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The insecticidal activity and efficacy of some insecticides against *Helopeltis theobromae* Miller on cocoa

(Aktiviti keracunan dan keberkesanan beberapa racun serangga terhadap *Helopeltis theobromae* Miller pada koko)

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Key words: *Helopeltis theobromae* Miller, insecticidal activity, efficacy

Abstrak

Keberkesanan racun serangga campuran klorpirifos dan sipermetrin, sipermetrin, klorpirifos dan gamma-HCH terhadap *Helopeltis theobromae* Miller telah diselidiki di ladang. Aktiviti keracunan racun serangga ini pada kepekatan 10, 500 dan 1 000 bpj di permukaan buah didapati berbeza mengikut kepekatan yang digunakan. Pada amnya, campuran klorpirifos/ sipermetrin adalah lebih berkesan terhadap pengawalan *H. theobromae* daripada sipermetrin, klorpirifos dan gamma-HCH. Aktiviti keracunan klorpirifos/sipermetrin pada 1 000 bpj masih berkesan lagi sehingga hari yang ke-10 selepas rawatan menyebabkan 72% kematian serangga. Di ladang, penyemburan klorpirifos/sipermetrin pada 0.05, 0.11 dan 0.16% b.a. mengakibatkan peratus kematian yang lebih tinggi berbanding dengan sipermetrin, klorpirifos dan gamma-HCH pada 0.2% b.a. Tiada perbezaan yang ketara dari segi keberkesanan antara klorpirifos/sipermetrin dan sipermetrin, tetapi terdapat perbezaan yang ketara dengan klorpirifos dan gamma-HCH. Berdasarkan keracunan dan keberkesanan kos, campuran klorpirifos/sipermetrin sesuai sebagai racun serangga alternatif untuk mengawal *H. theobromae*.

Abstract

The efficacy of chlorpyrifos/cypermethrin mixture, cypermethrin, chlorpyrifos and gamma-HCH was investigated in the field against the mirid, *Helopeltis theobromae* Mill. The residual activity of these insecticides at 10, 500 and 1 000 ppm on pod surface was found to vary depending on the concentration used. Generally, the chlorpyrifos/cypermethrin mixture was more effective against *H. theobromae* than cypermethrin, chlorpyrifos and gamma-HCH. The residual activity of chlorpyrifos/cypermethrin at 1 000 ppm remained effective up to the 10th day after application giving about 72 % mortality. In field spraying, chlorpyrifos/cypermethrin at 0.05, 0.11 and 0.16% a.i. gave higher mirid mortality than cypermethrin, chlorpyrifos and gamma-HCH at 0.2% a.i. There was no significant difference between chlorpyrifos/cypermethrin mixture and cypermethrin, but there was significant difference between chlorpyrifos/ cypermethrin mixture and chlorpyrifos, and gamma-HCH. Based on efficacy and cost effectiveness, chlorpyrifos/cypermethrin mixture could be a suitable alternative insecticide for controlling infestation of *H. theobromae*.

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Introduction

The cocoa mirid, *Helopeltis theobromae* Miller is an important pest of cocoa in Peninsular Malaysia. Both adult and nymph damage the pods and may cause wilting of cherelles. Their infestation will also cause shoot dieback. Insecticides are still the major tool for controlling this mirid. In Peninsular Malaysia, gamma-HCH has been effectively used for controlling the mirid (Tan 1974; Ho 1987). The intensive use of gamma-HCH was facilitated by its quick and strong fumigant action and cost effectiveness compared with other insecticides (Ho 1987). Lately, however, indications of mirid resistance to gamma-HCH in Peninsular Malaysia (Dzolkifli et al. 1984) have necessitated the evaluation of alternative insecticides for mirid control. This study investigated the field efficacies of some commercial insecticides against *H. theobromae.*

Materials and methods

Insecticides

The insecticides used were cypermethrin [alpha-cyano-3-phenoxy benzyl-cis, trans-3-(2,2-dichlorovinyl)-2, 2-dimethyl cyclopropane carboxylate; *Nurelle* 10EC^R], chlorpyrifos [O,O-diethyl-(5,6-trichloropyridyl) phosphorothioate; *Lorsban* 40EC^R], gamma-HCH (1,2,3,4,5,6-hexachlorocyclohexane; *Lindane* 20EC^R) and a mixture of chlorpyrifos with cypermethrin (10:1) hereafter stated as chlorpyrifos/cypermethrin (*Nurelle*-D 505EC^R).

