UNIVERSITI PUTRA MALAYSIA

EFFICACY OF BACILLUS THURINGIENSIS BERLINER AGAINST METISA PLANA WALKER AND ITS APPLICATION USING THERMAL FOGGER AND MISTBLOWER

TAN SEK YEE.

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EFFICACY OF BACILLUS THURINGIENSIS BERLINER AGAINST METISA PLANUS WALKER AND ITS APPLICATION USING THERMAL FOGGER AND MISTBLOWER

By

TAN SEK YEE

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Agricultural Science

April 2004
Because of them,

"I have a new love for that glittering instrument, the human soul. It is a lovely and unique thing in the universe. It is always attacked and never destroyed — because 'Thou mayest'."

_East of Eden_
By John Steinbeck
The effectiveness of *Bacillus thuringiensis* Berliner (*Bt*) against the bagworm, *Metisa plana* Walker and its application using thermal fogger and mistblower was studied in three-year old oil palms.

Initially, a standardized rearing protocol of the bagworm was established to produce healthy test insects. *Metisa plana* was reared on oil palm seedlings from eggs surface-sterilized for one hour in 8% formaldehyde. This sterilization regime did not affect the egg hatchability and it significantly (*P*<0.05) increased the survivorship of the first to second instar larvae when compared to larvae hatched from unsterilized eggs.

Following a laboratory bioassay conducted against the third and fifth instar larvae at temperatures of 25-29°C and 50-80% relative humidity, formulations from both *Bt*
subsp. *kurstaki*: Dipel® ES, Dipel® DF, Dipel® WP and ABG-6429 FC; and *Bt* subsp. *aizawai*: Florbac® SC and Xentari® WG were shown to be effective on the bagworm.

Evaluation on the suitability and effectiveness of portable thermal fogging (PulsFog®-K10 and AgroFog® AF 35) and mistblower (Solo® Master 412) application of *Bt* (Dipel ES®) against *M. plana* in three-year old oil palm revealed that when water was used as the diluent in spray mixtures, efficacious activity was achieved which was attributed from the formation of an adequately stable emulsion. For both types of applicators, the kill of *M. plana* was shown to be positively dependent on droplet densities and concentrations of *Bt*. In the field trial on three-year old oil palm, AgroFog® AF 35 with AFX Fogging Solution and Solo® Master 412 Knapsack Mistblower were shown to give effective horizontal throw of 6 m whereas PulsFog®-K10 was only 2 m. Under the condition of these experiments, cost effectiveness analysis showed that the use of portable fogger to apply *Bt* formulation to control *M. plana* was not as cost-effective, practical or suitable as knapsack mistblower. The predicted kill of the bagworm obtained by mistblower was satisfactory and higher (50-92%) compared to thermal fogger (38-46%) at the middle and top strata of the oil palm. The poor deposition rates from fogging application in the palm increased the usage of Dipel® ES and AFX Fogging Solution thus incurred higher cost. Furthermore, the fogging application was limited to early morning or late evening, and that also incurred higher labour cost, notwithstanding the possibility of labour shortage. Comparatively, the use of mistblower gave higher deposition rates that reduced the rates of Dipel® ES per hectare thus saved cost. Mistblower is also easily available, versatile and can be used during the daytime.
Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains Pertanian

KEBERKESANAN BACILLUS THURINGIENSIS BERLINER TERHADAP METISA PLAN A WALKER DAN APPLIKASINYA DENGAN ALAT PENGABUT DAN PENYEMBUR KABUS

Oleh

TAN SEK YEE

April 2004

Chairman: Profesor Yusof Ibrahim, Ph.D.

Fakulti: Pertanian

Keberkesan \textit{Bacillus thuringiensis} Berliner (Bt) terhadap ulat bungkus, \textit{Metisa plana} Walker dan applikasinya dengan pengabut dan penyembur kabus telah dikaji pada kelapa sawit berumur tiga tahun.

Pada permulaannya, satu protokol standard untuk pembelaan ulat bungkus telah dihasilkan untuk memperoleh ulat yang sihat untuk ujian. \textit{Metisa plana} yang menetas daripada telur yang telah disterilkan permukaannya selama satu jam dengan 8\% formaldehid telah dipelihara di atas anak semaian kelapa sawit. Kaedah pensterilan ini tidak menjejaskan penetasan telur dan ia meningkatkan kemandirian ulat dengan signifikannya ($P<0.05$) daripada instar pertama ke instar kedua berbanding ulat daripada telur yang tidak disterilkan.

