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MANAGEMET OF OIL PALM BUNCH MOTH (Tirathaba mundella walker) IN YOUNG MATURE OIL PALM PLANTATION ON PEAT SOIL IN SARAWAK, MALAYSIA

SU CHONG MING

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By

SU CHONG MING

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MANAGEMENT OF OIL PALM BUNCH MOTH (*Tirathaba mundella* Walker) IN YOUNG MATURE OIL PALM PLANTATION ON PEAT IN SARAWAK, MALAYSIA

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Chairman : Associate Professor Joseph Bong Choon Fah, PhD
Faculty : Agriculture and Food Sciences, (Bintulu)

The oil palm bunch moth, *Tirathaba mundella* is one of the most important pests for oil palm planted in peat. Chronic outbreak of this pest is getting more pronounced in recent years when more peat lands were being cleared for oil palm in Sarawak. When proper control measures were not in place, the outbreak would cause a significant reduction on oil palm early yield. The results of three rounds field ablation demonstrated that percentages of new infested bunches in ablated fields were significantly higher (41.63%, 13.24%, 7.68%) than non ablated fields (17.21%, 4.78%, 4.55%), which is the control at week 20, week 28 and week 36 respectively. This suggested that it is not justifiable for oil palm growers to carry out field ablation as cultural control practice against oil palm bunch moth, *T. mundella* in young mature oil palm plantation as commonly believed. Further studies were being conducted to evaluate the effectiveness of seven insecticides namely *Bacillus thuringiensis*, Flubendiamide, Chlorantraniliprole, Pyridalyl, Fipronil, Cypermethrin and Flufenoxuron on controlling oil palm bunch moth, *T. mundella* in a young mature oil palm plantation. Two insecticides namely Chlorantraniliprole and Flubendiamide outweighed the other conventional and biological insecticides in controlling oil palm bunch moth, *T. mundella* with significantly higher percentages of uninfested bunches with their effectiveness stretching to six months after treatment. These treatments also showed significantly lower percentages of new infested bunches, old infested bunches and number of larvae count within the monitoring period. The effect of controlling *T. mundella* using biological insecticide, *Bacillus thuringiensis*, which was the conventional practice in the oil palm plantation were inconsistent and fluctuated across all the parameters studied. This study also assessed the detrimental effects of selected insecticides on oil palm natural pollinators, *Elaeidobius kamerunicus*. Out of eight insecticides namely Flubendiamide, Chlorantraniliprole, Dinotefuran, Fipronil, Cypermethrin, Flufenoxuron, Pyridalyl and Indoxacarb which were selected for the study, only three insecticides were found to have

detrimental effects on *E. kamerunicus*. The mean number of newly emerged adult *E. kamerunicus* obtained from male inflorescences treated with Dinotefuran, Fipronil and Cypermethrin were only 0.58, 4.74 and 6.05 respectively. This is significantly lower as compared to other insecticides namely *Bacillus thuringiensis* (56.31), Flubendiamide (19.72), Chloratraniliprole (23.61), Flufenoxuron (36.96), Pyridalyl (30.93), Indoxacarb (38.16) and control (43.06). The effectiveness of the six *E. kamerunicus* friendly insecticides on controlling oil palm bunch moth, *T. mundella* were then evaluated in the follow-up study where one round of field ablation was incorporated before the insecticides treatment. The results of the study suggested that there were no additional benefit in conducting one round of field ablation before the insecticide application in controlling *T. mundella*. Among the six insecticides which were found to be safe for oil palm pollinators, Chlorantraniliprole and Flubendiamide demonstrated the best control results throughout the six months monitoring period with only two rounds of spraying at 14 days interval. From these studies, it is recommended that young mature oil palm fields with severe *T. mundella* infestation can be controlled most effectively with two rounds of Chloratrniliprole at 14 days interval. These should be followed by two rounds of Flufenoxuron at 14 days interval, after 3 months of the second spraying of Chlorantraniliprole. With these practice, the control of oil palm bunch moth can be effectively sustained for six months without affecting the survival of oil palm pollinators. This is very crucial to achieve sustainability of oil palm production for young mature plantation.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan ijazah Sarjana Sains

