EFFECTS OF DECAMETHRIN AND PERMETHRIN ON THE BIOLOGY OF TWO COCCINELLID PREDATORS OF BLACK BEAN APHIDS

Erlinda A. Vasquez, Emiliana N. Bernardo
and Lorenza B. de Pedro

Science Research Specialist, and former Director, Philippine Root Crop Research and Training Center, Baybay, Leyte, Philippines; and Instructor, Department of Plant Protection, Visayas State College of Agriculture, Baybay, Leyte, Philippines.

Portion of M.S. thesis conducted by the senior author at ViSCA.

Funded by the Philippine Developmental Scholarship Program.

ABSTRACT

The two species of coccinellid predators (*Chilomenes sexmaculata* Fabr. and *Coleophora inaequalis* Fabr.) treated with decamethrin and permethrin showed slightly longer total developmental period, higher mortality rate and lower fecundity rate than the untreated ones, particularly *C. inaequalis.* No significant differences were found in percent egg hatchability and adult longevity. These results were observed only in the first generation where individuals were in direct contact with the insecticides but not in the second and succeeding generations.

Data generally suggest that decamethrin is relatively safe to the two species of predators and that decamethrin-coccinellid combination could be recommended for black bean aphid control.

Ann. Trop. Res. 9:212-223

KEY WORDS: Decamethrin. Permethrin. Coccinellid predators. Biology. Black bean aphids.

INTRODUCTION

Several studies on the effects of insecticides on the natural enemies of insect pests have been conducted over the years. Natural enemy mortality is often associated with intensive pesticide application,

resulting in renewed pest outbreaks. Disruptive effects of insecticides create an imbalance between the population of pests and their natural enemies (Ripper, 1956).

Insecticides usually have direct lethal effects on predators and adult parasites. Newsom (1974) stressed that insecticides may affect predators more adversely than the pests because the former is exposed to the toxic materials as well as to the additional hazards of an insecticide-induced shortage of prey. They could also affect the natural enemies indirectly by eliminating the prey as source of food or by affecting the prey as source of secondary poisoning (Croft and Brown, 1975).

Techniques for laboratory evaluation of insecticidal effects on predators had been worked out. Standard laboratory ball jar tests using a wide range of insecticides showed that organo-phosphorus insecticides (e.g. parathion, malathion, chlorthion and diazinon) are more toxic to the convergent lady beetle, *Hippodamia convergence* Guerin and the spotted lady beetle, *Coleomegilla maculata* Deg. than the chlorinated hydrocarbons (DDT, ethyl DDD, campechlor, heptachlor, toxaphene, endrin and dieldrin) (Spiller, 1961).

Schour and Crowder (1980) reported that third instar larvae of the common green lace wing (*Chrysopha carnea* Stephens) can tolerate a wide dosage range of pyrethroid insecticides: fenvalerate, permethrin, and cis- and trans-permethrin. When treated topically with 250 μg of the insecticides, all larvae exhibited marked tolerance to all pyrethroids over a 72-hour period. Survival of larvae, adult emergence, and fecundity were affected by permethrin but not by fenvalerate at 100 μg/g level through one generation (larva to larva).

The effect of sublethal doses of insecticides (either at a level which causes no mortality on the population or at a toxic level which leaves some survivors) on arthropod pests has been thoroughly reviewed by Moriarty (1969). However, similar data on the predators and parasites of insect pests are limited. Hence, this study was conducted to determine the effects of two pyrethroids, decamethrin and permethrin, on the biology of the coccinellid predators, *Chilomenes sexmaculata* Fabr. and *Coleophora inaequalis* Fabr., and of the black bean aphid (*Aphis craccivora*).

