kian menjadi tumpuan. Tambahan pula, tumbuh-tumbuhan mempunyai mekanisme antioksidan yang dihasilkan akibat daripada tekanan biotik dan abiotik. Untuk penilaian secara komprehensif ke atas interaksi kelapa sawit-*G. boninense* dan kelapa sawit-*T. harzianum*, analisis pengekspresan secara jaluran gen-gen utama dalam tapak jalan asid lemak dan gen antioksidan penghapus spesis oksijen reaktif dijalankan pada anak pokok kelapa sawit yang diinokulat secara artifisial. Keputusan yang diperolehi menunjukkan bahawa acetyl-CoA carboxylase, β-ketoacyl-ACP synthases II and III, Δ^9-stearoyl-acyl carrier protein desaturase, palmitoyl-ACP thioesterase, oleoyl-ACP thioesterase dan glycerol-3-phosphate acyltransferase mempamirkan tindak balas yang serupa dalam tisu akar dan daun bagi kulat yang sama. Interaksi anak pokok kelapa sawit dan *G. boninense* meningkatkan pengekspresan gen-gen ini dalam akar dan tisu daun serta merangsang tindak balas pertahanan pokok pada 21 selepas inokulasi (si). Selepas itu pengeluaran gejala-gejala fizikal berlaku pada 42 dan 63 si, selari dengan perencatan ekspresi gen-gen tersebut. Dalam interaksi anak pokok kelapa sawit dengan *T. harzianium*, peningkatan kadar pengekspresan gen-gen ini telah diperhatikan dalam kedua-dua tisu seiring dengan penyebaran pada akar serta peningkatan

pertumbuhan pokok pada 3-63 si. Keputusan analisis tahap transkripsi gen antioksidan penghapus spesis oksijen reaktif, metallothionein jenis 3 (*MT3-A dan MT3-B*) menunjukkan penghasilan corak pengekspresan gen yang berbeza. Pengekspresan *MT3-A* dalam akar meningkat secara tinggi pada anak pokok kelapa sawit yang diinokulat dengan *G. boninense* pada 21 si. Sementara itu, gen-gen transkrip *MT3-A* dan *MT3-B* disintesis pada daun yang telah diinokulat dengan *G. boninense* pada 42 si, dimana pengekspresan gen-gen ini tidak dikesan sebelum 42 si. Dalam anak pokok yang diinokulat dengan *T. harzianum*, pengekspresan gen *MT3-A* meningkat secara tinggi dalam akar pada 3 si dan ia kekal pada tahap yang sama selepas itu. Pengekspresan gen *MT3-A* dan gen *MT3-B* teraruh dalam daun pada 3 si dan kekal pada tahap yang sama sehingga 63 si. Perbezaan dalam profil pengekspresan gen asid lemak semasa interaksi patogenik dan simbiotik menunjukkan peranan mereka dalam mekanisme pertahanan dan penggalak pertumbuhan oleh *T. harianum* dan boleh menjadi asas bagi penghasilan penanda molekul untuk pengesanan awal jangkitan penyakit. Gen antioksidan penghapus spesis oksijen reaktif yang diekspresi dalam daun dan tisu akar semasa interaksi anak pokok kelapa sawit dan kulat telah membawa kepada penemuan penanda yang berpotensi bagi pengesanan tekanan oksidatif.

ACKNOWLEDGEMENTS

I would like to express my gratitude to my supervisor Associate Professor Datin Dr. Siti Nor Akmar Abdullah for her constant supervision, guidance and support. I appreciate all your efforts, advice and fruitful discussions. With her broad scientific knowledge, patience, and enthusiasm, Associate Professor Datin Dr. Siti Nor Akmar Abdullah was an excellent guide. This PhD could not have eventuated without the help from you, so thank you.

I really appreciate my co-supervisors Associate Professor Dr. Chong Pei Pei and Professor Dr. Umi Kalsom Yusuf for the guidance and advice. My appreciation goes out to the technical staff at the Institute of Tropical Agriculture and Department of Biology, Faculty of Science for their time and assistance with technical instruments.

I wish to acknowledge UPM, Institute of Tropical Agriculture and Faculty of Science for providing all the essential working facilities for this research. I gratefully acknowledge Associate Professor Dr. Ahmad Selamat for statistical analysis.

Nevertheless, this is an outcome of collative efforts from my parents, family and friends. Deepest thanks are due to my husband and son for their patience, understanding and moral support during the course of this study. I love you: thank you for helping me.

Last and foremost, my deepest admiration goes out to the late Professor Dr. Faridah Abdullah for her encouragement and guidance. To all of you, thank you so much.

I certify that a Thesis Examination Committee has met on 3 April 2012 to conduct the final examination of Fahimeh Alizadeh on her thesis entitled "Response of oil palm to *Ganoderma boninense*, *Trichoderma harzianum* and *Glomus etunicatum* interactions" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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This thesis was submitted to the senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of **Doctor of Philosophy**. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is original work except for quotation and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or any other institutions.

FAHIMEH ALIZADEH

Date: 3 April 2012

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACC	Acetyl–CoA carboxylase
ACP	Acyl carrier protein
ACS	1–aminocyclopropane–1–carboxylate synthase
ACT	Glycerol–3–phosphate acyltransferase
AMF	Arbuscular mycorrhizal fungi
ATCC	American Type Culture Collection
AVR protein	Avirulent protein
BSR	Basal stem rot
CABI	Centre for Agricultural Bioscience International
CDPKs	Calcium–dependent protein kinases
CFU	Colony forming units
CoA	Coenzyme A
Cys	Cysteine
DAG	Diacylglycerol
DAMPs	Damage–associated molecular patterns
DGDG	Digalactosyldiacylglycerol
dpi	days postinoculation
EFB	Empty fruit bunches
ET	Ethylene
ETI	Effector triggered immunity
FA	Fatty acid
FAD	FA desaturase
FAS	Fatty acid synthase
G	*G. boninense* inoculated
GL	Glycerolipids
Glo	*G. etunicatum* inoculated
GloU	*G. etunicatum* uninoculated
G–protein	Guanine nucleotide-binding protein

G3P	Glycerol–3–phosphate
GSM	*Ganoderma* Selective Medium
GU	*G. boninense* uninoculated
HR	Hypersensitive response
IAC	Internal amplification control
ISR	Induced systemic resistance
JA	Jasmonic acid
K	Kinase
KAS	β–ketoacyl–ACP synthases
MAMPs	Microbe–associated molecular patterns
MAPK	Mitogen–activated protein kinase
MEA	Malt extract agar
MGDG	Monogalactosyldiacylglycerol
MPOB	Malaysian Palm Oil Board
MT	Metallothionein
NC	Untreated negative control
NCBI	National Center for Biotechnology Information
OP	Oil palm
OPWEA	Oil palm wood extract agar
OTE	Oleoyl–ACP thioesterase
P	Peptone
PA	Posphatidic acid
PAMPs	Pathogen–associated molecular patterns
PAS	Periodic acid-schiff
PDA	Potato dextrose agar
PG	Phosphatidylglycerol
PP	Phosphatase
PRRs	Pattern recognition receptors
PTE	Palmitoyl–ACP thioesterase
PTI	Patterns–triggered immunity
R	Rubber

RGR	Relative growth rate
R protein	Resistance protein
ROS	Reactive oxygen species
RT-PCR	Reverse transcription polymerase chain reaction
RWB	Rubber wood block
RWEA	Rubber wood extract agar
SA	Salicylic acid
SAD	Δ^9-stearoyl-acyl carrier protein desaturase
SAR	Systemic acquired resistance
SL	Sulfolipid
T	*T. harzianum* inoculated
TAG	Triacylglycerol
TE	Acyl–ACP thioesterase
TU	*T. harzianum* uninoculated
VLCFA	Very long–chain fatty acid
WP	Wood powder

CHAPTER 1

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is the most profitable oil-bearing tropical crop. The extracted oil is widely used for diverse industrial applications including food, cosmetics, oleo-chemicals and bio-fuel. One of the important factors contributing to significant economic losses in oil palm industry is basal stem rot (BSR) caused by the fungi of *Ganoderma* species (Paterson *et al*., 2009).

Plants employ a wide range of defense mechanisms both performed and induced responses to protect themselves against pathogens. However when performed defense is suppressed, inducible defense is triggered by recognition of the pathogen/microbe (Kachroo and Kachroo, 2009). In addition to the major phytohormone-mediated defense pathways, fatty acid (FA) pathways play significant roles in pathogen defense and abiotic stress (Venugopal *et al.*, 2009a). Historically, plant FAs are believed to play passive roles in plant defense such as serving as precursors of the phytohormone jasmonic acid and cuticular wax components. Recent evidence demonstrates direct roles for FAs and their degradation products in plant defenses (Kachroo and Kachroo, 2009; Brown *et al*., 2009).

To avoid potential damage of reactive oxygen species (ROS), plants contain several protective antioxidant scavenging systems such as production of metallothioneins

(MTs) that protect plant DNA from oxidative damage of ROS. The expression of *MT* genes is regulated by some important developmental processes and in response to various abiotic and biotic stresses (Dauch and Jabaji-Hare, 2006; Obertello *et al.*, 2007).

Studying the genotypic and phenotypic diversity and the dynamics of pathogen populations can be achieved by recovery and isolation of plant pathogens (Amiri *et al*., 2009). Isolation of *Ganoderma* species is difficult due to the presence of bacterial, yeast, and several fast-growing fungal species. The nature of a particular culture medium has a major role to play in the growth of fungi (Zhao and Shamoun, 2006). For this reason, it is possible to develop a substantial number of alternative rapid culture media to produce results more quickly for various biotechnological applications.

Since the BSR disease occurs as the result of interaction between plant roots and the soil environment (Mazliham *et al*., 2007), understanding the microbial relationship of oil palm-*Ganoderma boninense* interactions may be useful for the development of early detection and respective preventive measures. It is important to advance knowledge on soil microfungal communities as biological indicators in oil palm cultivated area. Based on plant-microbe interactions, it is possible to develop microbial inoculants for use in agricultural biotechnology.

Molecular responses to *G. boninense* in oil palm can be a useful tool to design appropriate strategies to produce palms resistant to *Ganoderma*. As *G. boninense*, *Trichoderma harzianum* and *Glomus etunicatum* undergo pathogenic or symbiotic

development at different points in their infection cycle; both pathogenic and symbiotic fungi are uniquely suitable for studies aimed at uncovering unifying principles underlying both types of interaction.

General objective:

To investigate microbial and molecular relationship of oil palm-*G. boninense*, *T. harzianum* and *G. etunicatum* interactions.

Specific objectives:

1. To improve culture media for *Ganoderma* and to find a medium that would allow for rapid colony growth.
2. To analyze density of soil microfungal community as well as growth profile of plant during oil palm-*G. boninense*, *T. harzianum* and *G. etunicatum* interactions.
3. To investigate the expression profiles of defense-associated and antioxidant ROS scavenger genes in oil palm tissues during oil palm-*G. boninense* and *T. harzianum* interactions.
4. To assess the potential role for FA biosynthetic pathway genes in oil palm defense response during oil palm-*G. boninense* and *T. harzianum* interactions.

Thus this study was undertaken with the ultimate goal to develop a medium for rapid growth of *Ganoderma* species and finding the probable microbial indicator and molecular markers in oil palm.

REFERENCES

Adaskaveg, J.E., Blanchetter, A. and Gilbertsorn, L. (1991). Decay of date palm wood by white-rot and brown-rot fungi. *Canadian Journal of Botany*. 69(3): 615-629.