PENGURUSAN KUPU-KUPU TANDAN BUAH KELAPA SAWIT (*Tirathaba mundella* Walker) DI LADANG KELAPA SAWIT BERTANAH GAMBUT DI SARAWAK, MALAYSIA

Oleh

SU CHONG MING

Februari 2016

Pengerusi : Profesor Madya Joseph Bong Choon Fah, PhD
Fakulti : Sains Pertanian dan Makanan, (Bintulu)

Kupu-kupu tandan buah kelapa sawit, *Tirathaba mundella* merupakan salah satu serangga perosak yang utama bagi tanaman kelapa sawit di kawasan tanah gambut. Serangan kronik perosak ini menjadi semakin ketara sejak kebelakangan ini apabila semakin banyak kawasan tanah gambut dimajukan untuk tanaman kelapa sawit di negeri Sarawak. Tanpa kawalan perosak yang baik, hasil tanaman kelapa sawit akan menurun secara signifikan. Hasil kajian lapangan daripada tiga pusingan pelelasan atau pengembirian pada pokok kelapa sawit mendapati bahawa peratusan tandan kelapa sawit dengan serangan baru *T. mundella* di kawasan yang dilelaskan adalah sebanyak 41.63%, 13.24% dan 7.68%, iaitu adalah lebih tinggi berbanding dengan kawasan kawalan yang hanya 17.21%, 4.78% dan 4.55% sahaja pada minggu ke-20, 28 dan 36 masing-masing. Keputusan ini mencadangkan bahawa adalah sukar dijustifikasikan bagi pengusaha-pengusaha tanaman kelapa sawit untuk menjalankan pelelasan sebagai langkah kawalan yang efektif sepertimana yang dipercayai selama ini. Kajian selanjutnya dijalankan untuk menilai keberkesanan tujuh jenis racun serangga perosak iaitu *Bacillus thuringiensis*, Flubendiamide, Chlorantraniliprole, Pyridalyl, Fipronil, Cypermethrin dan Flufenoxuron terhadap penggorek tandan buah kelapa sawit, *T. mundella* di ladang kelapa sawit matang muda. Kajian mendapati dua jenis racun perosak iaitu Chlorantraniliprole dan Flubendiamide adalah lebih baik daripada racun perosak konvensional dan biologi dalam mengawal serangan kupu-kupu tandan buah kelapa sawit, *T. mundella*, di mana jumlah peratusan tandan buah kelapa sawit tanpa serangan perosak adalah lebih tinggi secara signifikan dalam tempoh enam bulan selepas rawatan. Kedua-dua rawatan ini juga menunjukkan jumlah peratusan buah kelapa sawit dengan kesan serangan baru, kesan serangan lama dan kepadatan larva penggorek tandan buah kelapa sawit adalah lebih rendah secara signifikan daripada kawalan dalam tempoh pemerhatian. Kesan rawatan dengan menggunakan racun serangga biologi, *Bacillus thuringiensis* yang merupakan amalan biasa