Insects

The F_1 generation adult *H. theobromae,* bred on cocoa pods in the laboratory conditions (28 ± 1 °C and 80–90% r.h.), were used. Two-day-old adults were used in all experiments, unless specified otherwise.

Insecticidal activity on pod surface

The insecticidal activity of gamma-HCH, chlorpyrifos, cypermethrin and chlorpyrifos/cypermethrin on 4-month-old cocoa pods was bioassayed using adult mirids in the field. The insecticides, prepared at 10, 500 and 1 000 ppm, were applied on pod surface using a brush until run-off. The treated pod was enclosed with a green nylon mesh cage. Five 2-day-old adult mirids were then introduced into each cage. For the 'control', the pod was treated with water only. All the treatments were replicated four times.

The mirid mortality was recorded every 2 days and the cumulative number of feeding punctures was counted simultaneously. Counting was stopped when the feeding punctures coalesced and became indistinguishable with the formation of lesions. After each recording, all the mirids were removed from the cage and replaced with five adult mirids. The experiment was continued until the 10th day after insecticide application.

The data were analysed by the analysis of variance at 1% and 5% levels of significance. A comparison of data on insect mortality was done using t-test at 5% level of significance.

Field spraying of insecticides against H. theobromae

The effectiveness of the insecticides viz. chlorpyrifos/cypermethrin mixture at 0.05, 0.11 and 0.16% active ingredient (a.i.), cypermethrin at 0.2% a.i., chlorpyrifos at 0.2% a.i. and gamma-HCH at 0.2% a.i., was determined in the field. Each treatment was carried out in an area of 50 m x 30 m with trees of about 15 years old. After random selection and tagging, 10 plants were artificially infested with 10 late instar (fourth and fifth instar) nymphs of *H. theobromae.* The insecticides were then sprayed using a mist blower (Maruyama MD300^R) directed at the main stem and upwards into the lateral branches. The 'control' trees were sprayed with water only. Post-spray counts on insect mortality after 24 h were made on 10 plants per treatment with one plant constituted as one replicate.

The mortality was based on the number of mirids collected from a piece of white cloth (2 m x 2 m) spread on the ground below the canopy of the treated plant. The analysis of variance was used and mortality means were compared using Duncan Multiple Range Test at 5% level of significance.

Results

Insecticidal activity on pod surface

The insect response varied with the chemicals and an increase in insect mortality was observed at higher dosages for all the chemicals *(Figure 1)*. The effectiveness of the chemicals as shown by the insect mortality was significantly different (ANOVA, $p = 0.01$) from each other *(Table 1)*. Interactions between insecticides and concentration, insecticides and day after application, concentration and day after application were also significantly different (ANOVA, $p = 0.01$). However, there was a slight interaction (Anova, $p = 0.05$) between the three selected factors *(Table 1)*.

The effectiveness of each insecticide declined gradually with time. A relatively large number of insects were still killed by the chlorpyrifos/cypermethrin mixture at all levels of concentration throughout the observation period *(Table 2)*. At 500 ppm concentration and on day 6, this mixture was significantly more effective than other chemicals. At 1 000 ppm, this insecticide remained effective until the 10th day of post-application. Cypermethrin at 1 000 ppm was also found to be significantly more effective than gamma-HCH and chlorpyrifos until the 10th day of post-application. Both insecticide chlorpyrifos/cypermethrin mixture and cypermethrin gave 72% and 55% of insect mortality respectively as compared with gamma-HCH and chlorpyrifos with 15% and 10% respectively at the 10th day after application.