MATERIALS AND METHODS

Solutions of decamethrin and permethrin causing 90, 70, 50 and 20 percent mortality on black bean aphid after 24 hours exposure were prepared. The corresponding concentrations were 3.00415^{-3} 2.13750^{-4}, 3.42700^{-5} and 1.82000^{-6} mg a.i./mL for decamethrin; and 9.65272^{-3}, 9.80350^{-4}, 2.01110^{-4} and 1.58300^{-5} mg a.i./mL for permethrin. Each of the above concentrations was sprayed separately on aphid infested bean plants. Water was used as control.

Live aphids were brushed off separately from each treatment after 24-48 hours of pesticide application and were offered as feed to newly emerged larvae of the two species of coccinellid predators, *C. sexmaculata* and *C. inaequalis*.

The larvae were kept individually in 10 mL glass vials placed in a plastic tray. One hundred individual cultures of each species (divided into 4 replications of 25 cultures each) were subjected to each treatment. The treatments were arranged using the completely randomized design (CRD).

Survivor larvae were fed continuously with treated aphids until the pre-pupal stage. Newly emerged male and female adults were paired, placed in rearing jars, given untreated aphids attached to a leaf or pod, and were allowed to mate and oviposit on plant parts. Eggs laid were incubated at room temperature. Adults were continuously fed with untreated aphids until death. At least 400 eggs from each treatment were incubated and percent hatchability was determined.

One hundred of the resultant larvae were again reared individually using the same method but fed with untreated aphids. This was done to determine whether the effect of insecticide on the first generation was carried over to the second generation.

Developmental period, mortality, fecundity, egg hatchability and adult longevity of the two generations were used as parameters to evaluate the effects of insecticidal treatments on the biology of the predators.

The data were statistically analyzed and treatment means were compared using the Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Effects of Decamethrin and Permethrin on the Biology of C. sexmaculata and C. inaequalis

Total Developmental Period

The effects of decamethrin and permethrin on the average developmental periods of the different stages of *C. sexmaculata* and *C. inaequalis* reared for two generations are shown in Table 1.

Although statistical differences were observed in the length of larval and pupal periods, differences in the total developmental period were considered more important. This parameter indicates the number of generations that can be completed within a given time to estimate the rate of population build-up.

The adverse effect of decamethrin was manifested only on individuals which were in direct contact with the insecticide but not on the succeeding generation. Decamethrin lengthened the total developmental period of the two predators during the first generation by about one day but shortened the same parameter during the second generation by about half day. Unlike decamethrin, permethrin showed no definite trend. A statistically longer developmental period of *C. sexmaculata* in

Table 1. Effect of decamethrin and permethrin at different lethal concentrations on developmental periods (days) of *Chilomenes sexmaculata* and *Coleophora inaequalis* for two generations.[1]

Insecticide/ Predator Species/ Lethal Concentration[2]	Incubation Period		Total Larval Period		Pupal Period		Total Developmental Period	
	First Generation	Second Generation	First Generation	Second Generation	First Generation	Second Generation	First Generation	Second Generation
Decamethrin								
C. sexmaculata								
LC_{90}	3.00	2.13	6.75a	6.56ab	2.87b	2.90a	12.62b	11.59b
LC_{70}	3.00	2.10	6.98a	6.27b	3.21a	2.87a	13.19a	11.24c
LC_{50}	3.00	2.19	5.67b	6.27b	2.98a	2.52b	11.65c	10.98c
LC_{20}	3.00	2.13	6.83a	6.73a	2.74b	2.84a	12.57b	11.70ab
Control	3.00	2.18	5.80b	6.77a	2.76b	3.01a	11.56c	11.96a
C. inaequalis								
LC_{90}	3.00	2.27b	8.31a	7.68ab	3.30b	3.13	14.61a	13.08b
LC_{70}	3.00	2.25b	7.65cd	7.52bc	3.55a	3.15	14.20bc	12.92b
LC_{50}	3.00	2.33b	7.88bc	7.52bc	3.39ab	3.19	14.27b	13.04b
LC_{20}	3.00	2.60a	7.52d	7.12c	3.37b	3.24	13.89d	12.96b
Control	3.00	2.49a	7.97b	7.98a	3.01c	3.12	13.98cd	13.59a

Table 1. Continued....

