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LIFE CYCLE AND JUSTIFICATION OF SUSTAINABLE CHEMICAL CONTROL OF OIL PALM FRUIT BUNCH MOTHS ON PEAT OIL PALM ESTATES

SU CHONG MING

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By

SU CHONG MING

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

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LIFE CYCLE AND JUSTIFICATION OF SUSTAINABLE CHEMICAL CONTROL OF OIL PALM FRUIT BUNCH MOTHS ON PEAT OIL PALM ESTATES.

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October 2020

Chairman : Patricia King Jie Hung, PhD
Faculty : Agriculture and Food Sciences, Bintulu Campus

Indonesia and Malaysia are the world's biggest oil palm producers that contribute 85% of the global palm oil supply, equivalent to 34% of world vegetable oils consumption in 2018. However, the oil palm industry is facing multifaceted challenges; among them are severe oil palm bunch moth, *Tirathaba mundella* Walker infestation that adversely affected the oil palm yield. In order to effectively and sustainably manage the pest, their life cycle and sensitivity to pesticide need to be understand. This study aims to formulate *Tirathaba*-specific artificial diet to allow laboratory rearing of the pest to study their life cycle. Second, to determine the economic destruction by *T. mundella* in the field through inter-correlate field census, fruit set counting and oil to bunch analysis. Third, to determine the optimum dosage of an anthranilic diamide insecticide, chlorantraniliprole as well as chromafenozide, an insect growth regulator against oil palm bunch moth, *T. mundella* Walker. Fourth, to identify the impact of insect growth regulators (IGRs) and other potential chemicals on the survival of oil palm pollinators, *Elaeidobius kamerunicus*. Last but not least, to evaluate the effectiveness of rotation mechanisms among chlorantraniliprole, insect growth regulators (IGRs), biological insecticide, *Bacillus thuringiensis* and other potential weevil friendly chemical insecticides with different mode of actions against *T. mundella* Walker in young mature oil palm plantation. The study found that the mean lifespan of *T. mundella* was 47 ± 4 days with 49% spent as larvae. The economic damage caused by *T. mundella* mainly in larvae stage and the result showed that the larvae count was positively correlated with the economic losses and number of malformed fruitlets. The overall oil extraction rate (OER) of moderate and severely infested fruit bunches was significantly reduced as compared to clean fruit bunches. Based on average crude palm oil market price and production per hectare, an Economic Injury Level (EIL) for *T. mundella* was estimated at 110 bunches with moderate infestation or 81 bunches of severe infestation. Such a low EIL would require an effective pest control approach that is not only cost effective and which will not harm the pollinating weevil. The results of this study suggested that both chromafenozide and pyridalyl were weevil friendly insecticides in addition to chlorantraniliprole, which has been established as weevil friendly insecticides in

previous study. The optimum and most cost-effective pest control approach for one-year protection was found to be two rounds of 30.0 g active ingredient of chlorantraniliprole per ha rotated with two rounds of 25.0 g active ingredient of chromafenozide. The finding of this study would benefit future pest management practice in oil palm plantation established on peatland.

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

KITARAN HIDUP DAN JUSTIFIKASI KAWALAN KUPU-KUPU TANDAN BUAH KELAPA SAWIT SECARA KIMIA DAN LESTARI DI LADANG-LADANG KELAPA SAWIT ATAS TANAH GAMBUT.

Oleh

SU CHONG MING

Oktober 2020

Pengerusi : Patricia King Jie Hung, PhD
Fakulti : Sains Pertanian dan Makanan, Kampus Bintulu