pengusaha ladang kelapa sawit menunjukkan keputusan yang tidak konsisten dalam semua parameter yang dikaji. Dalam kajian ini juga dilakukan penilaian kesan mudarat racun serangga yang dipilih ke atas agen pendebungaan kelapa sawit, *E. kamerunicus*. Daripada lapan jenis racun perosak yang dipilih dalam kajian ini iaitu Flubendiamide, Chlorantraniliprole, Dinotefuran, Fipronil, Cypermethrin, Flufenoxuron, Pyridalyl dan Indoxacarb, hanya tiga jenis racun serangga yang didapati mempunyai kesan mudarat kepada *E. kamerunicus*. Purata serangga *Elaeidobius kamerunicus* dewasa yang dijumpai di bunga jantan yang telah dirawat dengan Dinotefuran, Fipronil dan Cypermethrin adalah sekadar 0.58, 4.74 dan 6.05 sahaja masing-masing. Jumlah ini adalah secara signifikan apabila dobanding dengan racun serangga yang lain seperti Bt (56.31), Flubendiamide (19.72), Chlorantraniliprole (23.61), Flufenoxuron (36.96), Pyridalyl (30.93), Indoxacarb (38.16) dan kawalan (43.06). Ini menunjukkan bahawa Dinotefuran, Fipronil dan Cypermethrin bukan merupakan racun serangga yang sesuai untuk mengawal *T. mundella* memandangkan kesan mudaratnya kepada *E. kamerunicus*. Keberkesanan enam jenis racun serangga yang mesra *E. kamerunicus* dalam kawalan terhadap T. mundella dikaji dengan selanjutnya di mana satu pusingan pelelasan dilakukan sebelum rawatan. Hasil kajian mendapati tidak ada kelebihan tambahan dalam mengawal *T. mundella* dengan melakukan pelelasan sebelum rawatan racun serangga. Antara enam racun perosak yang didapati selamat terhadap agen pendebungaan kelapa sawit, Chlorantraniliprole dan Flubendiamide menunjukkan hasil kawalan yang paling baik sepanjang enam bulan tempoh pemerhatian, dengan hanya dua pusingan rawatan pada selangan 14 hari. Daripada hasil kajian ini, adalah dicadangkan bahawa ladang kelapa sawit matang muda yang diserang oleh *T. mundella* dapat dikawal dengan paling berkesan dengan melakukan dua pusingan rawatan Chlorantraniliprole pada selangan 14 hari. Ini diikuti oleh dua pusingan rawatan Flufenoxuron pada selangan 14 hari, selepas 3 bulan dari pusingan rawatan kedua Chlorantraniliprole. Dengan cara rawatan ini, kawalan serangga penggoerek buah dapat dikawal dengan berkesan selama enam bulan tanpa mendatangkan kesan negative kepada kemandirian ajen pendebungaan kelapa sawit. Ini adalah sangat penting untuk mencapai kelestarian dalam penghasilan kelapa sawit bagi ladang kelapa sawit matang muda.

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I certify that a Thesis Examination Committee has met on 5th February 2016 to conduct the final examination of Su Chong Ming on his thesis entitled "Management of Oil Palm Bunch Moth (Insecta: Lepidoptera) in Young Mature Oil Palm Plantation On Peat Soil in Sarawak, Malaysia" 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 Master of Science in Entomology.

Members of the Thesis Examination Committee were as follows:

Mohd. Hanafi Bin Idris, PhD
Associate Professor
Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia
Bintulu Sarawak Campus
(Chairman)

Patricia King Jie Hung, PhD
Senior Lecturer
Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia
Bintulu Sarawak Campus
(Internal Examiner)

Idris Abd. Ghani, PhD
Professor
Faculty of Science and Technology
University Kebangsaan Malaysia
(External Examiner)

ZULKARNAIN ZAINAL, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 27 May 2016

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Joseph Bong Choon Fah, PhD
Associate Professor
Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia
(Chairman)

Khairulmazmi bin Ahmad, PhD
Senior Lecturer
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

BUJANG KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

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Signature: _____
Name of Chairman of Supervisory Committee: Joseph Bong Choon Fah

Signature: _____
Name of Member of Supervisory Committee: Khairulmazmi bin Ahmad

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

%	Percentage
Ha	Hectare
Bt	*Bacillus thuringiensis*
CPO	Crude palm oil
SAS	Statistical analysis variance
ANOVA	Analysis of variance
WG	Water dispersible granule
EC	Emulsifiable concentrate
ES	Emulsified soluable

CHAPTER 1

INTRODUCTION

In South East Asia, particularly Malaysia and Indonesia, oil palm cultivation has rapidly expanded into degraded peat soils. Currently it is estimated that there are about 5,392,235 ha of land in Malaysia that have been developed for oil palm cultivation and this include 1,263,391 ha in Sarawak, 2,617,334 ha in Peninsular and 1,511,510 ha in Sabah (MPOB Statistic, 2014). Such a large area converted from heterogeneous climatic climax vegetation into a mono species crop as oil palm had indirectly upset the natural biological balances between hosts, pests and natural enemies of pests, which have been built up over the millennia. Therefore, for oil palm cultivated on peat, pests such as termites, nettle caterpillars, bagworms, bunch moth, rhinoceros beetles and rats have become problematic. Among these common pests, *Tirathaba mundella* Walker (Pyralidae), commonly known as the oil palm bunch moth is becoming a very important bunch feeding pest of oil palm planted on peat soil.

