PERFORMANCE OF PALM-BASED EMULSIONS IN WATER (EW)-INSECTICIDE FORMULATIONS AGAINST INSECT PESTS ON CHILLI AND BRINJAL

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ABSTRACT

The performance of palm-based emulsions in water (EW)-insecticide formulations was evaluated in the field against insect pests on chilli and brinjal crops. The insecticides used were deltamethrin and lambda-cyhalothrin. Phytotoxicity symptoms were also evaluated on the treated crops. The untreated plots gave the highest number of damaged fruits in chilli and brinjal when compared to the treated plots. In addition, no phytotoxicity symptom was observed in both the brinjal and chilli crops, meaning that they showed good tolerance to all the treatments. Statistical analyses (using Duncan's multiple range test at the probability, P, of less than 0.05) of the differences between treatments indicated that the palm EW-pyrethroid insecticide formulations were equally effective or significantly better than the commercial emulsifiable concentrates (EC) formulations at the recommended (10 ml/10 litres) and lower (7.5 ml/10 litres) doses in controlling the pests on chilli and brinjal crops. The residues of the EW-pyrethroid insecticides on the crops were also determined.

Keywords: palm-based inert ingredients, EW-pyrethroid insecticides, brinjal, chilli.

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INTRODUCTION

Insecticides comprise about 20% (w/w) of the total pesticides marketed in Malaysia. Of this percentage, more than 55% are in the form of emulsifiable concentrates (EC), which consist of solvents derived 100% from petroleum, such as xylene, kerosene, toluene and other petroleum-based solvents (Abdullah and Mohtar, 1993; Tadros; 1995; Ismail *et al.*, 1998; 2005; Mulqueen, 2003; MCPA, 2008/2009). In fact, these solvents tend to produce medical problems (*e.g.*, skin and eye irritation) to operators or workers, plus they are highly flammable and non-biodegradable. Furthermore, petroleum products are known to be depleting.

Operators in the agriculture sector have over the years increasingly demanded safer and more convenient pesticide formulations to ensure easy application and effectiveness in killing the insect pests; but, most important of all, the insecticides should be safe to them. An example of such products that can meet the current demand and needs is the water-based emulsion (EW) instead of EC-insecticide formulations (Ismail, 2000; Mulqueen, 2003; Ismail *et al.*, 2004; 2007; 2009). EW-insecticides offer many advantages over the conventional EC-insecticide formulations. Being aqueous-based formulations, the EW may cause fewer medical problems, *e.g.*, skin and eye irritation, for the end-users or operators. They may also be less phytotoxic to plants. The formulations are cheaper to produce due to the fact that more than 70% water is used instead of oil.

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Furthermore, there is a shift from petroleum-based to natural-based materials as inert ingredients in insecticide formulations. This is illustrated by the change in preference by consumers (Cornish *et al*., 1993; Srivastava and Prasad, 2000). The natural-based materials are renewable, environmental-friendly and less flammable due to their higher flash points, as well as causing fewer medical problems and allergies to the end-users. Therefore, palm-based materials formulated into EW-insecticides have good potential for replacing petroleum-based materials which are now being used in EC-insecticide formulations.

The Malaysian Palm Oil Board (MPOB) has formulated several palm-based EW-insecticide formulations (Ismail, 2000; Ismail *et al*., 2004; 2005; 2007; 2009). These products have undergone complete physical stability and laboratory-scale efficacy tests. The results obtained indicate that the palm-based EW-insecticides have good potential in controlling pests in the agricultural sector, *e.g*., in vegetable farms (Ismail *et al*., 2007) and oil palm plantations (Ismail *et al*., 2009), and may also be useful in the public health sector. This article, therefore, discusses the performance and phytotoxicity of palm-based EW-insecticide formulations against insect pests on brinjal and chilli crops in the field.

METHODOLOGY

Materials

Insecticides. The insecticide treatments comprise: palm EW-lambda-cyhalothrin, 2.5% a.i. (w/w); palm EW-deltamethrin, 2.8% a.i. (w/w) - both at the recommended and at lower dosages; commercial EC-lambda-cyhalothrin, 2.5% a.i. (w/w) and commercial EC-deltamethrin, 2.8% a.i. (w/w) that were bought from Bright Resource Technology Sdn Bhd, a local agro-chemical company. The emulsifiers used in the EW-products were supplied by Cognis Oleochemicals (M) Sdn Bhd, a local oleochemical company.