Penilaian kesesuaian dan keberkesanan di dalam penggunaan pengabut (PulsFog®-K10 dan AgroFog® AF 35) dan penyembur kabus (Solo® Master 412) untuk menyembur Bt ke atas *M. plana* pada kelapa sawit berumur tiga tahun telah menunjukkan bahawa apabila Bt (Dipel® ES) dicampurkan ke dalam air, efikasi telah didapati oleh kerana disebabkan pembentukan emulsi yang stabil di dalam campuran semburan. Kedua-dua jenis aplikasi ini menunjukkan bahawa kawalan *M. plana* bergantung secara positif kepada kepadatan titisan dan kepekatan Bt. Dalam aplikasi penyemburan pada pokok-pokok kelapa sawit berumur tiga tahun, AgroFog® AF 35 dengan cecair pengabut AFX dan penyembur kabus Solo® Master 412 telah memberi jarak semburan mendatar 6 m yang berkesan manakala PulsFog®-K10 hanya memberi 2 m. Di bawah keadaan kajian ini, analisis keberkesanan kos menunjukkan penggunaan alat pengabut untuk formulasi Bt bagi mengawal *M. plana* adalah kurang kos-berkesan, praktikal atau sesuai berbanding dengan alat penyembur kabus. Jangkaan kematian ulat bungkus yang diperolehi daripada penyemburan kabus adalah memuaskan and lebih tinggi (50-92%) berbanding dengan alat pengabutan (38-46%) di stratum tengah and atas pokok kelapa sawit. Kadar taburan titisan yang rendah dari penyemburan kabut pada pokok kepala sawit telah meningkatkan penggunaan Dipel® ES dan AFX
Fogging Solution, oleh itu kos telah meningkat tinggi. Tambahan pula, kerja pengabutan agak terhad pada waktu awal pagi atau lewat petang dan ini telah meningkatkan kos buruh, malahan berkemungkinan akan mengalami kesukaran mendapat pekerja. Akan tetapi, penggunaan penyembur kabus memberi kadar taburan titisan yang lebih tinggi yang mana mengurangkan kadar penggunaan Dipel® ES per hektar maka dengan itu, kos dijimatkan. Alat penyembur kabus juga mudah didapati dan boleh digunakan pada bila-bila masa termasuk waktu kerja siang hari.
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I certify that an Examination Committee met on 26th April 2004 to conduct the final examination of Tan Sek Yee on her Master of Agricultural Science thesis entitled “Efficacy of *Bacillus thuringiensis* Berliner Against *Metisa plana* Walker and its Application Using Thermal Fogger and Mistblower” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

**Rita Muhammad, Ph.D.**  
Associate Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Chairman)

**Yusof Ibrahim, Ph.D.**  
Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Member)

**Dzolkhifli Omar, Ph.D.**  
Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Member)

**Gulam Rusul Rahmat Ali, Ph.D.**  
Professor/Deputy Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date: 17 JUN 2004
This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Master of Agricultural Science. The members of the Supervisory Committee are as follows:

Yusof Ibrahim, Ph.D.
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Dzolkhifli Omar, Ph.D.
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

AINI IDERIS, Ph.D.
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 10 JUL 2004
DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

TAN SEK YEE

Date: 10th July 2004. 
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8 GENERAL DISCUSSION AND CONCLUSION

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<td>Setting of egg incubators with: (A) petri dish 9 cm in diameter and (B) 100 mL specimen jar.</td>
<td>41</td>
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<tr>
<td>4.1</td>
<td>Device used for caging <em>M. plana</em> on treated excised oil palm leaflets. At left: side view of the cages, and right: front view.</td>
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<tr>
<td>4.2</td>
<td>The levels of kill achievable with the L3 and L5 of <em>M. plana</em> at various concentrations of Dipel® DF on the third and seventh DAT. The vertical lines are standard errors of means. Sources obtained from Appendices 4.1 and 4.2.</td>
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<tr>
<td>4.3</td>
<td>The levels of kill achievable with the L3 and L5 of <em>M. plana</em> at various concentrations of Dipel® ES on the third and seventh DAT. Vertical lines are standard errors of means. Sources obtained from Appendices 4.3 and 4.4.</td>
<td>50</td>
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</table>
The levels of kill achievable with the L3 and L5 of *M. plana* at various concentrations of Florbac® SC on the third and seventh DAT. The vertical lines are standard errors of means. Sources obtained from Appendices 4.5 and 4.6.

The levels of kill achievable with the L3 and L5 of *M. plana* at various concentrations of Xentari® WG on the third and seventh DAT. The vertical lines are standard errors of means. Sources obtained from Appendices 4.7 and 4.8.

The levels of kill achievable with the L3 of *M. plana* at various concentrations of Dipel® WP on the third and seventh DAT. The vertical lines are standard errors of means. Sources obtained from Appendix 4.9.

The levels of kill achievable with the L3 of *M. plana* at various concentrations of ABG-6429 FC on the third and seventh DAT. The vertical lines are standard errors of means. Sources obtained from Appendix 4.10.

Efficacy of *Bt* on the L5 of *M. plana* applied by PulsFog® K-10 using 160 mL/L of Dipel® ES diluted in diesel. Vertical lines are standard errors of the means. Sources were obtained from Appendix 5.2.

The fogging tunnel

Deflector setup to prevent fog from entering main tunnel.