Malaysia dan Indonesia merupakan pengeluar minyak kelapa sawit yang terbesar di dunia dan turut menyumbang kepada 85% bekalan minyak sawit sedunia, bersamaan dengan penggunaan 34% minyak sayuran sedunia pada tahun 2018. Walau bagaimanapun, industri kelapa sawit sedang menghadapi pelbagai aspek cabaran, antaranya termasuklah serangan kupu-kupu tandan buah kelapa sawit, *Tirathaba mundella* Walker yang memberi kesan negatif ke atas hasil kelapa sawit. Untuk mengawal serangga perosak ini secara berterusan dengan lebih berkesan, kitaran hidup dan tahap kepekaannya terhadap racun serangga perlu difahami. Pertama, kajian ini bertujuan untuk mencipta formulasi diet tiruan khas untuk *Tirathaba* supaya ia dapat dipelihara di dalam makmal untuk pengajian kitaran hidup mereka. Kedua, untuk menentukan aras kerosakan ekonomi bagi *T. mundella* dalam ladang kelapa sawit melalui perkaitan antara bancian dalam ladang, peratusan biji buah kelapa sawit yang baik dan peratusan kandungan minyak dalam tandan buah kelapa sawit. Ketiga, untuk menentukan kadar optima racun serangga jenis 'anthranilic diamide' iaitu klorantaniliprole dan juga khromafenozide, sejenis pengawal selia pertumbuhan serangga terhadap kupu-kupu tandan buah kelapa sawit, *T. mundella* Walker. Keempat, untuk mengesan implikasi pengawal selia pertumbuhan serangga dan racun-racun perosak berpotensi yang lain terhadap kehidupan serangga pendebungaan kelapa sawit, *Elaeidobius* kamerunicus. Yang terakhir tetapi tidak kurang pentingnya daripada yang lain adalah untuk menilai keberkesanan kaedah penggunaan racun perosak seperti klorantraniliprole, pengawal selia pertumbuhan serangga, racun perosak biologi, *Bacillus thuringiensis* dan racun-racun perosak berpotensi yang mesra terhadap serangga pendebungaan dalam pengawalan *T. mundella* Walker di ladang-ladang kelapa sawit matang muda. Kajian ini menunjukkan bahawa purata kitaran hidup bagi *T. mundella* adalah 47 ± 4 hari dengan sebanyak 49% masa dalam peringat larva. Kerosakan ekonomi dalam tandan-tandan buah kelapa sawit kebanyakkannya disebabkan oleh larva-larva *T. mundella*. Keputusan dalam kajian ini menunjukkan bahawa bilangan larva-larva mempunyai perkaitan yang positif dengan kerugian ekonomik dan kandungan jumlah biji-biji buah sawit yang tidak subur. Kadar pemerahan minyak yang diperolehi dari

tandan-tandan buah kelapa sawit yang telah diserang secara sederhana teruk dan teruk sekali adalah berkurangan secara nyata jika dibandingkan dengan kadar pemerahan minyak yang diperolehi dari tandan-tandan buah kelapa sawit yang bersih. Berdasarkan kepada purata harga minyak sawit mentah di pasaran dan pengeluaran sehektar, sebanyak 110 tandan buah kelapa sawit yang diserang secara sederhana teruk dan 81 tandan buah kelapa sawit yang diserang teruk sekali dapat dianggarkan. Paras kerosakan ekonomik yang begitu rendah memerlukan satu cara pengawalan serangga perosak yang berkesan bukan sahaja dari segi harga malah tidak akan membahayakan serangga pendebungaan. Keputusan kajian ini turut mencadangkan bahawa kedua-dua racun perosak iaitu khromafenozide dan pyridalyl tidak membahayakan serangga-serangga pendebungaan. Tambahan pula, klorantraniliprole telah terbukti dalam kajian sebelum ini sebagai racun serangga perosak yang mesra terhadap serangga pendebungaan. Kadar optima dan pendekatan pengawalan *T. mundella* yang paling ekonomik bagi perlindungan selama satu tahun adalah dengan menggunakan dua pusingan 30 g perawis aktif klorantraniliprole bergilir dengan dua pusingan 25 g perawis aktif khromafenozide sehektar. Hasil-hasil kajian ini akan memanfaatkan pengusaha kelapa sawit yang akan datang khususnya dari aspek pengurusan serangga perosak bagi tanaman kelapa sawit yang ditanam di atas tanah gambut.

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I certify that a Thesis Examination Committee has met on 6 October 2020 to conduct the final examination of Su Chong Ming on his thesis entitled "Life Cycle and Justification of Sustainable Chemical Control of Oil Palm Fruit Bunch Moths on Peat Oil Palm Estates" 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.

Members of the Thesis Examination Committee were as follows:

Osumanu Haruna Ahmed, PhD
Professor
Faculty of Agriculture and Food Science (Bintulu Campus)
Universiti Putra Malaysia
(Chairman)

Dzolkhifli b Omar, PhD
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

Nur Azura binti Adam, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

Edhi Martono, PhD
Professor Ir.
Faculty of Agriculture
Universitas Gadjah Mada
Indonesia
(External Examiner)

ZURIATI AHMAD ZUKARNAIN, PhD
Professor Ts. and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 27 May 2021

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

Patricia King Jie Hung, PhD
Associate Professor
Faculty of Agriculture and Food Science
Universiti Putra Malaysia Bintulu Sarawak Campus
(Chairman)