Crops and types of insects. Two experimental fields of brinjal and chilli crops were used. The insecticide treatments were tested against chilli borers (*Helicoverpa armigera* and *Bactrocera latifrons*), brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen).

Experimental Procedure

The experiments were conducted using a randomized complete block design (RCBD) with three replicates per treatment. Seven treatments were tested, as listed in *Table 1*. Each treatment was randomly placed within each replicate. Every plot contained three rows of chilli or brinjal plants with 20 plants per bed. The planting distance used was 50 cm within a row and 60 cm between the rows; hence, the total plant number per treatment plot was 60. In addition, wooden stakes were used to support the chilli and brinjal plants throughout the experimental period.

Palm-based inert ingredients consisting of palm-based solvents and emulsifiers were used to prepare the EW-insecticide formulations (*Figure 1*). Applications of the insecticides (*Figure 2*) were carried out at five-day intervals. The first application was carried out after the first flower was observed for both the brinjal and the chilli crops. Flowering and fruiting regions were the main targets of insecticide application. The chemicals were applied using a conventional knapsack sprayer with a solid cone nozzle at a spray volume of around 1000 litres ha^{-1}. A miticide such as Mitac and a conventional EC-insecticide such as profenofos were used as crop maintenance chemicals during the crops' vegetative growth.

TABLE 1. TREATMENTS USED IN THE EXPERIMENTS ON BRINJAL AND CHILLI

Code	Treatment (insecticide)	Dosage (ml/10 litres)
T1	Untreated (control)	-
T2	Commercial EC-deltamethrin, 2.8% a.i. (w/w)	4.6
T3	Commercial EC-lambda-cyhalothrin, 2.5% a.i. (w/w)	10.0
T4	Palm EW-deltamethrin, 2.8% a.i. (w/w)	4.6*
T5	Palm EW-deltamethrin, 2.8% a.i. (w/w) - lower rate	3.45
T6	Palm EW-lambda-cyhalothrin, 2.5% a.i. (w/w)	10.0*
T7	Palm EW-lambda-cyhalothrin, 2.5% a.i. (w/w) - lower rate	7.5

Note: *Recommended doses.
EW - emulsions in water.

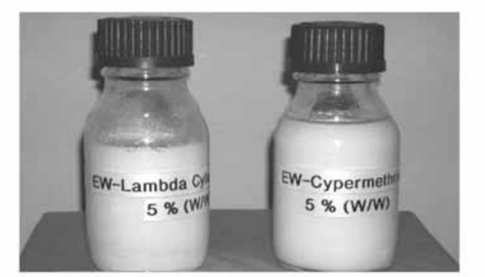

Figure 1. Palm emulsions in water (EW)-pyrethroid insecticide formulations.

(a)

(b)

Figure 2. Application of palm emulsion in water (EW)-insecticide solutions on (a) brinjal and (b) chilli in the field.

The fruits were harvested over a total of eight and 11 harvesting rounds for the brinjal and chilli crops, respectively, and damaged fruits were evaluated *in situ*. Only the percentages of damaged fruits were considered in the data analysis using the SAS software [namely, Duncan's multiple range test (DMRT) for the separation of means at the statistical level of probability, P, of less than 0.05].

Residue Analysis

The target insecticide residues were lambda-cyhalothrin and deltamethrin. Five hundred grammes each of chilli and brinjal leaves were collected randomly from the three replicates of each treatment. The insecticide residues in the leaves were analysed using a gas chromatography instrument, model Agilent 6890, with micro ECD as a detector at the Agricultural Chemical Analysis Laboratory, Technical Services Centre, Malaysian Agricultural Research and Development Institute (MARDI), Serdang, Selangor, Malaysia. The analyses were carried out on the leaf samples harvested at 0 (or 1-2 hr after application), one, three, five and seven days after the insecticide applications, respectively.

RESULTS AND DISCUSSION

The performance, phytotoxicity effect and residues of the palm EW-insecticides were field-evaluated and compared to the commercial EC-insecticides.

Brinjal

No phytotoxicity symptoms were observed on the brinjal crop in all the treatment plots as the crop showed good tolerance to all the treatments applied. Statistical analysis (DMRT, $P < 0.05$) among the treatments (*Table 2*) indicated that, in most cases, the percentage of damaged fruit was significantly reduced in the treated plots than in the untreated one throughout the harvesting period. However, the treatments showed no significant difference in percentage of damaged fruit, especially in the last two harvesting rounds.

