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INSECTICIDE TOXICITY TO THE ADULT STAGE OF *BACTROCERA PAPAYAE* AND *BACTROCERA CARAMBOLAE* (DIPTERA: TEPHRITIDAE)

M. Hasanuzzaman*[1] and A. B. Idris[2]

[1*]Institute of Food and Radiation Biology, Bangladesh Atomic Energy Commission, Ganakbari, Savar, GPO Box- 3787, Dhaka- 1000, Bangladesh.

[2]School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia.

ABSTRACT

Asian papaya fruit fly, *Bactrocera papayae* Drew and Hancock and carambola fruit fly, *Bactrocera carambolae* Drew and Hancock (Diptera: Tephritidae) are serious agricultural pests which attack a wide range of fruits and vegetables. The insecticide toxicity of cypermethrin and chlorantraniliprole to the adult (male and female) of these two *Bactrocera* species was observed in the laboratory reared populations. The LC_{50} (ppm) values of cypermethrin were 2.40, 2.02 and 1.48 ppm for male of *B. papayae* and 3.20, 2.58 and 2.14 ppm for male of *B. carambolae*; at 24h, 48h and 72h of post-treatment, respectively. It was found that the LC_{50} (ppm) values of cypermethrin and chlorantraniliprole for females of *B. papayae* and *B. carambolae* were slightly higher than that of males at 24h, 48h and 72h of post-treatment. Cypermethrin was more toxic than chlorantraniliprole to both species. Results showed that the LC_{50} (ppm) values for both sexes were 3-4 times higher for chlorantraniliprole than that of cypermethrin. This suggests that both *Bactrocera* species have moderately developed resistant to chlorantraniliprole as compared to cypermethrin. In conclusion, cypermethrin seems to be a better chemical to be used for control of these fruit fly species than that of chlorantraniliprole but with caution.

KEYWORDS

Toxicity, Fruit fly, Cypermethrin, Chlorantraniliprole and Tephritidae.

Author for Correspondence:

Hasanuzzaman M,

Institute of Food and Radiation Biology,

Bangladesh Atomic Energy Commission,

Ganakbari, Savar, Dhaka, Bangladesh.

Email: mhasanuzzaman72@yahoo.com

INTRODUCTON

A major category of important insect species includes those classified as agricultural pests. Some of the most devastating pests are Dipteran species in the family Tephritidae (the true fruit flies) such as the Mediterranean fruit fly (medfly, *Ceratitis capitata*) and species of the *Bactrocera*, *Rhagoletis* and *Anastrepha* genera[1]. Tephritid fruit flies are one of the most important insect pests of horticultural crops throughout the world. These are the major pests of fleshy fruits and vegetables which affect their production and represent the most economically important group of polyphagous dipterous pests[2]. Four hundred species belonging to the genus *Bactrocera* are widely distributed in tropical regions of Asia, South Pacific and Australia[3]. According to Clarke *et al.*,[4] the *Bactrocera dorsalis* complex (Diptera: Tephritidae) of tropical fruit flies contains 75 described species, largely endemic to Southeast Asia; and within the complex are a small number of polyphagous pests of international significance, including *Bactrocera dorsalis* sensu stricto, *Bactrocera papayae*, *Bactrocera carambolae*, and *Bactrocera philippinensis*. There are possibly at least a hundred *Bactrocera* species of which only approximately half have been recorded in Malaysia[5,6]. Asian papaya fruit fly, *Bactrocera papayae* Drew and Hancock and carambola fruit fly, *Bactrocera carambolae* Drew and Hancock (Diptera: Tephritidae) are most serious pests among them. These two *Bactrocera* species are belonging to the *Bactrocera dorsalis* complex and considered as sibling species. Both species are polyphagous and infest mainly carambola, *Averrhoa carambola* L.; water apple, *Eugenia* spp.; sapodilla (chiku), *Manilkara zapota* L.; guava, *Psidium guajava* L.; mango, *Mangifera indica* L.; soursop, *Annona muricata* L. In addition, *B. papayae* also infests papaya, *Carica papaya* L.; banana, *Musa* spp.; brinjal, *Solanum melongena* L. var. *esculentum*; and chili, *Capsicum annuum* L.[7]. Female flies lay their eggs in the fruits while the maggots devour the pulp. Subsequently, secondary infections with bacterial and fungal diseases are frequent and infested fruits drop down[1]. In 1987 economic losses by the fruit flies in Malaysia were estimated at 12.8 million ringgit[8].

The control of fruit flies is mainly dependent on the use of insecticides which have different methods of application such as baiting, attractant insecticides and cover sprays. The heavy infestation of fruit flies has lead to the use of cover sprays[9]. The insecticides, for example, organophosphate, carbamates and synthetic pyrethroids are being indiscriminately used by farmers as cover sprays[10-13]. Malathion, as organophosphorus insecticide, is most used insecticide in agriculture as well as for the control of fruit fly[14,15]. Its mode of action is anticholinesterase. Low toxicity of Malathion on mammalian and its low price have changed it as a good choice for control of fruit flies[16,17]. Trichlorfon is another organophosphorus insecticide. It is widely used in agriculture as a selective insecticide based on its mode of action (inhibitor of acetylcholinesterase)[18]. Current control measures against fruit flies mostly incorporate the use of insecticides as a cover spray or bait and targeting the adult flies[19]. Because female fruit flies lay eggs beneath the exocarp of the fruit and the larvae develop inside the fruit with little chance of insecticide affecting them[20].