Table 1. Analysis of variance for mean percentage for a 10-day period after insecticide application

Source	Degree of freedom	Means square
Insecticides	3	10 573.33**
Concentration	2	28 886.67**
Insect x Concentration	6	1 966.67**
Error (a)	36	361.11
Day	4	29 133.33**
Insect x Day	12	867.78**
Concentration x Day	8	1 203.33**
Insect x Concentration x Day	24	561.11*
Error (b)	144	334.72

** F-test significant at 1% level

* F-test significant at 5% level

Insecticidal activity on pod surface until the 10th day after application are as in *Figure 1*. A strongly negative correlation was observed between the percentage of insect mortality and the number of feeding punctures made on pod surface treated with all insecticides except the cypermethrin-treated pods (10 ppm). The insect mortality in this treatment remained low (10%) on the 6th, 8th and 10th day after application with increasing number of feeding punctures. The number of feeding punctures made by the insects decreased as the mortality rate increased and vice versa. Higher mortality rate with lesser feeding punctures was observed when higher insecticide concentrations were used. High insect mortality was also observed at the second and fourth day after application and gradually decreased until the 10th day of application.

At 500 and 1 000 ppm, chlorpyrifos/cypermethrin and cypermethrin were equally more effective than chlorpyrifos and gamma-HCH in terms of insect mortality. However, the cypermethrin-treated pods had the least feeding punctures. Counting of feeding punctures was discontinued as problems associated with counting were encountered.

Generally, chlorpyrifos/cypermethrin, cypermethrin, gamma-HCH and chlorpyrifos showed decreased in insecticidal activity. They could be ranked according to their respective insecticidal activity (insect mortality) at 1 000 ppm in a decreasing