Aghoram, K., Wilson, R.F., Burton, J.W. and Dew, R.E. (2006). A mutation in a 3-keto-acyl-ACP synthase II gene is associated with elevated palmitic acid levels in soybean seeds. *Crop Science.* 46(6): 2453-2459.

Amiri, A., Holb, I.J. and Schnabel, G. (2009). A new selective medium for the recovery and enumeration of *Monilinia fructicola*, *M. fructigena*, and *M. laxa* from stone fruits. *Phytopathology*. 99: 1199-1208.

Agosin, E., Blanchette, R.A., Silva, H., Lapierre, C., Cease, K.R., Ibach, R.E., Abad, A. and Mugas, P. (1990). Characterization of palo podrido, a natural process of delignification in wood. *Applied and Environmental Microbiology*. 56(1): 65-74.

Antoninka, A., Wolf, J.E., Bowker, M., Classen, A.T. and Johnson, N.C. (2009). Linking above-and belowground responses to global change at community and ecosystem scales. *Global Change Biology.* 15(4): 914-929.

Ariffin, D., Idris, A.S. and Singh, G. (2000). Status of *Ganoderma* in Oil Palm. In J. Flood., P.D. Bridge. and M. Holderness. *Ganoderma Diseases of Perennial Crops* (pp. 47-71). London: CABI.

Ariffin, D. and Mohd Basri, W. (2000). Intensive IPM for management of oil palm pests. *Oil Palm Bulletin.* 41: 1-14.

Arora, D.S. and Gill, P.K. (2000). Laccase production by some white rot fungi under different nutritional conditions. *Bioresource Technology*. 73(3): 283-285.

Asemota, O., San, C.T. and Shah, F.H. (2004). Isolation of a kernel oleoyl-ACP thioesterase gene from the oil palm *Elaeis guineensis* Jacq. *African Journal of Biotechnology*. 3(3): 199-201.

Asgher, M., Sharif, Y. and Bhatti, H.N. (2010). Enhanced production of ligninolytic enzymes by *Ganoderma lucidum* IBL-06 using lignocellulosic agricultural wastes. *International Journal of Chemical Reactor Engineering.* 8(A59): 1-19.

Azizah, H. (2003). *Ganoderma* versus mycorrhiza. *Oil Palm Bulletin.* 47: 6-14.

Badham, E.R. (1991). Growth and competition between *Lentinus edodes* and *Trichoderma harzianum* on sawdust substrates. *Mycologia.* 83(4): 455-463.

Badri Fariman, A. and Sariah, M. (2009). Molecular characterization of *Pseudomonas aeruginosa* UPM P3 from oil palm rhizosphere. *American Journal of Applied Science.* 6(11): 1915-1919.

Bais, H.P., Park, S.W., Weir, T.L., Callaway, R.M. and Vivanco, J.M. (2004). How plants communicate using the underground information superhighway. *TRENDS in Plant Science.* 9(1): 26-32.

Bal, U. and Altintas, S. (2008). Effects of *Trichoderma harzianum* on lettuce in protected cultivation. *Journal of Central European Agriculture.* 9(1): 63-70.

Bari, R. and Jones, J.D.G. (2009). Role of plant hormones in plant defense responses. *Plant Molecular Biology.* 69(4): 473-488.

Barker, S.J., Tagu, D. and Delp, G. (1998). Regulation of root and fungal morphogenesis in mycorrhizal symbioses. *Plant Physiology.* 116(4): 1201-1207.

Barry, K.M., Pearce, R.B., Evans, D., Hall, L.D. and Mohammed, C.M. (2001). Initial defense responses in sapwood of *Eucalyptus nitens* (Maiden) following wounding and fungal inoculation. *Physiological and Molecular Plant Pathology.* 58(2): 63-72.

Baud, S. and Lepiniec, L. (2010). Physiological and developmental regulation of seed oil production. *Progress in Lipid Research.* 49(3): 235-249.

Bent, E. (2006). Induced Systemic Resistance Mediated by Plant Growth-Promoting Rhizobacteria (PGPR) and Fungi (PGPF). In S. Tuzun. and E. Bent. *Multigenic and Indused Systemic Resistance in Plants* (pp. 225-258). New York: Springer Science and Business Media.

Bent, A.F. and Mackey, D. (2007). Elicitors, effectors, and R genes: the new paradigm and a lifetime supply of questions. *Annual Review of Phytopathology.* 45: 399-436.

Berg, G. (2009). Plant-microbe interactions promoting plant growth and health: perspectives for controlled use of microorganis: in agriculture. *Applied Microbiology and Biotechnology.* 84(1): 11-18.

Bertin, C., Yang, X. and Weston, L.A. (2003). The role of root exudates and allelochemicals in the rhizosphere. *Plant and Soil.* 256(1): 67-83.

Bever, J.D., Dickie, I.A., Facelli, E., Facelli, J.M., Klironomos, J., Moora, M., Rillig, M.C., Stock, W.D., Tibbett, M. and Zobel, M. (2010). Rooting theories of plant community ecology in microbial interactions. *TRENDS in Ecology and Evolution.* 25(8): 468-478.

Bhore, S.J. and Shah, F.H. (2011). Construction of efficient and effective transformation vectors for palmitoyl-acyl carrier protein thioesterase gene silencing in oil palm. *Bioinformation.* 6(6): 212-220.

Bivi, M.R., Farhana, M.S., Khairulmazmi, A. and Idris, A.B. (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.

Blal, B., Morel, C., Gianinazzi-Pearson, C., Fardeau, J.C. and Gianinazzi, S. (1990). Influence of vesicular-arbuscular mycorrhizae on phosphate fertilizer efficiency in two tropical acid soils planted with micropropagated oil palm (*Elaeis guineensis* jacq.). *Biology and Fertility of Soils.* 9: 43-48.

Bolton, M.D. (2009). Primary metabolism and plant defense-fuel for the fire. *Molecular Plant-Microbe Interactions.* 22(5): 487-497.

Booth, C. (1971). Fungal Culture Media. In C. Booth. *Methods in Microbiology* (pp. 49-94). London and New York: Academic Press.

Bouwmeester, H.J., Roux, C., Lopez-Raez, J.A. and Becard, G. (2007). Rhizosphere communication of plants, parasitic plants and AM fungi. *TRENDS in Plant Science.* 12(5): 224-230.

Breton, F., Hasan,Y., Hariadi, Z. and Franqueville, H. (2006). Characterization of parameter for the development of an early screening test for basal stem rot tolerance in oil palm progenies. *Journal of Oil Palm Research.* Special Issue: 24-36.

Brkljacic, J.M., Samardzic, J.T., Timotijevic, G.S. and Maksimovic, V.R. (2004). Expression analysis of buckwheat (*Fagopyrum esculentum* Moench) metallothionein-like gene (*MT3*) under different stress and physiological conditions. *Journal of Plant Physiolology.* 161(6): 741-746.

Brown, A.P., Slabas, A.R. and Rafferty, J.B. (2009). Fatty Acid Biosynthesis in Plants-Metabolic Pathways, Structure and Organization. In H. Wada. and N. Murata. *Lipids in Photosynthesis: Essential and Regulatory Functions* (pp. 11-34). Dordrecht: Springer Science + Business Media B.V.

Bruce, T.J. and Pickett, J.A. (2007). Plant defense signaling induced by biotic attacks. *Current Opinion in Plant Biology.* 10(4): 387-392.

Butt, A., Mousley, C., Morris, K., Beynon, J., Can, C., Holub, E., Greenberg, J.T. and Buchanan-Wollaston, V. (1998). Differential expression of a senescence-enhanced metallothionein gene in *Arabidopsis* in response to isolates of *Peronospora parasitica* and *Pseudomonas syringae*. *The Plant Journal.* 16(2): 209-221.

Byfield, G.E., Xue, H. and Upchurch, R.G. (2006). Two genes from soybean encoding soluble Δ^9 stearoyl-ACP desaturases. *Crop Science.* 46(4): 840-846.

Byfield, G.E. and Upchurch, R.G. (2007). Effect of temperature on delta-9 stearoyl-ACP and microsomal omega-6 desaturase gene expression and fatty acid content in developing soybean seeds. *Crop Science.* 47(4): 1698-1704.

Cao, Y., Xian, M., Yang, J., Xu, X., Liu, W. and Li, L. (2010). Heterologous expression of stearoyl-acyl carrier protein desaturase (S-ACP-DES) from *Arabidopsis thaliana* in *Escherichia coli*. *Protein Expression and Purification.* 69(2): 209-214.

Carginale, V., Maria, G., Capasso, C., Ionata, E., Cara, F.L., Pastore, M., Bertaccini, A. and Capasso, A. (2004). Identification of genes expressed in response to phytoplasma infection in leaves of *Prunus armeniaca* by messenger RNA differential display. *Gene.* 332: 29-34.

Caruso, M., Colombo, A.L., Fedeli, L., Pavesi, A., Quaroni, S., Saracchi, M. and Ventrella, G. (2000). Isolation of endophytic fungi and actinomycetes taxane producers. *Annals of Microbiology.* 50(1): 3-13.

Chan, D.I. and Vogel, H.J. (2010). Current understanding of fatty acid biosynthesis and the acyl carrier protein. *Biochemical Journal.* 430(1): 1-19.

Chan, J.J., Latiffah, Z., Liew, K.W. and Idris, A.S. (2011). Pathogenicity of monokaryotic and dikaryotic mycelia of *Ganoderma boninense* on oil palm seedlings and germinated seeds in Malaysia. *Australasian Plant Pathology.* 40(3): 222-227.

Chanda, B., Venugopal, S.C., Kulshrestha, S., Navarre, D.A., Downie, B., Vaillancourt, L., Kachroo, A. and Kachroo, P. (2008). Glycerol-3-phosphate levels are associated with basal resistance to the hemibiotrophic fungus *Colletotrichum higginsianum* in *Arabidopsis*. *Plant Physiology.* 147(4): 2017-2029.

Chandra, S. and Kehri, H.K. (2006). *Biotechnology of VA Mycorrhiza: Indian Scenario*. New Delhi: New India Publishing Agency.

Chatthai, M., Osusky, M., Osuska, L., Yevtushenko, D. and Misra, S. (2004). Functional analysis of a Douglas-fir metallothionein-like gene promoter: transient assays in zygotic and somatic embryos and stable transformation in transgenic tobacco. *Planta*. 220(1): 118-128.

Chin, K.L., Hng, P.S., Wong, L.J., Tey, B.T. and Paridah, M.T. (2010). Optimization study of ethanolic fermentation from oil palm trunk, rubberwood and mixed hardwood hydrolysates using *Saccharomyces cerevisiae*. *Bioresource Technology*. 101(9): 3287-3291.

Cho, E.J., Lee, D.J., Wee, C.D., Kim, H.L., Cheong, Y.H., Cho, J.S. and Sohn, B.K. (2009). Effects of AMF inoculation on growth of *Panax ginseng* C.A. Meyer seedlings and on soil structures in mycorrhizosphere. *Scientia Horticulturae*. 122(4): 633-637.

Choi, D., Kim, H.M., Yun, H.K., Park, J.A., Kim, W.T. and Bok, S.H. (1996). Molecular cloning of a metallothionein-like gene from *Nicofiana glufinosa* L. and its induction by wounding and tobacco mosaic virus infection. *Plant Physiolology*. 112(1): 353-359.

Chu, E.Y. (1999). The effects of arbuscular mycorrhizal fungi inoculation on *Euterpe oleracea* mart. (acai) seedlings. *Pesquisa Agropecuaria Brasileira*. 34(6): 1019-1024.