Insecticide/ Predator Species/ Lethal Concentration[2]	Incubation Period		Total Larval Period		Pupal Period		Total Developmental Period	
	First Generation	Second Generation	First Generation	Second Generation	First Generation	Second Generation	First Generation	Second Generation
Permethrin								
C. sexmaculata								
LC_{90}	3.00	2.83a	6.84	6.63b	2.98	2.76c	12.82	12.22ab
LC_{70}	3.00	2.20b	6.66	6.85b	3.10	3.04ab	12.76	12.09bc
LC_{50}	3.00	2.05c	6.68	7.12a	3.00	2.89bc	12.68	12.06bc
LC_{20}	3.00	2.25b	6.49	7.28a	3.08	2.93bc	12.57	12.46a
Control	3.00	2.09c	6.83	6.72b	2.95	3.07a	12.78	11.88c
C. inaequalis								
LC_{90}	3.00	2.74a	7.31a	7.47	3.19	3.13	13.50a	13.34
LC_{70}	3.00	2.64b	6.89b	7.44	3.10	3.03	12.99b	13.11
LC_{50}	3.00	2.69ab	7.19ab	7.25	3.08	3.12	13.27ab	13.06
LC_{20}	3.00	2.61b	7.34a	7.32	3.27	3.20	13.61a	13.13
Control	3.00	2.68ab	7.04ab	7.19	3.20	3.22	13.24ab	13.09

[1] In a column, treatment means followed by the same letter and those without postscripts are not significantly different from each other at 5% level, DMRT.

[2] Lethal concentrations to which survivor black bean aphids given to predaceous larvae as feed were exposed earlier.

permethrin which was not observed during the first generation, was evident during the second generation. However, this phenomenon could not be explained since no further study on the insecticidal effect on the predator was made. *C. inaequalis*, on the other hand, showed slightly longer developmental period during the first generation only.

Mortality

Table 2 presents the percent mortality of immatures (larvae and

Table 2. Effect of decamethrin and permethrin at different lethal concentrations on mortality of *Chilomenes sexmaculata* and *Coleophora inaequalis* immatures (larvae and pupae) for two generations.[1]

Insecticide/ Lethal Concentration[2]	Average Total Percentage Mortality			
	C. sexmaculata		*C. inaequalis*	
	First Generation	Second Generation	First Generation	Second Generation
Decamethrin				
LC_{90}	51a	20	48a	21
LC_{70}	41a	17	38abc	20
LC_{50}	51a	27	32bc	17
LC_{20}	41a	28	33bc	14
Control	26b	23	23c	20
Permethrin				
LC_{90}	46a	18	41a	18
LC_{70}	42a	22	34a	18
LC_{50}	26b	20	23b	17
LC_{20}	27b	23	23b	16
Control	25b	17	20b	18

[1] In a column, treatment means followed by the same letter and those without postscripts are not significantly different from each other at 5% level, DMRT.

[2] Lethal concentrations to which survivor black bean aphids given to predaceous larvae as feed were exposed earlier.

pupae) of the two predators as affected by decamethrin and permethrin. The effects of both insecticides on the predators were apparent during the first generation only which suggest the absence of carry over effect of the insecticides.

The higher death rate of the untreated control insects during the first generation could be attributed to poor handling technique. However, this shortcoming was slightly checked during the second generation. Moreover, higher percent mortality might also be due to the delicate response of the first instar larvae to handling as compared to the later instars. A decrease in mortality rate was observed as the insect matured.

Fecundity

The average fecundities of adult *C. sexmaculata* and *C. inaequalis* females are shown in Table 3. The data revealed that the egg-laying capacity of *C. sexmaculata* was not affected by the two insecticides used. However, both insecticides irrespective of their lethal concentration statistically decreased the total number of eggs laid by *C. inaequalis* females in the first generation, although the same response was not carried over in the second. Moreover, these insecticides did not alter the preoviposition and oviposition behavior of the two beetle species. Egg laying started a few days after mating and occurred any time of the day.