More severe outbreaks of *Tirathaba mundella* can occur on young plantings particularly in peat areas planted with oil palms for the first time. Bunch abortion could occur when the attack is severe and no proper control is in place (Mohd Tayeb, 2005). Continuous chronic outbreaks of *Tirathaba mundella* infestation often occur in the first two years of harvesting and estimated crop losses can be as high as 50 per cent (Lim, 2012).

The oil palm bunch moth, *Tirathaba mundella* infested both male inflorescences and various stages of bunch formation of the oil palm. Severe infestation on the male inflorescences would required chemical treatment at fortnightly interval in order to control the pest more effectively. It is understood that the natural oil palm pollinator, *Elaeidobius kamerunicus*, completed its full life cycle on the spikelets of the oil palm male inflorescences. Therefore, it poses a threat for the industry to impose chemical treatments in a large scale to control *Tirathaba mundella* outbreak, especially for oil palm planted on peat under Sarawak conditions. Nonetheless, there is a marked lack of published information on the management of *Tirathaba mundella* either through field ablation or chemical control using insecticides as well as the detrimental effects of these chemicals on the survival of oil palm poolinators, *Elaeidobius kamerunicus*.

Therefore, the present study was undertaken with the following objectives:

1. To determine the effects of field ablation as cultural control for oil palm bunch moth, *T. mundella* in young mature oil palm.

2. To assess the effect of eight different novel insecticides in the control of oil palm bunch moth, *T. mundella* in young mature oil palm.

3. To study the survival of the oil palm pollinators, *Elaeidobius kamerunicus* after treatment with novel insecticides used for controlling oil palm bunch moth, *Tirathaba mundella*.

4. To investigate the combination effects of one round field ablation followed by two rounds of insecticides treatment on the control of oil palm bunch moth, *T. Mundella* in young mature oil palm.

REFERENCES

Adaigbe, V.C., Odebiyi, J.A., Omoloye, A.A., Aisagbonhi, C.I., and Iyare, O. 2011. Host location and ovipositional preference of *Elaeidobius kamerunicus* on four host palm species. *Journal of Horticulture and Forestry* Vol.3(5): 163-166.

Amrith, S.G. and Tresca, T. 2007. Environmental fate of fipronil. Environmental Monitoring Branch, Department of Pesticide Regulation, California Environmnetal Protection Agency, Sacramento, CA 95812, USA. Revised March 2007, pp. 1-25.

Adriana, M. 2003. Environmental fate of indoxacarb. Environmental monitoring branch. Department of pesticide regulation. Sacramento, CA 95812-4015. March 2003:1-8.

Andrea, B., Rison, J. L., and Wiles, J. A. 2009. Chlorantraniliprole (DPX-EZY45, Rynaxypyr®, Coragen®), a new diamide insecticide for control of codling moth (*Cydia pomonella*), Colorado potato beetle (*Leptinotarsa decemlineata*) and European grapevine moth (*Lobesia botrana*). *Zbornik predavanj in referatov 9. slovenskega posvetovanja o varstvu rastlin z mednarodno udeležbo Nova Gorica* 4-5:39-45.

Arlin, L.B., Sinchai, S. and Laili, B.D. 1996. Activity of fipronil on diamondback moth.Online:http://web.entomology.cornell.edu/shelton/diamondback-moth/pdf/1996 papers/1996DBM32.pdf.