Chua, B.H., Rajinder, S., Tan, S.G., Faridah, Q.Z. and Cheah, S.C. (2006). Oil palm microsatellites: implications and potentials. *Jilid*. 12(2): ISSN 1394-5750.

Claassens, S., Riedel, K.J., Van Rensburg, L., Morgenthal, T.L. and Jansen Van Rensburg, P.J. (2005). Soil microbial properties in coal mine tailings under rehabilation. *Applied Ecology and Environmental Research*. 4(1): 75-83.

Cobbett, C. and Goldsbrough, P. (2002). Phytochela and metallothioneins: roles in heavy metal detoxification and homeostasis. *Annual Review of Plant Biology*. 53: 159-182.

Dabire, A.P., Hien, V., Kisa, M., Bilgo, A., Sangare, K.S., Plenchette, C., Galiana, A., Prin, Y. and Duponnois, R. (2007). Responses of soil microbial catabolic diversity to arbuscular mycorrhizal inoculation and soil disinfection. *Mycorrhiza*. 17(6): 537-545.

Dauch, A.L. and Jabaji-Hare, S.H. (2006). Metallothionein and *bZIP* transcription factor genes from velvetleaf and their differential expression following *Colletotrichum coccodes* infection. *Phytopathology*. 96(10): 1116-1123.

Dehesh, K., Edwards, P., Fillatti, J., Slabaugh, M. and Issue, J.B. (1998). KAS IV: a 3-ketoacyl-ACP synthase from *Cuphea* sp. is a medium chain specific condensing enzyme. *The Plant Journal.* 15(3): 383-390.

Dehesh, K., Tai, H., Edwards, P., Byrne, J. and Jaworski, J.G. (2001). Over expression of 3-ketoacyl-acyl-carrier protein synthase IIIs in plants reduces the rate of lipid synthesis. *Plant Physiology.* 125(2): 1103-1114.

Diederichs, C. (1991). Influence of different P sources on the efficiency of several tropical endomycorrhizal fungi in promoting the growth of *Zea mays* L. *Fertilizer Research Netherlands.* 30: 39-46.

Distefano, G., La Malfa, S., Vitale, A., Lorito, M., Deng, Z. and Gentile, A. (2008). Defense-related gene expression in transgenic lemon plants producing an antimicrobial *Trichoderma harzianum* endochitinase during fungal infection. *Transgenic Research.* 17(5): 873-879.

Dormann, P., Frentzen, M. and Ohlrogge, J.B. (1994). Specificities of the acyl-acyl carrier protein (ACP) thioesterase and glycerol-3-phosphate acyltransferase for octadecenoyl-ACP isomers (identification of a petroselinoyl-ACP thioesterase in umbelliferae). *Plant Physiology.* 104(3): 839-844.

Dowd, C., Wilson, I.W. and McFadden, H. (2004). Gene expression profile changes in cotton root and hypocotyl tissues in response to infection with *Fusarium oxysporum* f. sp. *Vasinfectum. Molecular Plant-Microbe Interactions.* 17(6): 654-667.

Druzhinina, I. and Kubicek, C.P. (2005). Species concept and biodiversity in *Trichoderma* and *Hypocrea*: from aggregate species to species clusters? *Journal of Zhejiang University Science.* 6B(2): 100-112.

Druzhinina, I.S., Kopchinskiy, A.G. and Kubicek, C.P. (2006). The first one hundred of *Trichoderma* species is characterized by molecular data. *Mycoscience.* 47: 55-64.

Druzhinina, I.S., Kubicek, C.P., Komon-Zelazowska, M., Belayneh Mulaw, T.B. and Bissett, J. (2010). The *Trichoderma harzianum* demon: complex speciation history resulting in coexistence of hypothetical biological species, recent agamospecies and numerous relict lineages. *BMC Evolutional Biology.* 10: 94.

Durand-Gasselin, T., Asmady, H., Flori, A., Jacquemard, J.C., Hayun, Z., Breton, F. and De Franqueville, H. (2005). Possible sources of genetic resistance in oil palm (*Elaeis guineensis* Jacq.) to basal stem rot caused by *Ganoderma boninense*-prospects for future breeding. *Mycopathologia.* 159(1): 93-100.

Eastburn, D.M. and Butler, E.E. (1988). Microhabitat characterization of *Trichoderma harzianum* in natural soil evaluation of factors affecting population density. *Soil Biology and Biochemistry*. 20(4): 541-545.

Elisashvili, V., Kachlishvili, E. and Penninckx, M. (2008). Effect of growth substrate, method of fermentation, and nitrogen source on lignocellulose-degrading enzymes production by white-rot basidiomycetes. *Journal of Industrial Microbiology and Biotechnology*. 35(11): 1531-1538.

Elisashvili, V., Kachlishvili, E., Tsiklauri, N., Metreveli, E., Khardziani, T. and Agathos, S.N. (2009). Lignocellulose-degrading enzyme production by white-rot *Basidiomycetes* isolated from the forests of Georgia. *World Journal of Microbiology and Biotechnology*. 25(2): 331-339.

Elissetche, J.P., Ferraz, A., Freer, J. and Rodriguez, J. (2007). Enzymes produced by *Ganoderma australe* growing on wood and in submerged cultures. *World Journal of Microbiology and Biotechnology*. 23(3): 429-434.

Eyles, A., Beadle, C., Barry, K., Francis, A., Glen, M. and Mohammed, C. (2008). Management of fungal root-rot pathogens in tropical Acacia mangium plantations. *Forest Pathology*. 38(5): 332-355.

FAOSTAT Online Statistical Service; Food and Agriculture Organization, United Nations Food and Agriculture Organization: Rome, 2011.

Farmer, E.E. (1994). Fatty acid signaling in plants and their associated microorganisms. *Plant Molecular Biology*. 26(5): 1423-1437.

Figueroa-Balderas, R.E., Garcia-Ponce, B. and Rocha-Sosa, M. (2006). Hormonal and stress induction of the gene encoding common bean acetyl-coenzyme A carboxylase. *Plant Physiology*. 142(2): 609-619.

Flood, J., Bridge, P. D. and Holderness, M. (2000). *Ganoderma Diseases of Perennial Crops*. Wallingford: CABI Publishing.

Flood, J., Keenan, L., Wayne, S. and Hasan, Y. (2005). Studies on oil palm trunks as sources of infection in the field. *Mycopathologia*. 159(1): 101-107.

Garcia-Ponce, B. and Rocha-Sosa, M. (2000). The octadecanoid pathway is required for pathogen-induced multi-functional acetyl-CoA carboxylase accumulation in common bean (*Phaseolus vulgaris* L.). *Plant Science*. 157(2): 181-190.

Germida, J.J. and De Freitas, J.R. (2008). Cultural Methods for Soil and Root-Associated Microorganisms. In M.R. Carter. and E.G. Gregorich. *Soil Sampling and Methods of Analysis* (pp. 341-378). Florida: Boca Raton, CRC.

Giambernardi, T.A. and Klebe, R.J. (2000). Relative Reverse Transcription-Polymerase Chain Reaction In R.S. Tuan. and C.W. Lo. *Methods in molecular biology, Developmental biology protocols* (pp 51-85). Totowa: Humana Press.

Gohre, V. and Robatzek, S. (2008). Breaking the barriers: microbial effector molecules subvert plant immunity. *Annual Review of Phytopathology.* 46: 189-215.

Gonzalez-Mellado, D., Von Wettstein-Knowles, P., Garces, R. and Martinez-Force, E. (2010). The role of β-ketoacyl-acyl carrier protein synthase III in the condensation steps of fatty acid biosynthesis in sunflower. *Planta*. 231(6): 1277-1289.

Gornicki, P., Faris, J., King, I., Podkowinski, J., Gill, B. and Haselkorn, R. (1997). Plastid-localized acetyl-CoA carboxylase of bread wheat is encoded by a single gene on each of the three ancestral chromosome sets. *Proceedings of the National Academy of Sciences of the USA.* 94(25): 14179-14184.

Grondona, I., Hermosa, R., Tejada, M., Gomis, M.D., Mateos, P.F., Bridge, P.D., Monte, E. and Garcia-Acha, I. (1997). Physiological and biochemical characterization of *Trichoderma harzianum*, a biological control agent against soil borne fungal plant pathogens. *Applied and Environmental Microbiology*. 63(8): 3189-3198.

Gupta, S.M., Ahmed, Z. and Kumar, N. (2009). Isolation of cDNA fragment of glycerol-3-phosphate acyltransferase gene from seabuckthorn. *Defense Science Journal.* 59(2): 147-151.

Habekost, M., Eisenhauer, N., Scheu, S., Steinbeiss, S., Weigelt, A. and Gleixner, G. (2008). Seasonal changes in the soil microbial community in a grassland plant diversity gradient four years after establishment. *Soil Biology and Biochemistry.* 40(10): 2588-2595.

Hadrami, A.E., Hadrami, I. and Daayf, F. (2009). Suppression of Induced Plant Defense Resposes by Fungal and Oomycetes Pathogens. In K. Bouarab., N. Brisson. and F. Daayf. *Molecular Plant-Microbe Interactions* (pp. 231-268). Cambridge: CABI.

Haralampidis, K., Milioni, D., Sanchez, J., Baltrusch, M., Heinz, E. and Hatzopoulos, P. (1998). Temporal and transient expression of stearoyl-ACP carrier protein desaturase gene during olive fruit development. *Journal of Experimental Botany.* 49(327): 1661-1669.

Harman, G.E., Howell, C.R., Viterbo, A., Chet, I. and Lorito, M. (2004). *Trichoderma* species-opportunistic, avirulent plant symbionts. *Nature Reviews Microbiology*. 2(1): 43-56.

Harman, G.E. (2006). Overview of mechanisms and uses of *Trichoderma* spp. *Phytopathology*. 96(2): 190-194.

Harwood, J.L. (1996). Recent advances in the biosynthesis of plant fatty acids. *Biochimica et biophysica acta.* 1301(1-2): 7-56.

Harwood, J.L. (2005). Fatty Acid Biosynthesis. In D.J. Murphy. *Plant Lipids: Biology, Utilisation and Manipulation* (pp. 27-66). Oxford: Blackwell publishing.

Ho, Y.W. and Nawawi, A. (1985). *Ganoderma boninense* Pat. from basal stem rot of oil palm (*Elaeis guineensis*) in Peninsular Malaysia. *Pertanika.* 8(3): 425-428.

Hu, W.J., Zhang, Z.B., Fu, Z.Y., Xu, P., Hu, S.B. and Li, W.Q. (2010). Significance of a β-ketoacyl-CoA synthase gene expression for wheat tolerance to adverse environments. *Biologia Plantarum*. 54(3): 575-578.

Huckelhoven, R. (2007). Cell wall-associated mechanisms of disease resistance and susceptibility. *Annual Review of Phytopathology*. 45: 101-127.

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(2): 12-18.

Idris, A.S., Kushairi, A., Ariffin, D. and Basri, M.W. (2006). Technique for inoculating oil palm germinated seeds. *MPOB TT*. 321: ISSN 1511-7871.

Ikram, A., Mahmud, A.W., Ghani, M.N., Ibrahim, M.T. and Zainal, A.B. (1992). Field nursery inoculation of *Hevea brasiliensis* Mueli. Arg. seedling rootstock with vesicular-arbuscular mycorrhizal (VAM) fungi. *Plant and Soil.* 145(2): 231-236.

Iriti, M. and Faoro, F. (2009). Chemical diversity and defense metabolism: how plants cope with pathogens and ozone pollution. *International Journal of Molecular Sciences.* 10(8): 3371-3399.