The difference between the efficacy of the EC and EW formulations was also not significant. This shows that they were equally effective against the pest. The results also indicate that the lower rate of EW-formulations for both deltamethrin (T5) and lambda-cyhalothrin (T7) showed effective control against the pest when compared to their recommended rates. These results confirmed the performance of palm EW-insecticides against insect pests on vegetables in the field (Ismail *et al*., 2007). The analysis also indicated that the untreated plots had a higher number of damaged fruit than the treated plots ($P < 0.05$; DMRT). However, almost all the plots produced an approximately similar number of fruit throughout the experimental period.

The untreated plots produced the highest percentage of damaged fruit throughout the period, while both the EC (T2 and T3) and EW-insecticide formulations (T4, T5, T6 and T7) gave consistently lower percentages of damaged fruit. The total number of damaged fruit was also compared with percentage of damaged fruit for all treatments (*Figure 3*).

While the total number of fruit harvested was approximately similar in all the treatments, the untreated plots gave a significantly higher percentage of damaged fruit than the treated plots.

The insecticide residues on the brinjal leaves rapidly declined after the first day of application. However, there was an obvious difference in the

TABLE 2. MEAN PERCENTAGE OF DAMAGED BRINJAL FRUIT BY THE FRUIT BORER AT VARIOUS HARVESTING TIMES

Treatment	% Damaged fruit at various harvest times (*DAT)								Mean, %
	48	52	55	58	63	69	73	79	
T1	0a	50.00a	28.35a	38.92a	32.34a	35.37a	29.21a	22.22a	29.61a
T2	0a	10.74bc	7.74b	17.24b	17.17b	19.42b	21.17a	21.27a	17.41b
T3	0a	0c	5.82bc	12.56b	12.29b	18.31b	20.44a	21.12a	14.99b
T4	0a	11.80bc	9.91b	10.68b	14.14b	19.64b	21.60a	22.40a	18.23b
T5	0a	2.56c	6.90bc	9.95b	15.57b	21.25b	21.50a	23.22a	17.52b
T6	0a	20.81b	6.13bc	9.30b	16.41b	24.20b	22.71a	10.22b	16.48b
T7	0a	27.38b	2.87c	10.40b	14.24b	20.53b	23.67a	12.85b	14.67b

Note: Means in each column bearing the same alphabet are not significantly different from one another (at $P < 0.05$) according to Duncan's multiple range test.

*DAT = days after transplanting.

residue values for T3 (~0.22 mg kg^{-1}) and T6 (~0.4 mg kg^{-1}) at day 1 after application. This could be due to a technical error during the analyses. In general, the residues decreased gradually to almost zero between day 3 and day 7 as presented in *Figures 4a* and *4b*. Both the EW and EC-insecticide formulations gave a similar trend in terms of the rate of decrease of deltamethrin and lambda-cyhalothrin residues within seven days of application.

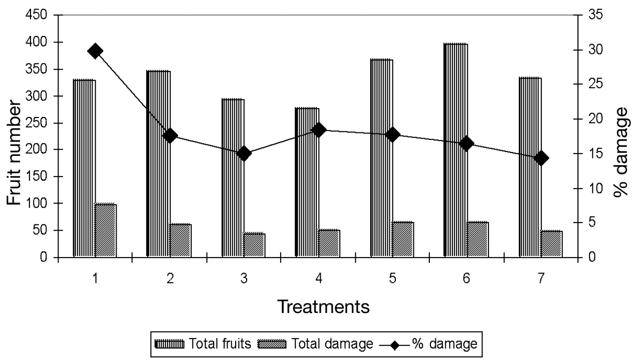

Figure 3. Percentage of brinjal fruit damage from the total number of fruit harvested.

At seven days after application, the amount of insecticide residues left on the leaf surfaces was very low in both the EW and the EC formulations, *i.e.*, 0.06-0.07 mg kg^{-1} and 0.01-0.03 mg kg^{-1} for deltamethrin and lambda-cyhalothrin, respectively. These levels are lower than the maximum residue limits for deltamethrin and lambda-cyhalothrin in food which are 0.2 mg kg^{-1} and 0.1 mg kg^{-1}, respectively (Food Act 1983 and Regulations, 2005; Ainie *et al.*, 2007).