Axel, D., Kristin, E.B., Niels, M.F., and Michael, D.W. 2009. Chlorantraniliprole (Rynaxypyr): A novel DuPont™ insecticide with low toxicity and low risk for honey bees (*Apis mellifera*) and bumble bees (*Bombas terrestris*) providing excellent tools for uses in integrated pest management. In Hazards of pesticides to bees – 10th International Symposium of the ICP-Bee Protection Group : 548–555.

Basri, M. W., Sharma, M., K. Norman. 1991. Field evaluation of insecticides and a cultural practice against the bunch moth, *Tirathaba rufivena* in a mature oil palm plantation. *Elaeis* **3**(2): 355-362.

B. Taniputra and Chairul Muluk, 1989. The Influence of *Elaeidobius kamerunicus* on the Yield Pattern of *Elaeis quineensis* at Bukit Sentang Estate, North Sumatra, Indonesia. *The Planter, Kuala Lumpur*, **65**: 493-499.

Brugger, K.E., and Kannuck, R.M. 1997. Tier 1 Environmental Risk Assessment of DPX- MP062 and Competitive Insecticides in the USA. Dupont Agricultural Products Document No. AMR 4635-97.

Caroline, C., 1996. Cypermethrin insecticide fact sheet. Journal of pesticide reform. Vol.16, No.2:15-20.

Chan, K.W., 1985. The status weevil effects on yield production in well manured palms under Malaysian conditions. *Planters*, **61**(714):439-453.

Chan, C.O., 1973. Some notes on the oil palm bunch moth (*Tirathaba mundella* Walk.) and its control. *Advances in oil palm cultivation*. R L Wastie and D A Earp(eds)., Incorporated Society of Planters, Kuala Lumpur: 396-401.

Chee, K. H., and Chiu, S.B., 1998. A study of *Elaedobius kamerunicus* in west Kalimantan oil palm plantations. *Planters* **74**(872): 587-595.

Chee, K.H., and Chiu, S.B., 1999. The oil palm pollinating weevil, *Elaeidobius kamerunicus* in Malaysia – A review. *Planters*, **75**(877):187-198

Chiu, S.B., 1984. Some aspects of the ecology of *Elaeidobius kamerunicus* Faust, the pollinating weevil of oil palm, with emphasis on developing sampling technique. M Sc. Thesis, Universiti Pertanian Malaysia.

Chiu, S.B., Khoo, K. C., and M. Y. Hussein, 1985. Extent of Rat on *Elaeidobius kamerunicus* Faust, the Pollinating Weevil of Oil Palm.*The Planter, Kuala Lumpur*, **61**: 101-112.

Corbel, V., Duchon, S., Zaim, M. and Hougard, J.M., 2004. Dinotefuran : A potential neonicotinoid insecticide against resistant mosquitoes. *Journal of medical entomology*. Vol. 41. No.4: 712-717.

Cordova, D., Benner, E.A., Sacher, M.D., Sopa, J.S., Lahm, G.P., Selby, T.P., Stevenson, T.M., Flexner, L., Gutteridge, S., Rhoades, D.F., Wu, L., Smith, R.M., Tao, Y., 2006. Anthranilic diamides: A new class of insecticides with a novel mode of action, ryanodine receptor activition. *Pestic. Biochem. Physiol.* 84: 196-214.

Corley, R.H.V. and Tinker, P.B.H. 2003. *The Oil Palm*, *4th Edition*. Blackwell Science Limited, England.

Ebbinghaus, D., Schnorbach, H. J., Elbert, A., 2007. Field development of flubendiamide (Belt®, Fame®, Fenos®, Amoli®) – a new insecticide for the control of lepidopterous pests. *Pflanzenschutz- Nachrichten Bayer* 60/2007, (2):219-246.

Furuzawa, K., Mikami, N., Yamada, H. and Miyamoto, J. 1981. Metabolism of the pyrethroids insecticide cypermethrin in cabbages. *Pesticide Science* **11**: 253-260.