The two insecticides, commonly used for fruit fly control, viz. cypermethrin (pyrethroid) and chlorantraniliplore (diamide/pyrazole) were used to observe mortality against the adult stage of *Bactrocera papayae* and *B. carambolae* in the laboratory reared populations.

MATERIAL AND METHODS

Laboratory Colonies of Fruit Fly

Asian papaya fruit fly, *B. papayae* and the carambola fruit fly, *B. carambolae* were collected from the Malaysian Agricultural Research and Development Institute (MARDI), Serdang. Colonies were reared in the Entomology laboratory, Universiti Kebangsaan Malaysia, Bangi. According to the procedure of Chang *et al*,[21] the rearing system was carried out in the laboratory which was maintained at 25±2ºC and 70-80% relative humidity with 12h light: 12h dark cycle. For adult diet, yeast and sugar (1:3) were provided and soaked cotton was supplied as water source. Fresh sweet gourds and star fruits were used for egg laying medium of *B. papayae* and *B. carambolae*, respectively. Larvae were grown on these media.

Bioassay Tests

The experiment was planned to determine the insecticide toxicity level (LC_{50} values) against the adult stage of *B. papayae* and *B. carambolae* in the laboratory reared population. Cypermethrin (5.5% w/w) (Hextar Cyper 5.5EC, Hextar Chemicals Sdn. Bhd. Malaysia) and chlorantraniliprole (34.9% w/w) (DuPont®Altacor 34.9 WG, Du Pont Malaysia

Sdn. Bhd.) insecticides were applied to the adult males and females of *B. papayae* and *B. carambolae* under laboratory conditions.

Toxicity experiments were conducted according to the procedure of Mosleh *et al*,[14]. A concentration of 5.5% cypermethrin is equivalent to 55,000 ppm and a 34.9% concentration of chlorantraniliprole is 349,000 ppm. The stock solution of each insecticide (100 ppm) was prepared by diluting it with distilled water. Preliminary observations were made to obtain the range of most practical concentration that yielded mortality between 5-95% in each insecticide[22]. Then six different concentrations of each insecticide were selected and prepared from the stock solution, diluted with distilled water as explained by Kok *et al,*[23], i.e., 1.25, 1.75, 2.25, 2.75, 3.25 and 3.75 ppm for cypermethrin and 7.00, 7.50, 8.00, 8.50, 9.00 and 9.50 ppm for chlorantraniliprole. In this study one litre plastic jars (diameter 12 cm, length 16 cm) were used. Pieces of cotton were immersed in the different concentrations of the tested insecticides. Then the cotton pieces were placed in small plastic cups (diameter, 6 cm) and put them into the plastic jars. For control experiment, cotton pieces soaked with distilled water were used. After that ten adult male and female of the two *Bactrocera* species (5-15 days old) were released into the jar separately for each experiment. The mouth of plastic jars was covered with a muslin cloth held in place with a rubber band for proper aeration and to prevent escape of fruit flies. Three replications were used for each concentration and three untreated replications were also set up as control. The plastic jars were examined at 24h, 48h and 72h post treatment and the dead flies were counted and recorded. The average percentage of adult mortality was calculated for each concentration as well as control.

Data for adult mortality was corrected by Abbott's formula[24] and then were subjected to probit analysis[25] and ran on the software of SPSS v.20 (SPSS Inc., Chicago, IL).

RESULTS AND DISCUSSION

In general, result showed that cypermethrin was 3-4 times more toxic than chlorantraniliprole to both species and sexes (Table No.1 and 2). The LC_{50} (ppm) values of cypermethrin for male of *B. papayae* were 2.40, 2.02 and 1.48 ppm at 24h, 48h and 72h of post-treatment, respectively, and these were not differed significantly as indicated by their overlapping of CI (95%). The same trend showed for the female except their LC_{50} values were somewhat higher than that of males and that there were no significant different among LC_{50} values of both sexes (Table No.1). The low LC_{50} values of cypermethrin on *B. papayae* indicate that this insecticide is still possible to be used for controlling *B. papayae* but with caution. *B. papayae* population was genetically homogenous (as there was no significant difference of chi-square values and lower slope values) (Table No.1), indicating resistant development could be delayed by proper use of insecticide[26].