Egg Hatchability

High percent egg hatchability in both species was still obtained even when the test individuals were exposed to high concentrations of insecticides. No significant differences were also noted between the two generations (Table 4).

Longevity

For two successive generations, the longevity of the adult coccinellid predators was not significantly affected by the application of decamethrin and permethrin (Table 5). Shorter life span noted on *C. inaequalis* than on *C. sexmaculata* was due to the inherent characteristic of the species and not to insecticide toxicity.

Implications of the Observed Effects of the Two Insecticides on the Biology of the Predators

As mentioned earlier, the adverse effects of decamethrin and permethrin on the average total developmental period and percent mortality of both species, and on fecundity of *C. inaequalis* were evident only during the first generation and at concentrations which caused more than 50% aphid mortality. Considering the overall effects of decamethrin and permethrin on the biology of the coccinellid predators, *C. sexmaculata* and *C. inaequalis*, the LC_{50} of these insecticides can be recommended for aphid control especially if the

Table 3. Effect of decamethrin and permethrin at different lethal concentrations on fecundity of *Chilomenes sexmaculata* and *Coleophora inaequalis* female adults for two generations.[1]

Insecticide/ Lethal Concentration[2]	Average Total Number of Eggs Laid/Female			
	C. sexmaculata		*C. inaequalis*	
	First Generation	Second Generation	First Generation	Second Generation
Decamethrin				
LC_{90}	572.50	703.85	537.86b	565.75
LC_{70}	549.05	619.30	541.50b	574.80
LC_{50}	501.88	717.28	513.65b	583.55
LC_{20}	588.40	689.85	509.90b	581.75
Control	618.85	722.75	602.50a	615.85
Permethrin				
LC_{90}	687.00	696.10	532.20b	586.35
LC_{70}	730.60	687.40	591.20ab	575.70
LC_{50}	740.05	705.90	557.85b	610.75
LC_{20}	662.55	714.30	555.95b	575.25
Control	722.95	677.55	637.40a	598.90

[1] In a column, treatment means followed by the same letter and those without postscripts are not significantly different from each other at 5% level, DMRT.

[2] Lethal concentrations to which survivor black bean aphids given to predaceous larvae as feed were exposed earlier.

density of predators present can reduce the number of the remaining aphid population.

In cases of severe aphid infestation and scarcity of predators, the above recommendation may not be effective for aphid control and application of LC_{90} would seem more practical. Under field conditions where mixed developmental

Table 4. Effect of decamethrin and permethrin at different lethal concentrations on egg hatchability of *Chilomenes sexmaculata* and *Coleophora inaequalis* for two generations.

Insecticide/ Lethal Concentration[1]	Average Percent Hatchability			
	C. sexmaculata		*C. inaequalis*	
	First Generation	Second Generation	First Generation	Second Generation
Decamethrin				
LC_{90}	84.32	89.88	89.80	93.65
LC_{70}	83.00	87.22	90.18	93.15
LC_{50}	84.52	87.12	89.62	95.33
LC_{20}	82.62	87.48	89.00	92.55
Control	86.90	88.10	92.88	94.10
Permethrin				
LC_{90}	92.00	87.48	92.15	93.20
LC_{70}	90.18	89.90	91.48	93.20
LC_{50}	86.42	90.45	92.52	93.62
LC_{20}	87.42	86.60	91.98	91.45
Control	91.50	90.15	94.88	93.80

[1]Lethal concentrations to which survivor black bean aphids given to predaceous larvae as feed were exposed earlier.

stages of the predators are found, the adverse effects of LC_{90} on mortality of predators is expected to be greater on earlier instars only, and slight on other stages.