Various droplet densities deposited by a fogger (PulsFog® K-10). The densities are given scores of 1 (bottom) to 6 (top).

Efficacy of *Bt* against L3 of *M. plana* in a fogging tunnel. Vertical lines are standard errors of means. Sources obtained from Appendix 5.7.

Efficacy of *Bt* against L5 of *M. plana* in a fogging tunnel. Vertical lines are standard errors of means. Sources obtained from Appendix 5.8.

Laboratory efficacy of *Bt* against L3 of *M. plana* in field. Vertical lines are standard errors of means. Sources obtained from Appendix 5.14.

Laboratory efficacy of *Bt* against the L5 of *M. plana* in field. Vertical lines are standard errors of means. Sources obtained from Appendix 5.15.
6.1 Laboratory efficacy of Bt on the L3 of *M. plana*. Treatments were applied by Agrofog® AF 35 in field at various concentrations of Dipel® ES and levels of DD. Vertical lines are standard errors of means. Sources obtained from Appendix 6.9.

6.2 Laboratory efficacy of Bt on the L5 of *M. plana*. Treatments were applied by Agrofog® AF 35 in field at various concentrations of Dipel® ES and ranges of DD. Vertical lines are standard errors of means. Sources obtained from Appendix 6.10.

6.3 The stratification and lay out of fogging procedure of Agrofog® AF 35 on three-year old oil palm. Q 1 to Q 4 represent quadrant one to four respectively. The symbol: ⊙ represents the location of pieces of white cardboard for droplets collection.

6.4 Number of droplets/cm² (± S.E.) deposited on upper and lower surfaces of leaflets of top, middle and bottom strata at three frond sections located from front to back canopy of three year old oil palm of various concentrations of AFX Fogging Solution (AFX) applied by Agrofog® AF 35. In X-axis, each point represents section in oil palm canopy: front canopy and back canopy, and frond sections: D = distal, M = middle and P = proximal. The four lines in each graph represent the concentrations of AFX: the symbols: X = 0% AFX, A = 10% AFX, ⊙ = 25% AFX and □ = 50% AFX.

6.5 Number of droplets/cm² (± S.E.) on the upper surface of leaflets in the top, middle and bottom strata at front and back canopies of the three-year old oil palm with various concentrations of AFX Fogging Solution (AFX) applied by Agrofog® AF 35. In each graph, bars followed by the same letter are not significantly different (P > 0.05) according to ANOVA and LSD.

6.6 Number of droplets/cm² (± S.E.) on the upper surface of leaflets at the top, middle and bottom strata in the front and back canopies of the three-year old oil palm with the application of 15% of AFX by Agrofog® AF 35. In each graph, bars followed by the same letter are not significantly different (P > 0.05) according to ANOVA and LSD.

7.1 Various droplet densities deposited by a knapsack mistblower (Solo® Master 412). The densities are given scores of 1 (bottom) to 6 (top).

7.2 Laboratory efficacy of Bt on the L3 of *M. plana* from treatments applied by Solo® in the field at various concentrations of Dipel® ES and levels of DD. Vertical lines are standard errors of means.
Laboratory efficacy of Bt on the L5 of *M. plana* from treatments applied by Solo® in the field at various concentrations of Dipel® ES and levels of DD. Vertical lines are standard errors of the means.

The layout of spray application by Solo® on the three-year old oil palm.

The trend of deposition rates on upper surface of the foliage at frond sections: proximal, middle and distal, and at the top, middle and bottom strata of three year-old oil palm after being sprayed with Solo® Master 412 knapsack mistblower at four different durations of spray time. In each graph, the four lines represent the duration of spray time. The symbols: X = 1.0 minute, A = 1.5 minutes, O = 2.0 minutes and □ = 2.5 minutes. Vertical lines indicate standard errors of mean number of droplets/cm².

The trend of deposition rates on lower surface of the foliage at frond sections: proximal, middle and distal, and at the top, middle and bottom strata of three-year old oil palm after being sprayed with Solo® Master 412 knapsack mistblower at four different durations of spray time. In each graph, the four lines represent the duration of spray time. The symbols: X = 1.0 minute, A = 1.5 minutes, O = 2.0 minutes and □ = 2.5 minutes. Vertical lines indicate standard errors of mean number of droplets/cm².

General spray deposition profile at various sections in a quadrant of three-year old oil palm canopy after being sprayed with Solo® Master 412 knapsack mistblower. The darkest shade received the highest droplet deposition rates.

The trend of deposition rates at upper surface of leaflets at frond sections: proximal, middle and distal, in top, middle and bottom strata of three-year old oil palm after being sprayed by Solo® Master 412 knapsack mistblower at various durations of spray time and two restrictor settings. The symbols: A = Restrictor 2; 1.0 minute, O = Restrictor 2; 1.5 minutes and □ = Restrictor 1; 2.5 minutes. Vertical lines indicate standard errors of means number of droplets/cm². Sources obtained from Appendix 7.26.