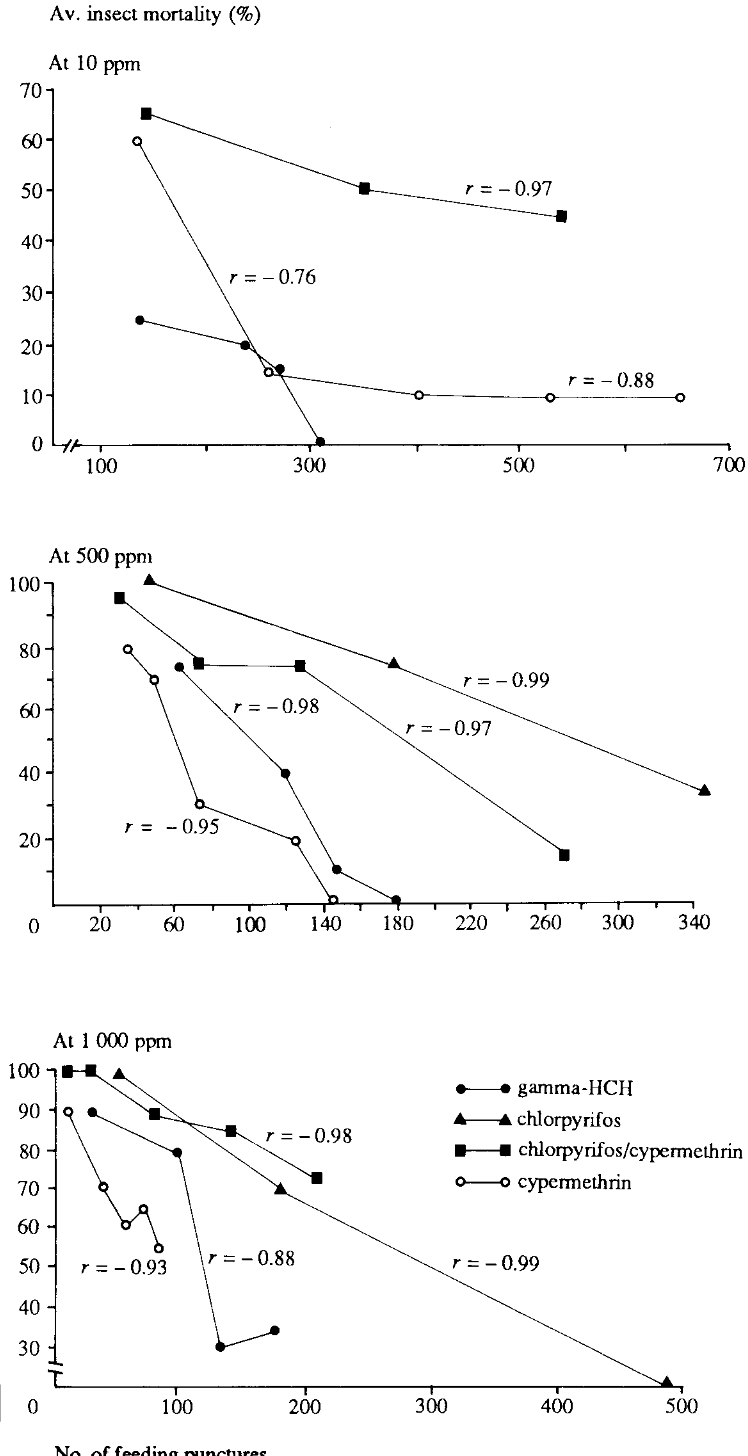

Figure 1. Relationship between average insect mortality and cumulative number of feeding punctures on insecticide-treated cocoa pods recorded at 2-day intervals until the 10th day post-application (only more than 2 data-points were presented)

Table 2. Mean insect mortality at 2-day intervals until the 10th day of insecticide application

Concentration (ppm)	Insecticide	Insect mortality (%) at days after application				
		2	4	6	8	10
10	Gamma–HCH	25a*	20a	15ab	0a	0a
	Chlorpyrifos	50a	45a	30a	10a	10a
	Cypermethrin	60a	15b	10b	10a	10a
	Chlorpyrifos/cypermethrin	65a	50a	45a	5a	10a
	Water	5b	5c	5b	5a	0a
500	Gamma–HCH	75b	40a	10a	0a	0b
	Chlorpyrifos	100a	75a	35b	15a	15ab
	Cypermethrin	80ab	70a	30b	20a	0b
	Chlorpyrifos/cypermethrin	95a	75a	75c	15a	35a
	Water	5c	5b	5a	5a	0b
1 000	Gamma–HCH	90a	80a	30b	35b	15b
	Chlorpyrifos	100a	70a	20b	15b	10b
	Cypermethrin	90a	70a	60ab	65a	55a
	Chlorpyrifos/cypermethrin	100a	100a	90a	85a	72a
	Water	5b	5b	5c	5c	0b

* Means with a common letter in the same column of each concentration are not significantly different at $p = 0.05$ by t-test

order as follows: chlorpyrifos/cypermethrin > cypermethrin > gamma-HCH > chlorpyrifos.

Field spraying of insecticides

At the tested concentrations, chlorpyrifos/cypermethrin, cypermethrin and chlorpyrifos gave significantly higher insect mortality compared with gamma-HCH *(Table 3)*. Chlorpyrifos/cypermethrin at 0.05% and 0.11% a.i. were found to be significantly more effective than chlorpyrifos and gamma-HCH both at 0.2% a.i. There was no significant difference in insect mortality between cypermethrin and chlorpyrifos (ANOVA, $p = 0.05$).

Discussion

Field studies showed that the chlorpyrifos/cypermethrin mixture was more effective than cypermethrin, chlorpyrifos and gamma-HCH in controlling *H. theobromae*. The length of residual activity on the pod surface is generally linked to the concentration of the insecticide applied. The residual activity of all the chemicals tested against *H. theobromae* lasted for about 7–10 days. The presence of further activity was not confirmed conclusively as the experiment was terminated after 10 days.