Jeffries, P. and Barea, J.M. (2001). Arbuscular Mycorrhiza- a Key Component of Sustainable Plant-Soil Ecosystems. In B. Hock. *The Mycota: Vol IX: Fungal Associations* (pp. 95-113). Berlin: Springer.

Jha, J.K., Maitia, M.K., Bhattacharjeea, A., Basua, A., Senb, P.C. and Sena, S.K. (2006). Cloning and functional expression of an acyl-ACP thioesterase FatB type from *Diploknema (Madhuca) butyracea* seeds in *Escherichia coli*. *Plant Physiology and Biochemistry.* 44(11-12): 645-655.

Jiang, C.J., Shimono, M., Maeda, S., Inoue, H., Mori, M., Hasegawa, M., Sugano, S. and Takatsuji, H. (2009). Suppression of the rice fatty-acid desaturase gene OsSSI2 enhances resistance to blast and leaf blight diseases in rice. *Molecular Plant-Microbe Interactions.* 22(7): 820-829.

Johansson, T., Quere, A.L., Ahren, D., Soderstrom, B., Erlandsson, R., Lundeberg, J., Uhlen, M. and Tunlid, A. (2004). Transcriptional responses of *Paxillus involutus* and *Betula pendula* during formation of ectomycorrhizal root tissue. *Molecular Plant-Microbe Interactions.* 17(2): 202-215.

Jones, A., Davies, H.M. and Voelker, T.A. (1995). Palmitoyl-acyl carrier protein (ACP) thioesterase and the evolutidnary-origin of plant acyl-ACP thioesterases. *The Plant Cell.* 7(3): 359-371.

Jones, L.H. (1997). The effects of leaf pruning and other stresses on sex determination in the oil palm and their representation by a computer simulation. *Journal of Theoretical Biology.* 187(2): 241-260.

Jones, A.L., Herbert, D., Rutter, A.J., Dancer, J.E. and Harwood, J.L. (2000). Novel inhibitors of the condensing enzymes of the type II fatty acid synthase of pea (*Pisum sativum*). *Biochemical Journal.* 347(Pt1): 205-209.

Kachroo, P., Shanklin, J., Shah, J., Whittle, E.J. and Klessig, D.F. (2001). A fatty acid desaturase modulates the activation of defense signaling pathways in plants. *Proceedings of the National Academy of Sciences USA.* 98(16): 9448-9453.

Kachroo, A., Lapchyk, L., Fukushige, H., Hildebrand, D., Klessig, D. and Kachroo, P. (2003). Plastidial fatty acid signaling modulates salicylic acid and jasmonic acid-mediated defense pathways in the *Arabidopsis* ssi2 mutant. *The Plant Cell.* 15(12): 2952-2965.

Kachroo, P., Venugopal, S.C., Navarre, D.A., Lapchyk, L. and Kachroo, A. (2005). Role of salicylic acid and fatty acid desaturation pathways in *ssi2*-mediated signaling. *Plant Physiology.* 139(4): 1717-1735.

Kachroo, A. and Kachroo, P. (2007). Salicylic Acid, Jasmonic Acid, Ethylene-Mediated Regulation of Plant Defense Signaling. In J.K. Setlow. and A. Hollaender. *Genetic Engineering: Principles and Methods* (pp. 55-83). New York: Plenum.

Kachroo, A., Shanklin, J., Whittle, E., Lapchyk, L., Hildebrand, D. and Kachroo, P. (2007). The *Arabidopsis* stearoyl-acyl carrier protein-desaturase family and the contribution of leaf isoforms to oleic acid synthesis. *Plant Molecular Biology.* 63(2): 257-271.

Kachroo, A., Fu, D.Q., Havens, W., Navarre, D.R., Kachroo, P. and Ghabrial, S.A. (2008). An oleic acid-mediated pathway induces constitutive defense signaling and enhanced resistance to multiple pathogens in soybean. *Molecular Plant-Microbe Interactions.* 21(5): 564-575.

Kachroo, A. and Kachroo, P. (2009). Fatty acid-derived signals in plant defense. *Annual Review of Phytopathology*. 47: 153-176.

Kalm, E. and Kalyoncu, F. (2008). Mycelial growth rate of some morels *(Morchella* spp.) in four different microbiological media. *American-Eurasian Journal of Agricultural and Environmental Sciences.* 3(6): 861-864.

Kamaladini, H., Siti Nor Akmar, A. and Maheran, A.A. (2011). Metal inducible activity of the oil palm metallothionein-like gene promoter (MT3-A) in prokaryotes. *Journal of Bioscience and Bioengineering.* 111(2): 217-225.

Karagiannidis, N., Bletsos, F. and Stavropoulos, N. (2002). Effect of *Verticillium* wilt (*Verticillium dahlia* Kleb.) and mycorrhiza (*Glomus mosseae*) on root colonization, growth and nutrient uptake in tomato and eggplant seedlings. *Scientia Horticulturae.* 94(1-2): 145-156.

Kaundun, S.S. (2010). An aspartate to glycine change in the carboxyl transferase domain of acetyl CoA carboxylase and non-target-site mechanism(s) confer resistance to ACCase inhibitor herbicides in a *Lolium multiflorum* population. *Pest Management Science.* 66(11): 1249-1256.

Kiers, E.T., Adler, L.S., Grman, E.L. and Van der Heijden, M.G.A. (2010). Manipulating the jasmonate response: how do methyl jasmonate additions mediate characteristics of aboveground and belowground mutualisms? *Functional Ecology.* 24(2): 434-443.

Kirk, P.M., Cannon, P.F., Minter, D.W. and Stalpers, J.A. (2008). *Ainsworth and Bisby's dictionary of the fungi*. Wallingford: CAB International.

Knepper, C. and Brad, D. (2010). From perception to activation: the molecular-genetic and biochemical landscape of disease resistance signaling in plants. *The Arabidopsis Book.* 8: e012.

Krol, E., Mentzel, T., Chinchilla, D., Bolle, T., Felix, G., Kemmerling, B., Postel, S., Arents, M., Jeworutzki, E., Al-Rasheid, K.A.S., Becker, D. and Hedrich, R. (2010). Perception of the *Arabidopsis* danger signal peptide 1 involves the pattern recognition receptor AtPEPR1 and its close homologue AtPEPR2. *Journal of Biological Chemistry*. 285(18): 13471-13479.

Kruger, A., Skan-Berghofer, T.P., Frettinger, P., Herrmann, S., Buscot, F. and Oelmuller, R. (2004). Identification of premycorrhiza-related plant genes in the association between *Quercus robur* and *Piloderma croceum*. *New Phytologist.* 163(1): 149-157.

Kunkel, B.N. and Brooks, D.M. (2002). Cross talk between signaling pathways in pathogen defense. *Current Opinion in Plant Biology.* 5(4): 325-331.

Lambers, H., Mouge, C., Jaillard, B. and Hinsinger, P. (2009). Plant-microbe-soil interactions in the rhizosphere: an evolutionary perspective. *Plant and Soil.* 321(1-2): 83-115.

Lane, B., Kajioka, R. and Kennedy, T. (1987). The wheat-germ Ec protein is a zinc-containing metallothionein. *Biochemistry and Cell Biology*. 65(11): 1001-1005.

Latiffah, Z. and Ho, Y.W. (2005). Morphological characteristics and somatic incompatibility of *Ganoderma* from infected oil palm from three inland estates. *Malaysian Journal of Microbiology.* 1(2): 46-52.

Latiffah, Z., Kulaveraasingham, H., Tan, S.G., Faridah, A. and Ho, Y.W. (2005). Random amplified polymorphic DNA (RAPD) and random amplified microsatellite (RAMS) of *Ganoderma* from infected oil palm and coconut stumps in Malaysia. *Asia Pasific Journal of Molecular Biology and Biotechnology.* 13(1): 23-34.

Lelong, C.C.D., Roger, J.M., Bregand, S., Dubertret, F., Lanore, M., Sitorus, N.A., Raharjo, D.A. and Caliman, H.P. (2010). Evaluation of oil palm fungal disease infestation with canopy hyperspectral reflectance data. *Sensors.* 10(1): 734-747.

Leonowicz, A., Matuszewska, A., Luterek, J., Ziegenhagen, D., Wojtas-Wasilewska, M., Cho, N.S., Hofrichter, M. and Rogalski, J. (1999). Biodegradation of lignin by white rot fungi. *Fungal Genetics and Biology.* 27(2-3): 175-185.

Li, F., Liang, W., Zhang, X., Jiang, Y. and Wang, J. (2008). Changes in soil microbial biomass and bacterial community in a long-term fertilization experiment during the growth of maize. *Advances in Environmental Biology.* 2(1): 1-8.

Li, M.J., Li, A.Q., Xia, H., Zhao, C.Z., Li, C.S., Wan, S.B., Bi, Y.P. and Wang, X.J. (2009). Cloning and sequence analysis of putative type II fatty acid synthase genes from *Arachis hypogaea* L. *Journal of Biosciences.* 34(2): 227-238.

Li, R., Yu, K. and Hildebrand, D.F. (2010). *DGAT1*, *DGAT2* and *PDAT* expression in seeds and other tissues of epoxy and hydroxy fatty acid accumulating plants. *Lipids.* 45(2): 145-157.

Lim, K.C. and Zahrah, A. R. (2000). Decomposition and N & K release by oil palm empty fruit bunches applied under mature palms. *Journal of Oil Palm Research.* 12(2): 55-62.

Lim, H.P. and Fong, Y.K. (2005). Research on basal stem rot (BSR) of ornamental palms caused by basidiospores from *Ganoderma boninense*. *Mycopathologia.* 159(1): 171-179.

Lim, K.A., Shamsuddin, Z.H. and Ho, C.L. (2010). Transcriptomic changes in the root of oil palm (*Elaeis guineensis* Jacq.) upon inoculation with *Bacillus sphaericus* UPMB10. *Tree Genetics and Genomes.* 6(5): 793-800.

Lo, C.T. and Lin, C.Y. (2002). Screening strain of *Trichoderma* spp. for plant growth enhancement in Taiwan. *Plant Pathology Bulletin.* 11: 215-220.

Loguercio-Leite, C., Groposo, C. and Halmenschlager, M.A. (2005). Species of *Ganoderma* Karsten in a subtropical area (Santa Catarina State, Southern Brazil). *Iheringia Serie Botanica.* 60(2): 135-139.

Lu, X., Tintor, N., Mentzel, T., Kombrink, E., Boller, T., Robatzek, S., Schulze-Lefert, P. and Saijo, Y. (2009). Uncoupling of sustained MAMP receptor signaling from early outputs in an *Arabidopsis* endoplasmic reticulum glucosidase II allele. *Proceedings of the National Academy of Sciences USA.* 106: 22522- 22527.

Maeo, K., Tokuda, T., Ayame, A., Mitsui, N., Kawai, T., Tsukagoshi, H., Ishiguro, S. and Nakamura, K. (2009). An AP2-type transcription factor, WRINKLED1, of *Arabidopsis thaliana* binds to the AW-box sequence conserved among proximal upstream regions of genes involved in fatty acid synthesis. *Plant Journal.* 60(3): 476-487.

Madi, L., Wang, X., Kobiler, I., Lichter, A. and Prusky, D. (2003). Stress on avocado fruits regulates Δ^9-stearoyl ACP desaturase expression, fatty acid composition, antifungal diene level and resistance to *Colletotrichum gleosporiodes* attack. *Physiological and Molecular Plant Pathology.* 62(5): 277-283.

Madigan, M.T., Martinko, J.M. and Parker, J. (2000). *Brock Biology of Microorganisms*. Upper Saddle River: Prentice Hall.

Malaysian Palm Oil Council: Malaysia, 2011.