Ghanim, M., Ishaaya, I., 2010. Insecticides With Novel Modes of Action – Mechanism and Resistance Management. Online: http://www.agri.gov.il/download/files/Ghanim & Ishaaya 2010 Book Chapter K10919_C016.pdf.

Haaresh, G. S., Mahadeshwara, P., Ravindra, H. S., Preeti, G., 2010. Flubendiamide –Entry of a new insecticide into the field of clinical toxicology. *Journal of the India society of toxicology*. Vol 006, issue 002:46.

Hamadah, Kh. Sh., 2014. Metabolic activity of the chitin synthesis inihibitor, flufenoxuron, on the desert locust *Schistocerea gregaria* (Orthoptera: Acrididae). *Journal of Entomology and Zoology Studies*. 2 (1): 87-95.

Hamdy, E. M. H., Walaa El-Sayed., 2013. Efficacy of Bio-And Chemical Insecticides in the Control of *Tuta absoluta* (Meyrick) and *Helicoverpa armigera* (Hubner) Infesting Tomato Plants. *Australian Journal of Basic and Applied Sciences*. 7 (2): 943-948.

Hassan, F. D., Aida, S. K., Nehad, M. E. B. and Mona, F., A.A., 2011. Pyridalyl Effectiveness on Some Biological and Physiological Parameters of Cotton Leafworm *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae). *Journal of American Sciences*.7(12).

Idris, S.B., Ambali, S.F., and Ayo, J.O. 2012. Cytotoxicity of chlopyrifos and cypermethrin: The ameliorative effects of antioxidants. *African Journal of Biotechnology* Vol.11(99): 16461- 16467.

Jan, L., Iwona, P., and Krzysztof, Z., 2008. Contemporary trends in development of active substances possessing the pesticidal properties: ryanodine-receptor targeting insecticides. *Pestycydy/ Pesticides, ISSN 0208-8703*. (3-4): 15-26.

Ji-Young, Y., Jae-Hun, P., Hye-Ree, M., Guk-Tak, H. and Kyu-Seung, L. 2013. Residue patterns of indoxacarb and pyridalyl in treated cauliflower. *Journal of Agricultural Sciences Vol.4,* No. 3: 111-116.

Kumar, S., Chandra, A., and Pandey, K.C., 2008. *Bacillus thuringiensisI(Bt)* transgenic crop: An environment friendly insect-pest management strategy. *Journal of Environmental Biology*, **29**(5): 641-653.

Lahm, G.P., Selby, T. P., Freudenberger, J. H., Stevenson, T. N., Myers, B. J., Seburyamo, G., Smith, B.K., Flexner, L., Clark, C.E. and Cordova, D., 2005. Insecticidal anthranilic diamides: a new class of potent ryanodine receptor activators. *Bioorganic and Medicinal Chemistry Letters,* **15**: 4898-4906.

Lahm, G.P., Stevenson, T. M., Selby, T. P., Freudenberger, J. H., Cordova, D., Flexner, L., Bellin, C.A., Dubas, C.M., Smith, B.K., Hughes, K. A., Hollingshaus, J.G., Clark, C.E. and Berner, E. A., 2007. Rynaxypyr : a new insecticidal athranilic diamides that acts as a potent and selective ryanodine receptor activator. *Bioorganic and Medicinal Chemistry Letters, 17,* 6274-6279.

Lawton, J.H., Bignell, D.E., Bloemers, G.F., Eggleton, P. and Hodda, M.E. 1996. Carbon flux and diversity of nematodes and termites in Cameroon forest soils. *Biodiversity and Conservation* **5**: 261-273.

Liau, S.S., 1984. Predators of the pollinating weevil, *Elaeidobius kamerunicus* Faust (Curculionidae) in Malaysian oil palm estates. Paper presented at the *Symposium "Impact of the pollinating weevil on the Malaysian Oil Palm Industry"*. PORIM & MOPGC, Kuala Lumpur, Malaysia, pp.41-49.

Lim, K.H. 2012. Integrated Pest Management of Tirathaba Bunch Moth on Oil Palm planted on Peat. The Planter, Kuala Lumpur,**88**(1031):97-104.