However, an overall appraisal on the insecticidal activity could be infered. Chlorpyrifos/cypermethrin, cypermethrin, gamma-HCH and chlorpyrifos showed downward trend of insecticidal activity with days after application. The insecticidal activity of chlorpyrifos/cypermethrin at 1 000 ppm was still high even at the eighth day after its application. This was indicated by the higher rate of insect mortality than that on the cypermethrin-treated pods which, however, had the least number of feeding punctures. Similarly, the relatively lower activity of gamma-HCH and chlorpyrifos is reflected in the larger number of feeding punctures and lower percentage of insect mortality.

Lee et al. (1984) have shown that both cypermethrin and gamma-HCH remained active even after the 24th day of post-application. In this particular study, the activity of gamma-HCH was sustained for only 10 days. Differences in the experimental set up could be among the reasons attributed to this discrepancy. In the former study, insects were not introduced

Table 3. Mean mortality of *Helopeltis theobromae* at 24 h after insecticide spraying in the field

Insecticide	% a.i	Mortality (%) (mean ± S.E.)
Chlorpyrifos/cypermethrin	0.05	89.7 ± 5.56a
	0.11	91.0 ± 5.26a
	0.16	88.0 ± 5.33ab
Cypermethrin	0.20	81.0 ± 2.77ab
Chlorpyrifos	0.20	73.0 ± 4.23b
Gamma–HCH	0.20	55.36 ± 7.07c

*Means with a common letter are not significantly different at $p = 0.05$ by DMRT

regularly to the treated pods, instead observations depended mainly on the field number of nymphs on the pods around the main stem. The number which could normally be very small.

The presence of insecticidal activity on the pod surface for about 10 days after application indicates that the general spraying interval could be around 10–14 days as suggested by Smith (1979), Azhar (1984), Jamaludin and Khairuddin (1989). The actual spraying interval depends on the choice of chemical and rates used. For example in this study, the spraying interval for gamma-HCH at all the rates, cypermethrin at 500 ppm and chlopyrifos at 1 000 ppm should be less than 10 days for an effective control on newly emerged nymphs. Furthermore, the average incubation period of *H. theobromae* eggs under field conditions is 8.9 days (Jamaludin 1980). The spraying interval for chlorpyrifos/cypermethrin at concentrations between 500 ppm and 1 000 ppm could be increased to about 14 days as the mortality rate of the newly emerged nymphs will still be more than 50%. However, insecticide which provides long residual activity for use in commercial spraying programme, is suggested, especially when the follow-up interval of 10–14 days cannot be shortened (Ho et al. 1989).

Results from the field screening study showed that complete mortality of the mirids never occurred even at the higher insecticide concentrations. This could be due to the fact that complete coverage of the insecticides was rarely achieved under normal spraying practice using a mist blower. It was found in earlier studies that complete coverage was only obtained around the main stem. Coverage was relatively poor within the canopy (Jamaludin 1988).

The three rates of chlorpyrifos/ cypermethrin mixture used in field spraying were found to be equally effective and gave higher insect mortality than cypermethrin, chlorpyrifos and gamma-HCH. The relatively higher potency of this mixture indicated the presence of some synergistic effect since it was more effective than when the chemicals were applied individually. However, further studies are needed to confirm whether the chlorpyrifos/ cypermethrin mixture is truly synergistic.

Current study showed that chlorpyrifos/ cypermethrin mixture and cypermethrin could be suitable alternatives to gamma-HCH for controlling *H. theobromae* infestation. However, the chlorpyrifos/ cypermethrin mixture would be a better choice as it has greater efficacy than cypermethrin, besides being more cost effective. The cost of spraying chlorpyrifos/ cypermethrin at a rate of 0.16% a.i. was about M$27.60/ha compared with M$220.80/ha for cypermethrin at a rate of 0.2% a.i.

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