As for the cypermentrin, the LC_{50} values of chlorantraniliprole treated on *B. papayae* was not significantly different among times (post-treatment) (Table No.1). However, the values were 4x (for males) and 3x (for females) higher for chlorantraniliprole than that of cypermethrin and that the difference was highly significant (non-overlapping 95% CI). This indicates that *B. papayae* has somewhat developed resistant to chlorantraniliprole as compared to cypermethrin, but further study need to be done to the value of resistance ratio (RR) of each insecticides to ascertain their resistant level. This was found for other insect by Sial *et al.*[27] in *Choristoneura rosaceana*. So the use of this insecticide for controlling *B. papayae* has to be careful like less frequency or change to other non-similar group of insecticides.

Table No.2 shows the LC_{50} values of cypermethrin and chlorantraniliplore on males and females of the carambola fruit fly, *B. carambolae*. In female, the LC_{50} (ppm) values of cypermethrin were 3.55, 2.89 and 2.40 ppm at 24h, 48h and 72h, respectively. The overlapping of CI (95%) indicated that the LC_{50} values were not significantly different. The male showed same tendency with the exception of their LC_{50} values which were slightly lower than that of female. Thus there were no significant different among the LC_{50} values of cypermethrin in the males and females of *B. carambolae*. As for *B. papayae*, the low LC_{50} values of cypermethrin on *B.*

carambolae suggest that this insecticide can be used for the management of the carambola fruit fly but needs special care. It was also found that there was no significant difference of chi-square values and slop values (Table No.2). So it can be assumed that *B. carambolae* population was genetically homogenous. The appropriate use of cypermethrin can delay the rersistant development to the insecticide.

The LC_{50} (ppm) values of chlorantraniliprole were also not significantly different at various observation times in *B. carambolae* (Table No.2). The range of LC_{50} (ppm) values of chlorantraniliprole were 7.30-8.23 ppm for male and 7.87-8.73 ppm for female, which were higher that that of cypermethrin (2.14-3.20 ppm for male and 2.40-3.55 ppm for female). So it was observed that the difference was highly significant based on non-overlapping CI (95%). This result suggests that *B. carambolae* has also developed resistant to chlorantraniliprole as compared to cypermethrin.

Table No.1: Comparative toxicity of insecticides against adult males and females of *Bactrocera papaya*

Insecticides	Observation (hrs)	Male				Female			
		LC_{50} (ppm)	CI (95%)	Slope ± SE	χ^2	LC_{50} (ppm)	CI (95%)	Slope ± SE	χ^2
Cypermethrin	24	2.40	2.71-5.34	2.30±0.27	0.04*	2.76	2.39-5.05	1.94±0.29	0.09*
	48	2.02	2.76-5.36	2.62±0.26	0.07*	2.28	2.01-4.50	1.93±0.26	0.02*
	72	1.48	1.93-4.49	2.55±0.24	0.07*	1.95	2.51-5.07	2.50±0.25	0.05*
Chlorantraniliprole	24	8.52	6.05-14.81	2.36±0.05	0.42*	9.02	6.56-15.78	2.42±0.17	0.11*
	48	8.13	9.49-18.72	3.29±0.15	1.22*	8.52	5.23-13.85	2.16±0.02	0.11*
	72	7.86	8.97-18.20	3.27±0.14	0.42*	8.04	5.25-13.83	2.26±0.06	0.02*

d.f. = 4 (for each observation); *non-significant; LC_{50} = Lethal concentration; CI = Confidence interval

Table No.2: Comparative toxicity of insecticides against adult males and females of *Bactrocera carambolae*

Insecticides	Observation (hrs)	Male				Female			
		LC_{50} (ppm)	CI (95%)	Slope ± SE	χ^2	LC_{50} (ppm)	CI (95%)	Slope ± SE	χ^2
Cypermethrin	24	3.20	1.77-4.42	1.46±0.29	0.09*	3.55	1.86-4.53	1.36±0.29	0.08*
	48	2.58	1.52-3.97	1.51±0.26	0.16*	2.89	2.19-4.80	1.73±0.28	0.48*
	72	2.14	1.63-4.05	1.76±0.25	0.03*	2.40	2.49-5.09	2.16±0.27	1.67*
Chlorantraniliprole	24	8.23	9.05-18.18	3.17±0.13	0.07*	8.73	8.68-18.09	2.98±0.21	0.05*
	48	7.95	9.78-19.07	3.45±0.16	0.09*	8.32	6.97-15.79	2.63±0.06	0.11*
	72	7.30	7.71-17.36	3.20±0.23	0.22*	7.87	7.20-16.07	2.81±0.06	0.07*

d.f. = 4 (for each observation); *non-significant; LC_{50} = Lethal concentration; CI = Confidence interval

CONCLUSION

The LC_{50} (ppm) values of cypermethrin were lower than chlorantraniliprole insecticide in both *Bactrocera* species, irrespective of sexes (Table No.1 and 2). Cypermethrin can be more useful for the control of these two *Bactrocera* species, *Bactrocera papayae* and *B. carambolae*, compare to chlorantraniliplore insecticide. As there is an affinity to grow resistance to the extensively used insecticides, the application of cypermethrin needs more attention, i.e., it should be used in less frequency or alter to other non-similar group of insecticides.

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CONFLICT OF INTEREST

There is no conflict of interest.

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