Malcova, R., Vosatka, M. and Albrechtova, J. (1999). Influence of arbuscular mycorrhizal fungi and simulated acid rain on the growth and coexistence of the grasses *Calamagrostis villosa* and *Deschampsia flexuosa*. *Plant and Soil.* 207(1): 45-57.

Manaf, A.M. and Harwood, J.L. (2000). Purification and characterisation of acyl-CoA: glycerol 3-phosphate acyltransferase from oil palm (*Elaeis guineensis*) tissues. *Planta.* 210(2): 318-328.

Markom, M.A., Md Shakaff, A.Y., Adom, A.H., Ahmad, M.N., Wahyu Hidayat, Abdullah, A.H. and Fikri, N.A. (2009). Intelligent electronic nose system for basal stem rot disease detection. *Computers and Electronics in Agriculture.* 66(2): 140-146.

Martz, F., Kiviniemi, S., Palva, T.E. and Sutinen, M.L. (2006). Contribution of omega-3 fatty acid desaturase and 3-ketoacyl-ACP synthase II (*KASII*) genes in the modulation of glycerolipid fatty acid composition during cold acclimation in birch leaves. *Journal of Experimental Botany.* 57(4): 897-909.

Mat Yunus, A.M. and Parveez, G.K.A. (2008). Development of transformation vectors for the production of potentially high oleate transgenic oil palm. *Electronic Journal of Biotechnology.* 11(3): 23-31.

Mayer, K.M. and Shanklin, J. (2005). A structural model of the plant acyl-acyl carrier protein thioesterase FatB comprises two helix/4-stranded sheet domains, the N-terminal domain containing residues that affect specificity and the C-terminal domain containing catalytic residues. *Journal of Biological Chemistry.* 280(5): 3621-3627.

Mayer, K.M. and Shanklin, J. (2007). Identification of amino acid residues involved in substrate specificity of plant acyl-ACP thioesterases using a bioinformatics-guided approach. *BMC Plant Biology.* 7(1): 1-11.

Mayes, S., Hafeez, F., Price, Z., MacDonald, D., Billotte, N. and Roberts, J. (2008). Molecular Research in Oil Palm, the Key Oil Crop for the Future. In P.H. Moore. and R. Ming. *Genomics of Tropical Crop Plants* (pp. 371-404). New York: Springer.

Mazliham, M.S., Loonis, P. and Idris, A.S. (2007). Towards automatic recognition and grading of *Ganoderma* infection pattern using fuzzy systems. *International Journal of Biomedical Sciences.* 2: 89-94.

Mekhedov, S., Cahoon, E.B. and Ohlrogge, J. (2001). An unusual seed-specific 3-ketoacyl-ACP synthase associated with the, biosynthesis of petroselinic acid in coriander. *Plant Molecular Biology.* 47(4): 507-518.

Mendonca, R.T., Jara, J.F., Gonzalez, V., Elissetche, J.P. and Freer, J. (2008). Evaluation of the white-rot fungi *Ganoderma australe* and *Ceriporiopsis subvermispora* in biotechnological applications. *Journal of Industrial Microbiology and Biotechnology*. 35(11): 1323-1330.

Menon, N.R., Rahman, Z.A. and Bakar, N.A. (2003). Empty fruit bunches evaluation: mulch in plantation vs fuel for electricity generation. *Oil Palm Industry Economic Journal.* 3(2): 15-20.

Miller, R.N.G., Holderness, M., Bridge, P.D., Chung, G.F. and Zakaria, M.H. (1999). Genetic diversity of *Ganoderma* in oil palm plantings. *Plant Pathology*. 48(5): 595-603.

Mines, R.O. and Lackey, W.L. (2009). *Introduction to Environmental Engineering*. New York: Prentice Hall.

Mohd Basri, W., Siti Nor Akmar, A. and Henson, I.E. (2005). Oil palm-achievements and potential. *Plant Production Science.* 8(3): 288-297.

Moncalvo, J.M. (2000). Ganodermataceae: Nomenclature and Classification. In J. Flood., P.D. Bridge. and M. Holderness. *Ganoderma Diseases of Perennial Crops* (pp. 23-45). London: CABI.

Moreno-Perez, A.J., Sanchez-Garcia, A., Salas, J.J., Garces, R. and Martinez-Force, E. (2011). Acyl-ACP thioesterases from macadamia (*Macadamia tetraphylla*) nuts: cloning, characterization and their impact on oil composition. *Plant Physiology and Biochemistry.* 49(1): 82-87.

Mukherjee, P.K., Nautiyal, C.S. and Mukhopadhyay, A.N. (2008). Molecular Mechanisms of Biocontrol by *Trichoderma* spp. In C.S. Nautiyal. and P. Dion. *Molecular Mechanisms of Plant and Microbe Coexistence*. *Soil Biology 15* (pp. 243-263). Heidelberg: Springer-Verlag Berlin Heidelberg.

Murphy, D.J. and Piffanelli, P. (1998). Fatty Acid Desaturases, Structure, Mechanism and Regulation. In J.L. Harwood. *Plant Lipid Biosynthesis-Fundamentals and Agricultural Applications* (pp. 95-130). *Cambridge: Cambridge University.*

Murphy, D.J. (2009). Oil palm: future prospects for yield and quality improvements. *Lipid Technology*. 21(11-12): 257-260.

Nadarajah, P. (1980). Species of Endogonaceae and Mycorrhizal Association of *Elaeis guineensis* and *Theobroma cacao*. In P. Mikola. *Tropical Mycorrhiza Research* (pp. 232-237). Oxford: Clarendon Press.

Naidoo, S., Murray, S.L., Denby, K.J. and Berger, D.K. (2007). Microarray analysis of the *Arabidopsis thaliana* cir1 (constitutively induced resistance 1) mutant reveals candidate defence response genes against *Pseudomonas syringae* pv tomato DC3000. *South African Journal of Botany*. 73(3): 412-421.

Nakkaew, A., Chotigeat, W., Eksomtramage, T. and Phongdara, A. (2008). Cloning and expression of a plastid-encoded subunit, beta-carboxyltransferase gene (*accD*) and a nuclear-encoded subunit, biotin carboxylase of acetyl-CoA carboxylase from oil palm (*Elaeis guineensis* Jacq.). *Plant Science*. 175(4): 497-504.

Nandi, A., Krothapalli, K., Buseman, C.M., Li, M., Welti, R., Enyedi, A. and Shah, J. (2003). *Arabidopsis* sfd mutants affect plastidic lipid composition and suppress dwarfing, cell death, and the enhanced disease resistance phenotypes resulting from the deficiency of a fatty acid desaturase. *Plant Cell*. 15(10): 2383-2398.

Nandi, A., Moeder, W., Kachroo, P., Klessig, D.F. and Shah, J. (2005). *Arabidopsis* ssi2-conferred susceptibility to *Botrytis cinerea* is dependent on EDS5 and PAD4. *Molecular Plant-Microbe Interactions*. 18(4): 363-370.

Nasir, N. (2005). Diseases caused by *Ganoderma* spp. on perennial crops in Pakistan. *Mycopathologia*. 159(1): 119-121.

Nazir, A. and Bareen, F.E. (2011). Synergistic effect of *Glomus fasciculatum* and *Trichoderma pseudokoningii* on *Heliathus annuus* to decontaminate tannery sludge from toxic metals. *African Journal of Biotechnology*. 10(22): 4612-4618.

Nesci, A., Barros, G., Castillo, C. and Etcheverry, M. (2006). Soil fungal population in preharvest maize ecosystem in different tillage practices in Argentina. *Soil and Tillage Research*. 91(1-2): 143-149.

Nur Ain Izzati, M.Z. and Abdullah, F. (2008). Disease suppression in *Ganoderma*-infected oil palm seedlings treated with *Trichoderma harzianum*. *Plant Protection Science*. 44(3): 101-107.

Obertello, M., Wall, L., Laplaze, L., Nicole, M., Auguy, F., Gherbi, H., Bogusz, D. and Franche, C. (2007). Functional analysis of the metallothionein gene *cgMT1* isolated from the actinorhizal tree *Casuarina glauca*. *Molecular Plant-Microbe Interactions*. 20(10): 1231-1240.

Ohlrogge, J.B. and Jaworski, J.G. (1997). Regulation of fatty acid synthesis. *Annual Review of Plant Physiology and Plant Molecular Biology*. 48: 109-136.

Omidvar, V., Siti Nor Akmar, A., Marziah, M. and Maheran, A.A. (2008). A transient assay to evaluate the expression of polyhydroxybutyrate genes regulated by oil palm mesocarp-specific promoter. *Plant Cell Reports.* 27(9): 1451-1459.

Omidvar, V., Siti Nor Akmar, A., Izadfard. A., Ho, C.L. and Maziah, M. (2010). The oil palm metallothionein promoter contains a novel AGTTAGG motif conferring its fruit-specific expression and is inducible by abiotic factors. *Planta.* 232(4): 925-936.

Oo, K.C., The. S.K., Khor, H.T. and Ong. A.S.H. (1985). Fatty acid synthesis in the oil palm (*Elaeis guineensis*): incorporation of acetate by tissue slices of the developing fruit. *Lipids.* 20(4): 205-210.

Ooi, L.H. and Heriansyah (2005). Palm pulverisation is sustainable oil palm replanting. *Plant Production Science.* 8(3): 345-348.

Ortiz-Castro, R., Contreras-Cornejo, H.A., Macias-Rodriguez, L. and Lopez-Bucio. J. (2009). The role of microbial signals in plant growth and development. *Plant Signaling and Behavior.* 4(8): 701-712.

Ouziad, F., Hildebrandt, U. and Schmelzer, E. (2005). Differential gene expressions in arbuscular mycorrhizal-colonized tomato grown under heavy metal stress. *Hermann Bothea Journal of Plant Physiology.* 162(2): 634-649.

Ozbay, N. and Newman, S. (2004). Effect of *Trichoderma harzianum* strains to colonize tomato roots and improve transplant growth. *Pakistan Journal of Biological Sciences.* 7(2): 253-257.

Pallardy, S.G. and Kozlowski, T.T. (2008). *Physiology of Woody Plants*. San Diego: Academic Press.

Parveez, G.K.A. (2000). Production of Transgenic Oil Palm (*Elaeis guineensis* Jacq.) Using Biolistic Techniques. In S.M. Jain. and S.C. Minocha. *Molecular Biology of Woody Plants* (pp. 327-350). Dordrecht: Kluwer Academic Publishers.

Paterson, R.R.M., Holderness, M., Kelley, J., Miller, R. and O'Grady E. (2000). *In vitro* Biodegradation of Oil Palm Stem Using Macroscopic Fungi from Southeast Asia: A Preliminary Investigation. In J. Flood., P.D. Bridge. and M. Holderness. *Ganoderma Diseases of Perennial Crops* (pp. 129-138). London: CABI.

Paterson, R.R.M. (2007a). *Ganoderma* disease of oil palm- a white rot perspective necessary for integrated control. *Crop Protection.* 26(9): 1369-1376.

Paterson, R.R.M. (2007b). Internal amplification controls have not been employed in fungal PCR hence potential false negative results. *Journal of Applied Microbiology.* 102(1): 1-10.

Paterson, R.R.M., Sariah, M. and Lima, N. (2009). The feasibility of producing oil palm with altered lignin content to control *Ganoderma* disease. *Journal of Phytopathology.* 157(11-12): 649-656.

Pearce, R.B. (2000). Decay development and its restrictionin trees. *Journal of Arboriculture.* 26(1): 1-11.

Phosri, C., Rodriguez, A., Sanders, I.R. and Jeffries, P. (2010). The role of mycorrhizas in more sustainable oil palm cultivation. *Agriculture, Ecosystems and Environment.* 135(3): 187-193.