Chilli

No phytotoxicity symptom was observed on the chilli plants in all the treatments, indicating good tolerance of the chilli crop to all the treatments. As described previously, the percentage of damaged fruit was significantly reduced in the treated plots

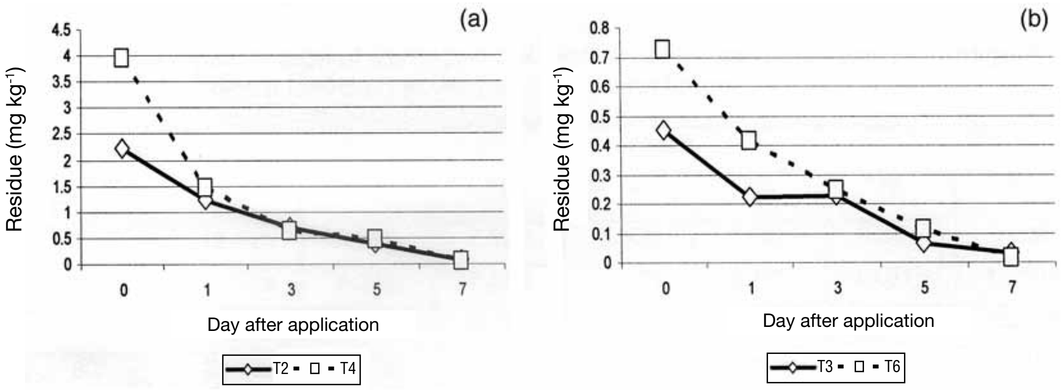

Figure 4. Amount of residues of (a) deltamethrin and (b) lambda-cyhalothrin on brinjal leaves from 0 to seven days after application.

compared to the untreated one throughout the harvesting period (P < 0.05; DMRT).

Comparing between treatments, the EC and EW-insecticide formulations were not significantly different, meaning that they were equally effective against the pests. Also, the results indicate that the lower dosages of EW-formulations, using deltamethrin (T5) and lambda-cyhalothrin (T7) as the active ingredients, gave approximately similar performance in controlling the pests when compared to their recommended dosages (*Table 3*). As before, these results also confirmed the performance of palm EW-insecticides against insect pests on vegetables in the field (Ismail *et al*., 2007).

Statistical analysis of data on the percentage of total fruit damage also indicates that the untreated plots gave the highest amount of fruit damage compared to the treated plots (P < 0.05; DMRT). In addition, the plots treated with both the EC and EW-formulations, consisting of deltamethrin and lambda-cyhalothrin, showed approximately similar effects against the pests. These results are in accordance with the performance of field trials carried out on other types of vegetables (Ismail *et al*., 2007).

The field trial results show that the untreated plots resulted in the highest percentage of damaged fruit throughout the experimental period. However, both the EC (T2 and T3) and EW (T4, T5, T6 and T7) insecticidal formulations gave lower percentages of damaged chilli fruit than the untreated plots (T1).

Figure 5 shows the total number of fruit harvested, which was approximately similar for all the treatments. The total number of damaged fruit and its percentage in relation to total harvested fruit are also shown for all the treatments.

The insecticide residues on chilli leaves also rapidly reduced from the first day of application (except for the lambda-cyhalothrin residue which did not change significantly at day 1) and gradually decreased to almost zero between day 3 and day 7 as shown in *Figures 6a* and *6b*.

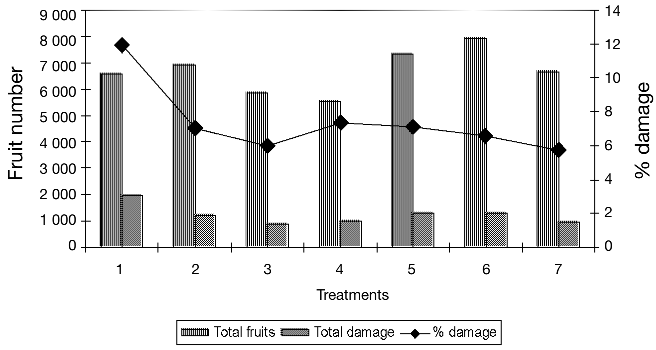

Figure 5. Percentage of damaged chilli fruit from the total fruit harvested.