Kwan Yee Min, PhD
Senior Lecturer
Faculty of Agriculture and Food Science
Universiti Putra Malaysia Bintulu Sarawak Campus
(Member)

Zakry Fitri bin Abdul Aziz, PhD
Senior Lecturer
Faculty of Agriculture and Food Science
Universiti Putra Malaysia Bintulu Sarawak Campus
(Member)

Joseph Bong Choon Fah, PhD
Associate Professor
Faculty of Agriculture and Food Science
Universiti Putra Malaysia Bintulu Sarawak Campus
(Member)

ZALILAH MOHD SHARIFF, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 10 June 2021

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Name and Matric No.: Su Chong Ming GS48880

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Signature: _____
Name of Chairman of Supervisory Committee: Assoc. Prof. Dr. Patricia King Jie Hung

Signature: _____
Name of Member of Supervisory Committee: Dr. Kwan Yee Min

Signature: _____
Name of Member of Supervisory Committee: Dr. Zakry Fitri bin Abdul Aziz

Signature: _____
Name of Member of Supervisory Committee: Assoc. Prof. Dr. Joseph Bong Choon Fah

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIAITONS

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

CHAPTER 1

INTRODUCTION

Recent studies have shown that oil palm estates established on peat frequently faced more severe pest infestation than mineral soil estates. (Su, 2016; Prasetyo *et al*., 2018). Among the common pests, oil palm bunch moth, *Tirathaba mundella* Walker (Pyralidae), is becoming a prominent pest in oil palm estates established on peat, causing more than 50% of crop losses when there is a severe outbreak (Lim, 2012). Bunch abortion is a common scenario when the attack is severe and no proper control is in place (Su, 2016).

In order to effectively and sustainably controlling *T. mundella*, their life cycle and susceptibility to chemical pesticides control need to be understood. The only documented life cycle for *T. mundella* was reported in 1977 by Ng (Ng, 1977). The report was based on limited samples gathered from the field. There are possibility of some larvae instars may be missed. In this study, we were reexamined the life cycle by studying at least five generations of the pest in the laboratory.

It is known that a substantial loss in yield could occur due to *T. mundella* infestation. However, pest control measures are often costly. Therefore, in this study, the economic injury level (EIL) of *T. mundella* for oil palm plantation was investigated to estimate the economic losses and determine the breakout point where a pest control treatment must be carried out.

For an effectively and sustainably controlling the pest, an optimum dosage of several suitable and environmentally friendly pesticides needs to be determined. The pesticides selected should not have severe detrimental effect to the beneficial insects such as pollinators. In this study, several pesticides were tested their effect on oil palm pollinating weevils, *Elaeidobius kamerunicus*. In addition, these pesticides were also tested for their optimum dosage for controlling the pest and how these pesticides can be rotatedly use to minimise the risk of pesticide resistance development by the pest.
Therefore, the present study was undertaken with the following objectives:

1. to formulate suitable artificial diet for oil palm bunch moth and life cycle study throughout five generations of propagation under laboratory conditions.

2. to determine the economic destruction by *T. mundella* in the field through inter-correlate field census, fruit set counting and oil to bunch analysis.

3. to determine the optimum dosage of an anthranilic diamide insecticide, chlorantraniliprole, as well as chromafenozide, an insect growth regulator against oil palm bunch moth, *T. mundella* Walker.

4. to identify the impact of insect growth regulators (IGRs) and other potential chemicals on the survival of oil palm pollinators, *Elaeidobius kamerunicus*.

5. to evaluate the effectiveness of rotation mechanisms among chlorantraniliprole, insect growth regulators (IGRs), biological insecticide, *Bacillus thuringiensis* and other potential weevil friendly chemical insecticides with different mode of actions against *T. mundella* Walker in young mature oil palm plantation.

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BIODATA OF STUDENT

Su Chong Ming was born on 26th December 1979 in Miri Sarawak, Malaysia. He received his primary education in Sekolah Rendah Bantuan Chuang Hua, Miri. In 1993, he pursued his secondary secondary education in Sekolah Menengah Bantuan Chung Hua, Miri. He completed his Sijil Tinggi Pelajaran Malaysia (STPM) in Kolej Tun Datu Tuanku Haji Bujang, Miri in 1999. In the following year, he continued his higher education in Universiti Malaysia Sabah and graduated with Bachelor of Science in Plant Technology. In 2013, he was enrolled in degree of Master in Plant Entomology and graduate in year 2016. After graduated from his Master, he decided to pursue in degree of Doctor of Philosophy in Plant Entomology since year 2017.