Pieterse, C.M.J., Leon-Reyes, A., Van der Ent, S. and Van Wees, S.C.M. (2009). Networking by small-molecule hormones in plant immunity. *Nature Chemical Biology.* 5(5): 308-316.

Pidkowich, M.S., Nguyen, H.T., Heilmann, I., Ischebeck, T. and Shanklin, J. (2007). Modulating seed β-ketoacyl-acyl carrier protein synthase II level converts the composition of a temperate seed oil to that of a palm-like tropical oil. *Proceedings of the National Academy of Sciences.* 104(11): 4742-4747.

Pilotti, C.A., Sanderson, F.R. and Aitken, E.A.B. (2003). Genetic structure of a population of *Ganoderma boninense* on oil palm. *Plant Pathology.* 52(4): 455-463.

Pilotti, C.A., Sanderson, F.R., Aitken, E.A.B. and Armstrong, W. (2004). Morphological variation and host range of two *Ganoderma* species from Papua New Guinea. *Mycopathologia.* 158(2): 251-265.

Pilotti, C.A. (2005). Stem rots of oil palm caused by *Ganoderma boninense*: pathogen biology and epidemiology. *Mycopathologia.* 159(1): 129-137.

Podkowinski, J., Jelenska, J., Sirikhachornkit, A., Zuther, E., Haselkorn, R. and Gornicki, P. (2003). Expression of cytosolic and plastid acetyl-CoA carboxylase genes in young wheat plants. *Plant Physiology.* 131(2): 763-772.

Pollard, M.R., Anderson, L., Fan, C., Hawkins, D. J. and Davies, H.M. (1991). A specific acyl-ACP thioesterase implicated in medium-chain fatty acid production in immature cotyledons of *Umbellularia californica*. *Archives of Biochemistry and Biophysics.* 284(2): 306-312.

Porras, M., Barrau, C. and Romero, F. (2007). Effects of soil solarization and *Trichoderma* on strawberry production. *Crop Protection.* 26(5)**:** 782-787.

Price, Z, Mayes, S., Billotte, N., Hafeez, F., Dumortier, F. and MacDonald, D. (2007). Oil palm. In C. Kole. *Technical Crops*: *Genome Mapping and Molecular Breeding in Plants* (pp. 93-108). Heidelberg: Springer Berlin Heidelberg New York.

Raffaele, S., Leger, A. and Roby, D. (2009). Very long chain fatty acid and lipid signaling in the response of plants to pathogens. *Plant Signaling and Behavior.* 4(2): 94-99.

Ramli, U.S., Baker, D.S., Quant, P.A. and Harwood, J.L. (2002a). Control mechanisms operating for lipid biosynthesis differ in oil-palm (*Elaeis guineensis* Jacq.) and olive (*Olea europaea* L.) callus cultures. *Biochemical Journal.* 364 (Pt2): 385-391.

Ramli, U.S., Baker, D.S., Quant, P.A. and Harwood, J.L. (2002b). Regulation of fatty acid synthesis. *Biochemical Society Transactions.* 30(6): 1043-1046.

Ramli, U.S., Sambanthamurthi, R., Choo, C.S., Alwee, S.S.R.S., Rashid, O., Siti Nor Akmar, A., Ghulam Kadir, A.P., Manaf, M.A., Othman, A., Mat Yunus, A.M., Aminuddin, Z. and Mohd Basri, W. (2004). Beta-ketoacyl ACP synthetase II (KAS II). *MPOB TT.* 219: ISSN1511-7871.

Ramli, U.S., Salas, J.J., Quant, P.A. and Harwood, J.L. (2009). Use of metabolic control analysis to give quantitative information on control of lipid biosynthesis in the important oil crop, *Elaeis guineensis* (oil palm). *New Phytologist.* 184(2): 330-339.

Ravnskov, S., Jensen, B., Knudsen, I.M.B., Bodkera, L., Jensen, D. F., Karlinski, L. and Larsen, J. (2006). Soil inoculation with the biocontrol agent *Clonostachys rosea* and the mycorrhizal fungus *Glomus intraradices* results in mutual inhibition, plant growth promotion and alteration of soil microbial communities. *Soil Biology and Biochemistry.* 38(12): 3453-3462.

Rees, R.W., Flood, J., Hasan, Y., Potter, U. and Cooper, R.M. (2009). Basal stem rot of oil palm (*Elaeis guineensis*); mode of root infection and lower stem invasion by *Ganoderma boninense*. *Plant Pathology.* 58(5): 982-989.

Redecker, D., Kodner, R. and Graham, L.E. (2000). Glomalean fungi from the ordovician. *Science.* 289(5486): 1920-1921.

Redecker, D. and Raab, P. (2006). Phylogeny of the *Glomeromycota* (arbuscular mycorrhizal fungi): recent developments and new gene markers. *Mycologia.* 98(6): 885-895.

Redecker, D., Raab, P., Oehl, F., Camacho, F.J. and Courtecuisse, R. (2007). A novel clade of sporocarp-forming species of glomeromycotan fungi in the diversisporales lineage. *Mycological Progress.* 6(1): 35-44.

Reynolds, H. L., Packer, A., Bever, J.D. and Clay, K. (2003). Grassroots ecology: plant-microbe-soil interactions as drivers of plant community structure and dynamics. *Ecology.* 84(9): 2281-2291.

Rigas, F., Papadopoulou, K., Dritsa, V. and Doulia, D. (2007). Bioremediation of a soil contaminated by lindane utilizing the fungus *Ganoderma australe* via response surface methodology. *Journal of Hazardous Materials.* 140(1-2): 325-332.

Rodriguez, M.C.S., Petersen, M. and Mundy, J. (2010). Mitogen-activated protein kinase signaling in plants. *Annual Review of Plant Biology.* 61: 621-649.

Rodriguez-Llorente, I.D., Perez-Palacios, P., Doukkali, B., Caviedes, M.A. and Pajuelo, E. (2010). Expression of the seed-specific metallothionein *mt4a* in plant vegetative tissues increases Cu and Zn tolerance. *Plant Science.* 178(3): 327-332.

Rousselin, P., Molinier, J., Himber, C., Schontz, D., Prieto-Dapena, P., Jordano, J., Martini, N., Weber, S., Horn, R., Ganssman, M., Grison, R., Pagniez, M., Toppan, A., Friedt, W. and Hahne, G. (2002). Modification of sunflower oil quality by seed-specific expression of a heterologous Δ^9-stearoyl-(acyl carrier protein) desaturase gene. *Plant Breeding.* 121(2)**:** 108-116.

Rungjindamai, N., Pinruan, U., Choeyklin, R., Hattori, T. and Jones, E.B.G. (2008). Molecular characterization of basidiomycetous endophytes isolated from leaves, rachis and petioles of the oil palm, *Elaeis guineensis*, in Thailand. *Fungal Diversity.* 33: 139-161.

Ruuska, S.A., Girke, T., Benning, C. and Ohlrogge, J.B. (2002). Contrapuntal networks of gene expression during *Arabidopsis* seed filling. *Plant Cell.* 14(6): 1191-1206.

Salas, J.J. and Ohlrogge, J.B. (2002). Characterization of substrate specificity of plant FatA and FatB acyl-ACP thioesterases. *Archives of Biochemistry and Biophysics.* 403(1): 25-34.

Sambanthamurthi, R., Abrizah, O. and Ramli, U.S. (1999). Biochemical factors that control oil compositon in the oil palm. *Journal of Oil Palm Research.* Special Issue: 24-33.

Sambanthamurthi, R., Sundram, K. and Tan, Y.A. (2000). Chemistry and biochemistry of palm oil. *Progress in Lipid Research.* 39(6): 507-558.

Samuels, G.J. (2006). *Trichoderma*: systematics, the sexual state, and ecology. *Phytopathology.* 96: 195-206.

Samuels, L. Kunst, L. and Jetter, R. (2008). Sealing plant surfaces: cuticular wax formation by epidermal cells. *Annual Review of Plant Biology.* 59: 683-707.

Sanchez-Garcia, A., Moreno-Perez, A.J., Muro-Pastor, A., M., Salas, J.J., Garces, R. and Martinez-Force, E. (2010). Acyl-ACP thioesterases from castor (*Ricinus communis* L.): an enzymatic system appropriate for high rates of oil synthesis and accumulation. *Phytochemistry.* 71(8-9): 860-869.

Sanderson, F.R. (2005). An insight into spore dispersal of *Ganoderma boninense* on oil palm. *Mycopathologia.* 159(1): 139-141.

Sankaran, K.V., Bridge, P.D. and Gokulapalan, C. (2005). *Ganoderma* diseases of perennial crops in India-an overview. *Mycopathology.* 159(1): 143-152.

Santosh, K., Ghosh, S.K., Bhattacharjee, A., Jha, J.K., Mondal, A.K., Maiti, M.K., Basu, A., Ghosh, D., Ghosh, S. and Sen, S.K. (2007). Characterization and cloning of a stearoyl/oleoyl specific fatty acyl-acyl carrier protein thioesterase from the seeds of *Madhuca longifolia* (latifolia). *Plant Physiology and Biochemistry*. 45(12): 887-897.

Sapak, Z., Sariah, M. and Ahmad, Z.A.M. (2008). Effect of endophytic bacteria on growth and suppression of *Ganoderma* infection in oil palm. *International Journal of Agriculture and Biology*. 10(2): 127-132.

Sariah, M., Hussin, M.Z., Miller, R.N.G. and Holderness, M. (1994). Pathogenicity of *Ganoderma boninense* tested by inoculation of oil palm seedlings. *Plant Pathology*. 43(3): 507-510.

Sariah, M. and Zakaria, H. (2000). The Use of Soil Amendments for the Control of Basal Stem Rots of Oil Palm Seedlings. In J. Flood., P.D. Bridge. and M. Holderness. *Ganoderma Diseases of Perennial Crops* (pp. 89-100). London: CABI.

Sasaki, Y. and Nagano, Y. (2004). Plant acetyl-CoA carboxylase: structure, biosynthesis, regulation, and gene manipulation for plant breeding. *Bioscience, Biotechnology,* and *Biochemistry*. 68(6): 1175-1184.

Sathish, D.K. and Mohankumar, C. (2007). RAPD markers for identifying oil palm (*Elaeis guineensis* Jacq.) parental varieties (*dura* & *pisifera*) and the hybrid tenera. *Indian Journal of Biotechnology*. 6(3): 354-358.

Schuster, A. and Schmoll, M. (2010). Biology and biotechnology of *Trichoderma*. *Applied Microbiology and Biotechnology*. 87(3): 787-799.

Schwarzott, D., Walker, C. and Schubler, A. (2001). *Glomus*, the largest genus of the arbuscular mycorrhizal fungi (Glomales), is nonmonophyletic. *Molecular Phylogenetics and Evolution.* 21(2): 190-197.

Seo, G.S. and Kirk, P.M. (2000). Ganodermataceae: Nomenclature and Classification. In J. Flood., P.D. Bridge. and M. Holderness. *Ganoderma Diseases of Perennial Crops* (pp. 3-22). London: CABI.

Seres, A., Bakonyi, G. and Posta, K. (2006). Zn uptake by maize under the influence of AM-fungi and *Collembola Folsomia candida*. *Ecological Research.* 21(5): 692-697.

Serrano-Vega, M.J., Garces, R. and Martınez-Force, E. (2005). Cloning, characterization and structural model of a FatA-type thioesterase from sunflower seeds (*Helianthus annuus* L.). *Planta.* 221(6): 868-880.