Mahsa, S., and Oruj, V., 2014. Study of Henna Powder Synergistic Effects When Mixed with Pyridalyl against *Spodoptera exigua* (Hubner) in Sugar Beets. *Advances in Environmental Biology*, 8(10): 57-61.

Malaysian Oil Palm Board (MPOB).2014. Oil palm planted area by state as at December 2014. Economic and Industry Development Division. Online:http://bepi.mpob.gov.my/index.php/statistics/area/132-area-2014/713-oil-palm-planted-area-dec-2014.html

Mohd Najib, A., Ramlah Ali, A.S., Mohamed Mazmira, M.M. and Basri, M. W., 2009. Effect of *Bacillus thuringiensis*, Terakil-1^{R} and Teracon-1^{R} against oil palm pollinator, *Elaeidobius kamerunicus*, and beneficial insects associated with *Cassia cobanensis*. Journal of Oil Palm Research Vol. 21:667-674.

Mohd Najib, A., Ramlah Ali, A.S., Mohamed Mazmira, M.M. and Basri, M. W., 2012. Effect of *Bt* Products, Lepcon-1, Bafog-1 (S) and Ecobac-1 (EC), against the oil palm pollinating weevil, *Elaeidobius kamerunicus*, and beneficial insects associated with *Cassia cobanensis*. Journal of Oil Palm Research Vol. 24:1442-1447.

Mohd., Nazeeb., A., Letchumanan., S.G., Loong., 1988. A study of ablation of oil palms in peninsular Malaysia after the introduction of the pollinating weevils (*E. kamerunicus*). The Planter, Kuala Lumpur, 64: 245-251.

Mohd., Tayeb, D., 2005. Technologies for planting oil palm on peat. Malaysian Palm Oil Board, Kuala Lumpur, pp. 63.

Moradi-Vajargah, M., Rafiee-Dastjerdi, H., Golizadesh, A., Hassanpour, M. and Naseri, B. 2013. Laboratory Toxicity and Field Efficacy of Lufenuron, Dinotefuran and Thiamethoxam against *Hypera postica* (Gyllenhal, 1813) (Coleoptera: Curculionidae). Munis Entomology & Zoology, 8(1):448-457.

Nester, W. E., Thomashow, L.S., Matthew, M. and Gordon, M. 2002. 100 years of *Bacillus thuringiensis*, a paradigm for producing transgenic organisms: A critical scientific assessment. American Academy of Microbiology. Online: http://www.asmusa.org.

Ng, K. Y. 1977b. Bionomics of *Tirathaba mundella*, a pest of oil palm. Master of agriculture science thesis, University of Malaya, Kuala Lumpur : 30-37.

Noriyasu, S., Nobuhito, U., Kimitoshi, U., Sanshiro, M., Toru, H., Takuo, F. and Yoshitaka, T. 2005. Research and development of a novel insecticide 'pyridalyl'. Online: http://www.sumitomo-chem.co.jp/ english/rd/report/theses/docs/20050103.p01.pdf.

Paramananthan, S., 2008. Tropical lowland peats:To conserve or develop them? In International Palm Oil Sustainability Conference, Kota Kinabalu, Sabah.

Peter, G. Kevan, Hussien, M. Y., Hussey, N. and Wahid, M.B., 1986. Modelling the Use of *Elaeidobius kamerunicus* for Pollination of Oil Palm. *The Planter, Kuala Lumpur*, **62**: 89-99.

Ponnamma, K.N., 1999. Diurnal variation in the population of *Elaeidobius kamerunicus* on the anthesising male inflorescences of oil palm. *Planters*, **75**(881): 405-410.

Rakid, M.R.M., C.F.J. Bong, A. Khairulmazmi and A.S. Idris. 2014. Occurrence and spatial distribution of *Ganoderma* species causing upper and basal stem rot in oil palm. *Journal of Food, Agriculture and Environment* **12**: 360-364.

Rao, V. and Law, I. H., 1998. The problem of poor fruit set in parts of East Malaysia. *The Planter, Kuala Lumpur*, **74**(870):463-483.