Negligible lengthening of the developmental period and slight decrease in fecundity as affected by the two insecticides were observed in the first generation of *C. inaequalis*. Due to this, it can be speculated that decamethrin and permethrin would not adversely affect the population build-up of the predators during the second and succeeding generations.

Table 5. Effect of decamethrin and permethrin at different lethal concentrations on longevity of *Chilomenes sexmaculata* and *Coleophora inaequalis* adults for two generations.

Insecticide/ Lethal Concentration [1]	Average Longevity (days)			
	C. sexmaculata		*C. inaequalis*	
	First Generation	Second Generation	First Generation	Second Generation
Decamethrin				
LC_{90}	30.47	35.24	28.96	31.34
LC_{70}	32.74	33.60	30.15	32.16
LC_{50}	33.08	31.22	29.41	27.43
LC_{20}	33.35	36.84	23.12	28.72
Control	34.74	37.01	31.29	30.65
Permethrin				
LC_{90}	33.04	33.17	27.41	29.28
LC_{70}	34.99	33.94	29.05	30.16
LC_{50}	36.92	33.13	30.20	30.08
LC_{20}	38.09	32.81	31.68	30.88
Control	36.44	33.06	30.56	31.70

[1] Lethal concentrations to which survivor black bean aphids given to predaceous larvae as feed were exposed earlier.

There is no apparent need to modify the current recommended dosages of both insecticides even if the aphid population is high since the said rates are expected to cause 95-96% mortality of the aphids (Table 6). In addition, these insecticides especially decamethrin are still relatively safe to the predators. Hence, the remaining aphid population that may resurge later could be checked by the unaffected predators.

Table 6. Projected effects of the different lethal concentrations including manufacturer's recommended rate (RR) of decamethrin and permethrin for black bean aphids on mortality of the two coccinellid predators.

Insecticide/ Lethal Concentration	Percent Mortality after 24 Hours Exposure			
	C. sexmaculata		*C. inaequalis*	
	Larvae[1]	Adults	Larvae[1]	Adults
Decamethrin				
LC_{20}	2	0	1	0
LC_{50}	7	3	4	2
LC_{70}	14	9	9	6
LC_{90}	29	24	19	12
RR^{2}	41	40	30	31
Permethrin				
LC_{20}	0	4	2	0
LC_{50}	3	22	12	5
LC_{70}	10	30	28	16
LC_{90}	32	56	60	50
RR^{3}	50	69	71	70

[1] Third instar larvae

[2] Recommended rate of the pesticide which is expected to effect 96% aphid mortality.

[3] Recommended rate of the pesticide which is expected to effect 95% aphid mortality.

Results further show that decamethrin is safer to use than permethrin when predators are present. The recommended rate for decamethrin can cause less than 50% mortality of the two predaceous species while permethrin caused 50-71% mortality (Table 6).

Based on the above results, repetitive application of pyrethroids for effective aphid control may no longer be necessary with pyrethroid-coccinellid combination. This integrated control can also lessen the chances of developing pyrethroid-resistant aphid biotypes which may result from continuous insecticide application. Thus, pyrethroid-coccinellid combination can be an economical, effective and a safe control method against the black bean aphid.

LITERATURE CITED

CROFT, B.A. and BROWN, A.W.A. 1975. Responses of arthropod natural enemies to insecticides. Annu. Rev. Entomol. 20:285-355.

MORIARTY, F. 1969. The sublethal effects of synthetic insecticides on insects. Biol. Rev. 44:321-357.

NEWSOM, L.D. 1974. Predator-insecticide relationships. Entomophaga. Mem. H.S. 7:13-23.

RIPPER, W.E. 1956. Effects of pesticides on balance of arthropod population. Annu. Rev. Entomol. 1:403-438.

SCHOUR, M.H. and CROWDER, L.A. 1980. Effects of pyrethroids on the common green lacewing. J. Econ. Entomol. 73:306-309.

SPILLER, D. 1961. A digest of available information on the insecticide malathion. Adv. Pest Control Res. pp. 249-336.