Shah, F.H., Rashid, O. and San, C.T. (2000). Temporal regulation of two isoforms of cDNA clones encoding delta 9-stearoyl-ACP desaturase from oil palm (*Elaies guineensis*). *Plant Science.* 152(1): 27-33.

Shah, J. (2003). The salicylic acid loop in plant defense. *Current Opinion in Plant Biology.* 6(4): 365-371.

Shah, F.H., Bhore, S., Cha, T.S. and Tan, C.L. Current status in genetic alteration of fatty acid composition in oil palm. 16th International Plant Lipid Symposium, Budapest, Hungary. June 2004.

Shah, J. (2005). Lipids, lipase and lipid-modifying enzymes in plant disease resistance. *Annual Review of Phytopathology.* 43: 229-260.

Shamala, S., Chris, D., Sioban, O. and Idris, A.S. (2006). Preliminary studies on the development of monoclonal antibodies against mycelia of *Ganoderma boninense*, the causal pathogen of basal stem rot of oil palm. *Malaysian Journal of Microbiology.* 2(1): 30-34.

Shanklin, J. and Cahoon, E.B. (1998). Desaturation and related modifications of fatty acids. *Annual Review of Plant Physiology and Plant Molecular Biology.* 49: 611-641.

Shi, Z.Y., Chen, Z.C., Zhang, L.Y., Feng, G., Christie, P., Tian, C.Y. and Li, X.L. (2007). Diversity and zonal distribution of arbuscular mycorrhizal fungi on the northern slopes of the Tianshan Mountains. *Science in China Series D-Earth Sciences.* 50(1): 135-141.

Shoresh, M., Harman, G.E. and Mastouri, F. (2010). Induced systemic resistance and plant responses to fungal biocontrol agents. *Annual Review of Phytopathology.* 48: 21-43.

Shorrosh, B.S., Dixon, R.A. and Ohlrogge, J.B. (1994). Molecular cloning, characterization, and elicitation of acetyl-CoA carboxylase from alfalfa. *Proceedings of the National Academy of Sciences USA.* 91(10): 4323-4327.

Sieverding, E. and Howeler, R.H. (1985). Influence of species of VA mycorrhizal fungi on cassava yield response to phosphorus fertilization. *Plant and Soil.* 88: 213-221.

Siguenza, C., Crowley, D.E. and Allen, E.B. (2006). Soil microorganisms of a native shrub and exotic grasses along a nitrogen deposition gradient in southern California. *Applied Soil Ecology.* 32(1): 13-26.

Silva, A.D., Uhlmann, A., Silva, J.V. and Sturmer, S.L. (2010). How mycorrhizal associations and plant density influence intra- and inter-specific competition in two tropical tree species: *Cabralea canjerana* (Vell.) Mart. and *Lafoensia pacari* A.St.-Hil. *Plant and Soil.* 330(1-2): 185-193.

Silvar, C., Casas, A.M., Kopahnke, D., Habekuß, A., Schweizer, G., Garcia, M.P., Lasa, J.M., Ciudad, F.J., Molina-Cano, J.L., Igartua, E. and Ordon, F. (2009). Screening the Spanish Barley Core Collection for disease resistance. *Plant breeding.* 129(1): 45-52.

Sikes, B.A. (2010). When do arbuscular mycorrhizal fungi protect plant roots from pathogens? *Plant Signal and Behavior.* 5(6): 763-765.

Siti Nor Akmar, A., Cheah, S.C., Aminah, S., Leslie, C.L. and Murphy, D.J. (1999). Characterization and regulation of the oil palm (*Elaeis guineensis*) stearoyl-ACP desaturase genes. *Journal of Oil Palm Research.* Special Issue: 1-l7.

Siti Nor Akmar, A., Cheah, S.C. and Murphy, D.J. (2002). Isolation and characterisation of two divergent type 3 metallothioneins from oil palm, *Elaeis guineensis*. *Plant Physiology and Biochemistry.* 40(3): 255-263.

Siti Nor Akmar, A. and Zubaidah, R. (2008). Mesocarp-specific metallothionein-like gene promoter for genetic engineering of oil palm. *Journal of Oil palm Research.* 2(Special Issue): 1-8.

Slocombe, S.P., Cummins, I., Jarvis, R.P. and Murphy, D.J. (1992). Nucleotide sequence and temporal regulation of a seed-specific *Brassica napus* cDNA encoding a stearoyl-acyl carrier protein (ACP) desaturase. *Plant Molecular Biology.* 20(1): 151-155.

Stergiopoulos, I. and De Wit, P.J.G.M. (2009). Fungal effector proteins. *Annual Review of Phytopathology.* 47: 233-263.

Sundari, S.K. and Adholeya, A. (2003). Growth profile of ectomycorrhizal fungal mycelium: emphasis on substrate pH influence. *Antonie van Leeuwenhoek.* 83(3): 209-214.

Susanto, A., Sudharto, P.S. and Purba, R.Y. (2005). Enhancing biological control of basal stem rot disease (*Ganoderma boninense*) in oil palm plantations. *Mycopathologia.* 159(1): 153-157.

Sylvia, D.M., Alagely, A., Kent, D. and Mecklenburg, R. (1998). Mycorrhizae of landscape trees produced in raised beds and containers. *Journal of Arboriculture.* 24(6): 308-314.

Tai, H. and Jaworski, J.C. (1993). 3-Ketoacyl-acyl carrier protein synthase III from spinach (*Spinacia oleracea*) is not similar to other condensing enzymes of fatty acid synthase. *Plant Physiology.* 103(4): 1361-1367.

Teerapatsakul, C., Abe, N., Bucke, C., Kongkathip, N., Jareonkitmongkol, S. and Chitradon, L. (2007). Novel laccases of *Ganoderma sp*. KU-Alk4, regulated by different glucose concentration in alkaline media. *World Journal of Microbiology and Biotechnology.* 23(11): 1559-1567.

Ting, N.C., Noorhariza, M.Z., Rozana, R., Low, E.T., Ithnin, M., Cheah, S.C., Tan, S.G. and Singh, R. (2010). SSR mining in oil palm EST database: application in oil palm germplasm diversity studies. *Journal of Genetics.* 89(2): 135-145.

The, O.K. and Ramli, U.S. (2010). Characterization of a KCS-like KASII from *Jessenia bataua* that elongates saturated and monounsaturated stearic acids in *Arabidopsis thaliana*. *Molecular Biotechnology*. 48(2): 97-108.

Thiel, H. and Varrelmann, M. (2009). Identification of *Beet necrotic yellow vein virus* P25 pathogenicity factor-interacting sugar beet proteins that represent putative virus targets or components of plant resistance. *Molecular Plant-Microbe Interactions.* 22(8): 999-1010.

Topp, G.C. (2008). Soil Water Content. In M.R. Carter. and E.G. Gregorich. *Soil Sampling and Methods of Analysis* (pp. 541-558). *Florida: Boca Raton, CRC.*

Torres-Franklin, M.L., Contour-Ansel, D., Zuily-Fodil, Y. and Pham-Thi, A.T. (2008). Molecular cloning of glutathione reductase cDNAs and analysis of GR gene expression in cowpea and common bean leaves during recovery from moderate drought stress. *Journal of Plant Physiology*. 165(5): 514-521.

Tranbarger, T.T., Dussert, S., Joet, T., Argout, X., Summo, M., Champion, A., Cros, D., Omore, A., Nouy, B. and Morcillo, F. (2011). Regulatory mechanisms underlying oil palm fruit mesocarp maturation, ripening, and functional specialization in lipid and carotenoid metabolism. *Plant Physiology*. 156(2): 564-584.

Treu, R. (1998). Macrofungi in oil palm plantations of South-East-Asia. *Mycologist.* 12 (1): 10-14.

Turner, P.D. (1981). *Oil Palm Diseases and Disorders*. Oxford: Oxford University Press.

Turnham, E. and Northcote, D.M. (1982). The use of acetyl CoA carboxylase activity and changes in wall composition as measures of embryogenesis in tissue cultures of oil palm (*Elaeis guineensis*). *Biochemical Journal.* 208(2): 323-332.

Ulrich, C.E., Gathman, A.C. and Lilly, W.W. (2007). Amino acid pool composition of the basidiomycete *Coprinus cinereus*. *Canadian Journal of Microbiology*. 53(11): 1278-1281.

Upchurch, R.G. (2008). Fatty acid unsaturation, mobilization, and regulation in the response of plants to stress. *Biotechnology Letters*. 30(6): 967-977.

Utomo, C. and Niepold, F. (2000). Development of diagnostic methods for detecting *Ganoderma* infected oil palms. *Journal of Phytopathology*. 148(9-10): 507-514.

Uzarowska, A., Dionisio, G., Sarholz, B., Piepho, H.P., Xu, M., Ingvardsen, C.R., Wenzel, G. and Lubberstedt, T. (2009). Validation of candidate genes putatively associated with resistance to SCMV and MDMV in maize (*Zea mays* L.) by expression profiling. *BMC Plant Biology.* 9: 15.

Van Loon, L.C., Bakker, P.A. and Pieterse, C. M. (1998). Systemic resistance induced by rhizosphere bacteria. *Annual Review of Phytopathology*. 36: 453-483.

Varma, A. and Kharkwal, A.C. (2009). *Symbiotic Fungi. Principles and Practice (Soil Biology)*. Heidelberg: Springer-Verlag Berlin Heidelberg.

Van Wyk, J.P.H. (2001). Biotechnology and the utilization of biowaste as a resource for bioproduct development. *TRENDS in Biotechnology*. 19(5): 172-177.

Vazquez, M.M., Cesar, S., Azcon, R. and Barea, J.M. (2000). Interactions between arbuscular mycorrhizal fungi and other microbial inoculants (*Azospirillum*, *Pseudomonas*, *Trichoderma*) and their effects on microbial population and enzyme activities in the rhizosphere of maize plants. *Applied Soil Ecology*. 15(3): 261-272.

Vega, S.E., del Rio, A.H., Bamberg, J.B. and Palta, J.P. (2004). Evidence for the up-regulation of stearoyl-ACP (Δ^9) desaturase gene expression during cold acclimation. *American Journal of Potato Research*. 81(2): 125-135.

Venables, C.E. and Watkinson, S.C. (1989). Production and localization of proteinases in colonies of timber-decaying. *Journal of general microbiology*. 135(5): 1369-1374.

Venugopal, S.C., Jeong, R.D., Mandal, M.K., Zhu, S., Chandra-Shekara, A.C., Xia, Y., Hersh, M., Stromberg, A.J., Navarre, D.R., Kachroo, A. and Kachroo, P. (2009a). Enhanced disease susceptibility 1 and salicylic acid act redundantly to regulate resistance gene-mediated signaling. *Public Library of Science Genetics*. 5(7):e1000545.

Venugopal, S.C., Chanda, B., Vaillancourt, L., Kachroo, A. and Kachroo, P. (2009b). The common metabolite glycerol-3-phosphate is a novel regulator of plant defense signaling. *Plant Signaling and Behavior*. 4(8): 746-749.

Verhage, A., Van Wees, S.C.M. and Pieterse, C.M.J. (2010). Plant immunity: it's the hormones talking, but what do they say? *Plant Physiology*. 154(2): 536-540.

Vinale, F., Sivasithamparam, K., Ghisalberti, E.L., Marra, R., Barbetti, M.J., Li, H., Wo, S.L. and Lorito, M. (2008a). A novel role for *Trichoderma* secondary metabolites in the interactions with plants. *Physiological and Molecular Plant Pathology*. 72(1-3): 80-86.