Reda, F.A., Nehad, M. E., Mona F.A., Mohamed, H. A., and Hisham, M. E., 2010. Effect of chitin synthesis inhibitors (flufenoxuron) on some biological and biochemical aspects of the cotton leaf worm *Spodoptera littoralis Bosid* (Lepidoptera: Noctuidae). *Egypt. Acad., J. biolog. Sci.,*2(2):43-56.

Schnepf, E., N. Crickmore, J. Van Rie, D. Lereclus, J. Baum, J. Feitelson, D. R. Zeigler and D.H. Dean., 1998. *Bacillus thuringiensis* and its pesticidal crystal proteins. *Microbiology and molecular biology reviews*. 62(3):775-806.

Syed, R.A., 1981. Pollinating thrips of oil palm in West Malaysia. *Planters*, Kuala Lumpur, 57: 62-81.

Syed, R.A., 1982. Insect pollination of oil palm: Feasibility of introducing *Elaeidobius* spp into Malaysia. In. *The Oil Palm in Agriculture in the Eighties*. Vol. 1 (E Pushparajah & Chew Poh Soon, eds). The Incorporated Society of Planters, Kuala Lumpur. 263-289.

Syed, R.A., Law, I.H. and Corley, R.H.V., 1982. Insect pollination of oil palm: Introduction, establishment and pollinating efficiency of *Elaeidobius kamerunicus* in Malaysia. *Planters,* Kuala Lumpur, **58**: 547-561.

Thomas, F., and Rolf, H. 2003. Oil Palm: Management for large and sustainable yields. Potash & Phosphate Institute, east and southeast asia programs. International Potash Institute.

Toshiro, Y., Kazuko, Y. and Noaki, W. 2012. Influence of Dinotefuran and Clothianidin On A Bee Colony. Jpn. J. Clin. Ecol. Vol.21. No.1. Graduate School Of National Science & Technology, Kanazawa University.

Wahid, O., Nordiana, A.A., Ahmad, T.M., Mohd., H.H. and Ahmad, K.D. 2010. Mapping of oil palm cultivation on peatland in Malaysia*. MPOB Information Series*. ISSN1511-7871. No. 529, pp. 1-4.

Wakita, T., Yasui, N., Yamada, E., and Kishi, D., 2005. Development of a novel insecticide, Dinotefuran. *Journal of Pesticide Sciences*. **30** (2): 122-123.

Wetlands International – Malaysia. 2010. A quick scan of peatlands in Malaysia, March 2010. Project funded by the Kleine Natuur Initiatief Projecten, Royal Netherlands Embassy. Online:www.wetlands.org/Portals/o/publications/Report/Quickscan of peatlands in Malaysia_Feb 3.pdf.

Wood, B.J. and Ng, K.Y. 1974. Studies on the biology and control of oil palm bunch moth, *Tirathaba mundella* Walk. (Lepidoptera: Pyralidae). Malay.Agric. J., 49(3),310-331.

Yalamoussa, T., Herve, K.K. and Nklo, H., 2011. Biology of *Elaeidobius kamerunicus* and Elaedobius plagiatus (Coleoptera: Curculionidae) main pollinators of oil palm in West Africa. *European Journal of Scientific Research* Vol.49, No.3: 426-432.

Yussof, B., Jalani, B.S., and Chan, K.W., 2000. Advances in oil palm research. Malaysian Palm Oil Board, pp. 27-28.

BIODATA OF STUDENT

The student was born in 1979 in Miri. He did his primary schools in SRB Chung Hua, Miri. After finishing his primary 6 study, he continued his secondary study in SMK Chung Hua, Miri. After his SPM, he continued to study his form 6 in Kolej Tun Datu Tuanku Haji Bujang, Miri. He started undergraduate study in Universiti Malaysia Sabah in 2000 and obtained second class honour degree in Bachelor of Science Plant Technology. Then, he further pursues his master study in entomology with interest in the study of oil palm bunch moth.

PUBLICATION

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