TABLE 3. MEAN PERCENTAGE OF DAMAGED CHILLI FRUIT BY THE BORER (*Helicoverpa armigera* and *Bactrocera latifrons*) AT VARIOUS HARVESTING TIMES

% Damaged fruit at DAT*	Treatment						
	T1	T2	T3	T4	T5	T6	T7
63	19.52a	0.00b	1.52b	5.56b	0.00b	8.33b	3.03b
69	30.35a	8.31b	7.25b	10.77b	8.17b	13.61b	10.03b
74	29.2a	14.57b	18.35b	16.02b	11.19b	11.99b	13.38b
80	20.15a	8.10c	8.94bc	8.57bc	7.10c	7.10c	12.75b
84	16.28a	4.04c	8.51bc	12.28ab	13.86ab	11.11ab	9.99b
89	7.22a	1.61b	2.51b	2.92b	3.10b	3.73b	2.45b
96	4.39a	0.95b	2.01b	0.65b	1.87b	0.64b	1.69b
100	7.44a	0.69d	3.98b	2.48bc	3.15bc	2.02cd	3.32bc
108	13.76a	3.66c	6.05bc	8.61b	3.97c	3.47c	4.10c
110	15.93a	5.74b	7.20b	8.77b	8.71b	6.90b	8.01b
117	15.77a	10.50b	4.97c	8.43bc	7.15bc	7.12bc	6.54c
Mean, %	12.61a	3.64d	5.56bc	6.53b	5.12c	4.43cd	5.66bc

Note: Means in each column bearing the same alphabet are not significantly different from one another (P < 0.05) according to Duncan's multiple range test.
*DAT = days after transplanting.

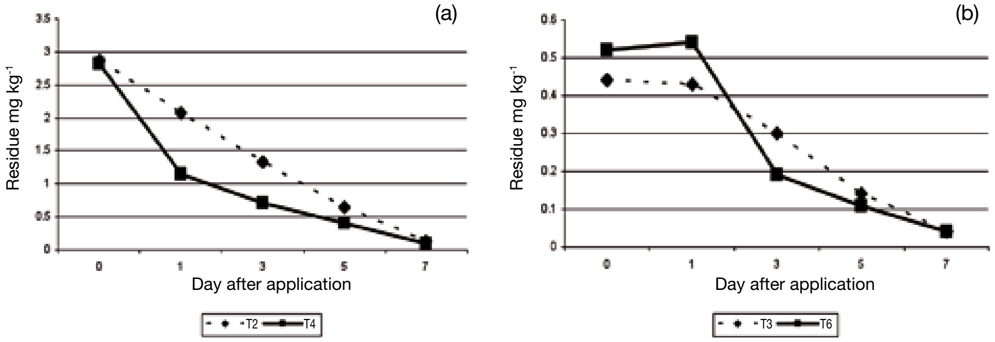

Figure 6. Amounts of residues of (a) deltamethrin and (b) lambda-cyhalothrin on chilli leaves from 0 to seven days after application.

At seven days after application, the amount of insecticide residues left on the leaf surfaces was very low in both the EW and the EC formulations, *i.e.*, 0.10-0.13 mg kg^{-1} and 0.037-0.043 mg kg^{-1} for deltamethrin and lambda-cyhalothrin, respectively. The results also indicate that the EW-insecticides were equally as good as EC-insecticide formulations in the amount of insecticide residues left on the leaf surfaces at seven days after application. As mentioned that the maximum residue limits for deltamethrin and lambda-cyhalothrin in food are 0.2 mg kg^{-1} and 0.1 mg kg^{-1}, respectively (Food Act 1983 and Regulations, Malaysia, 2005; Ainie *et al.*, 2007).

CONCLUSION

The results of the field performance trials show that palm EW-insecticide formulations with 2.5% a.i. (w/w) lambda-cyhalothrin at the standard and lower dosages (10 ml/10 litres and 7.5 ml/10 litres, respectively) and the commercial EC-insecticide formulations with 2.8% a.i. (w/w) deltamethrin and 2.5% a.i. (w/w) lambda-cyhalothrin were equally effective in controlling insect pests on both the brinjal and chilli crops in the field. Both the EC and EW-insecticide formulations gave consistently lower percentages of fruit damage than the untreated plots. The amount of insecticide residues left on the leaf surfaces was very low for both the EW and the EC-insecticide formulations at seven days after application. Also, the insecticide residues were lower than the allowable maximum residue limits set by the Malaysian Food Act 1983 and Regulations (Ainie *et al.*, 2007).

In summary, palm-based materials have good potential in substituting petroleum-based materials in agro-chemical formulations. Furthermore, the palm EW-insecticides may form the basis for a future trend in crop care and public health sectors in place of the conventional EC-insecticides currently used in Malaysia and elsewhere.

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