Vinale, F., Sivasithamparam, K., Ghisalberti, E.L., Marra, R., Woo, S.L. and Lorito, M. (2008b). *Trichoderma*-plant-pathogen interaction. *Soil Biology and Biochemistry*. 40(1): 1-10.

Vlot, A.C., Dempsey, D.M.A. and Klessig, D.F. (2009). Salicylic acid, a multifaceted hormone to combat disease. *Annual Review of Phytopathololog*y. 47: 177-206.

Wadekar, R.V., North, M.J. and Watkinson, S.C. (1995). Proteolytic activities in two wood-decaying basidiomycete fungi, *Serpula lacrymans* and *Coriolus versicolor*. *Microbiology*. 141(7): 1575-1583.

Walker, G. and White, N.A. (2005). Introduction to Fungal Physiology. In K. Kavanagh. *Fungi: Bbiology and Applications* (pp. 1-34). New York: John Wiley and Son.

Walters, D. (2011). *Plant Defense: Warding Off Attack by Pathogens, Herbivores and Parasitic Plants*. Chichester: Black well publishing.

Wamberg, C., Christensen, S., Jakobsen, I., Muller, A.K. and Sorensen, S.J. (2003). The mycorrhizal fungus (*Glomus intraradices*) affects microbial activity in the rhizosphere of pea plants (*Pisum sativum*). *Soil Biology and Biochemistry*. 35(10): 1349-1357.

Wang, C., Chin, C.K. and Chen, A. (1998). Expression of the yeast Δ^9 desaturase gene in tomato enhances its resistance to powdery mildew. *Physiological and Molecular Plant Physiology*. 52(6): 371-383.

Wang, X., Leikin-Frenkel, A., Madi, A., Lichter, A. and Prusky, D. (2003). Ethylene Enhances the Accumulation of an Antifungal Lipid in Avocado Fruit. In M. Vendrell., H. Klee., J.C. Pech. and F. Romojaro. *Biology and Biotechnology of the Plant Hormone Ethylene III* (pp. 248-249). Dordrecht: Kluwer Academic Publishers.

Wang, G.F., Seabolt, S., Hamdoun, S., Ng, G., Park, J. and Lu, H. (2011). Multiple roles of WIN3 in regulating disease resistance, cell death, and flowering time in *Arabidopsis*. *Plant Physiology*. 156(3): 1508-1519.

Wan Omar, W.S., Willis, L.B., Rha, C., Anthony, J.S., Ramli, U.S., Mat Yunus, A.M., Ghulam Kadir, A.P. and Sambanthamurthi, R. (2008). Isolation and utilization of cetyl-CoA carboxylase from oil palm (*Elaeis guineensis* Jacq.) mesocarp. *Journal of Oil Palm Research*. 2: 97-107.

Watanable, T. (2002). *Practical atlas of soil and seed fungi: Morphology of cultured fungi and key to species*. Boca Raton: CRC.

Weber, H. (2002). Fatty acid-derived signals in plants. *TRENDS in Plant Science*. 7(5): 217-224.

Whipps, J. M. (2001). Microbial interactions and biocontrol in the rhizosphere. *Journal of Experimental Botany*. 52(Special Issue): 487-511.

Wicklow, D.T. and Whittingham, W.F. (1974). Soil microfungal changes among the profiles of disturbed conifer-hardwood forests. *Ecology*. 55(1): 3-16.

Wong, H.L., Sakamoto, T., Kawasaki, T., Umemura, K. and Shimamoto, K. (2004). Down-regulation of metallothionein, a reactive oxygen scavenger, by the small *GTPase OsRac1* in rice. *Plant Physiol*ology. 135(3): 1447-1456.

Wu, P.Z., Li, J., Wei, Q., Zeng, L., Chen, Y.P., Li, M.R., Jiang, H.W. and Wu, G.J. (2009). Cloning and functional characterization of an acyl-acyl carrier protein thioesterase (JcFATB1) from *Jatropha curcas. Tree Physiology.* 29(10): 1299-1305.

Wu, G.Z. and Xue, H.W. (2010). *Arabidopsis* β-ketoacyl-[acyl carrier protein] synthase I is crucial for fatty acid synthesis and plays a role in chloroplast division and embryo development. *The Plant Cell.* 22(11): 3726-3744.

Wurtele, E.S. and Nikolau, B.J. (1990). Plants contain multiple biotin enzymes: discovery of 3-methylcrotonyl-CoA carboxylase, propionyl-CoA carboxylase and pyruvate carboxylase in the plant kingdom. *Archives of Biochemistry and Biophysics.* 278(1): 179-186.

Xiao, C.L. and Sitton, J.W. (2004). Effects of culture media and environmental factors on mycelia growth and pycnidial production of *Potebniamyces pyri. Mycological Research.* 108(8): 926-932.

Xiao, S. and Chye, M.L. (2009). An *Arabidopsis* family of six acyl-CoA-binding proteins has three cytosolic members. *Plant Physiology and Biochemistry.* 47(6): 479-484.

Xue, T., Li, X., Zhu, W., Wu, C., Yang, G. and Zheng, C. (2008). Cotton metallothionein *GhMT3a*, a reactive oxygen species scavenger, increased tolerance against abiotic stress in transgenic tobacco and yeast. *Journal of Experimental Botany.* 60(1): 339-349.

Yamada, T. (2001). Defense mechanisms in the sapwood of living trees against microbial infection. *Journal of Forest Research.* 6(3): 127-137.

Yamanaka, R., Soares, C.F., Matheus, D.R. and Machado, K.M.G. (2008). Lignolytic enzymes produced by *Trametes villosa* ccb176 under different culture conditions. *Brazilian Journal of Microbiology.* 39(1): 78-84.

Yamato, M. (2005). Morphological types of arbuscular mycorrhizas in pioneer woody plants growing in an oil palm farm in Sumatra, Indonesia. *Mycoscience.* 46(1): 66-68.

Yanga, W., Pollarda, M., Li-Beissona, Y., Beissona, F., Feigb, M., and Ohlroggea, J. (2010). A distinct type of glycerol-3-phosphate acyltransferase with sn-2 preference and phosphatase activity producing 2-monoacylglycerol. *Proceedings of the National Academy of Sciences USA.* 107(26): 12040-12045.

Yedidia, I., Srivastva, A.K., Kapulnik, Y. and Chet, I. (2001). Effect of *Trichoderma harzianum* on microelement concentrations and increased growth of cucumber plants. *Plant and Soil.* 235(2): 235-242.

Ying, S.T. and Qamaruz Zaman, F. (2006). DNA extraction from mature oil palm leaves. *Journal of Oil Palm Research.* 6: 219-24.

Yoder, D.W., Nampaisansuk, M., Pirtle, I.L. Chapman, K.D. and Pirtle, R.M. (1999). Molecular cloning and nucleotide sequence of a gene encoding a cotton palmitoyl-acyl carrier protein thioesterase. *Biochimica et Biophysica Acta.* 1446(3): 403-413.

Yu, L.H., Umeda, M., Liu, J.Y., Zhao, N.M. and Uchimiya, H. (1998). A novel *MT* gene of rice plants is strongly expressed in the node portion of the stem. *Gene.* 206(1): 29-35.

Zaborowska, Z., Starzycki, M., Femiak, I., Ewiderski, M.O. and Legocki, A.B. (2002). Yellow lupine gene encoding stearoyl-ACP desaturase-organization, expression and potential applicatio. *Acta Biochemica Polonica.* 49(1): 29-42.

Zhang, J. and Zhou, J.M. (2010). Plant immunity triggered by microbial molecular signatures. *Molecular Plant*. 3(5):783-793.

Zhao, S. and Shamoun, S.F. (2006). The effects of culture media, solid substrates, and relative humidity on growth, sporulation and conidial discharge of *Valdensinia heterodoxa*. *Mycological Research.*110: 1340-1346.

Zipfel, C. (2009). Early molecular events in PAMP-triggered immunity. *Current Opinion in Plant Biology*. 12(4): 414-420.

Zipfel, C. and Robatzek, S. (2010). Pathogen-associated molecular pattern-triggered **i**mmunity: veni, vidi? *Plant Physiology.* 154(2): 551-554.

Zubaidah, R. and Siti Nor Akmar, A. (2010). Functional characterisation of the oil palm type 3 metallothionein-like gene (MT3-B) promoter. *Plant Molecular Biology Reporter.* 28(3): 531-541.

Zuther, E., Huang, S., Jelenska, J., Eilenberg, H., Arnold, E.M., Su, X., Sirikhachornkit, A., Podkowinski, J., Zilberstein, A., Haselkorn, R. and Gornicki, P. (2004). Complex nested promoters control tissue-specific expression of acetyl-CoA carboxylase genes in wheat. *Proceedings of the National Academy of Sciences USA.* 101(5): 1403-1408.

BIODATA OF STUDENT

Fahimeh Alizadeh enrolled at Islamic Azad University and obtained her first degree in Bachelor of Biology-Microbiology. She continued her education in Master of Biology-Microbiology. After that, she worked as a lecturer in Islamic Azad University for 5 years. She enrolled at Universiti Putra Malaysia for PhD in the field of Microbial Biotechnology in 2007 under the guidance of Assoc. Prof. Datin Dr. Siti Nor Akmar Abdullah, Assoc. Prof. Dr. Chong Pei Pei and Prof. Dr. Umi Kalsom Yusuf. The title of her research was "Response of oil palm to *Ganoderma boninense*, *Trichoderma harzianum* and *Glomus etunicatum* interactions"

LIST OF PUBLICATIONS

Alizadeh, F., Siti Nor Akmar, A., Khodavandi, A., Faridah, A., Umi Kalsom, Y. and Chong, P.P. (2011). Differential expression of oil palm pathology genes during interactions with *Ganoderma boninense* and *Trichoderma harzianum*. *Journal of Plant Physiology*. 168(10): 1106-1113.

Siti Nor Akmar, A., **Alizadeh, F.**, Khodavandi, A., Faridah, A., Umi Kalsom, Y. and Chong, P.P. Expression profile of antioxidant scavenger metallothionein genes during oil palm-fungal interactions. International Conference on Food Security During Challenging Times, Universiti Putra Malaysia, Malaysia. July 2010.

Siti Nor Akmar, A., **Alizadeh, F.**, Nusaibah, A., Sariah, M. and Idris, A.S. Molecular and biochemical approaches in *Ganoderma* research. Second International Seminar on Oil Palm Diseases: Advances in *Ganoderma* research and Management, Yogyakarta-Indonesia. May 2010.

Alizadeh, F., Siti Nor Akmar, A., Khodavandi, A., Faridah, A., Umi Kalsom, Y. and Chong, P.P. (2011). Growth profile of different *Ganoderma* species on culture media improved by industrial wood waste. Submitted to *Crop Protection*.

Alizadeh, F., Siti Nor Akmar, A., Umi Kalsom, Y. and Chong, P.P. (2011). Oil palm-*Ganoderma boninense*, *Trichoderma harzianum* and *Glomus etunicatum* interactions reveal extensive differences in density of soil microfungal community and growth profile of plant. Submitted to *Europan Juornal of Plant Pathology*.

Alizadeh, F., Siti Nor Akmar, A., Umi Kalsom, Y. and Chong, P.P. (2011). Gene expression analysis of oil palm-*Ganoderma boninense* and *Trichoderma harzianum* interactions: evidence for a role of fatty acid biosynthetic pathway in plant defense response. Submitted to *Molecular Plant-Microbe Interactions*.

Siti Nor Akmar, A., **Alizadeh, F.**, Chong, P.P. and Umi Kalsom, Y. (2011). Early detection of *Ganoderma boninense* infection in oil palm based on expression of fatty acid biosynthetic pathway genes. UPM's Patent.