Effect of Insecticides on Development and Adult Survival of *Trichogramma chilonis* (Trichogrammatidae: Hymenoptera)

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Abstract— *The effect of insecticides on development and adult survival of Trichogramma chilonis was investigated under laboratory condition. Insecticides tested were endosulfan, coragen, monocrotophos and deltamethrin+triazophos on following concentration i.e. 0.009%, 0.010%, 0.020%, 0.022% and 0.024%. Treating eggs with all the concentration of chemical insecticides caused death of the emerged adults within few hours post emergence when the treatment was carried out 4 days post parasitism or one day before adult emergence. The number of host eggs turned to black (the parasitoid larvae developed to pupae) varied according to timing of treatment. Adult emergence rate varied according to the used insecticide, the parasitoid stage and the generation. All the concentration of insecticides, with the exception of endosulfan and some cases coragen, adversely affected T. chilonis emergence from Corcyra cephalonica host eggs when exposed at 1st, 2nd, 3rd, 5th and 6th day of developmental stages (larval and pupal) of T. chilonis. Regardless of the developmental stage treated, none of the insecticides tested had a significant effect on the emergence and survival of T. chilonis male and a female significantly varied among insecticide treatments, and were significantly affected by the developmental stage of parasitoid when treated. Based on toxicity, deltamethrin+triazophos was the most toxic followed by monocrotophos, which was comparatively less toxic compounds to adult male and female T. chilonis. No parasitoids emerged from parasitized eggs treated with deltamethrin+triazophos in second generation.*

Keywords— Insecticides, Effect, Development, Survival, Trichogramma.

I. INTRODUCTION

Recently, integrated pest management strategy has recommended, minimizing the use of chemical pesticides. It is very important to study the side effect of insecticides on the natural enemies to exclude the ones that have detrimental effect on such natural enemies. *Trichogramma* spp. has been extensively used as biological control agent. During the past two decades, *Trichogramma* spp. wasps have been evaluated as biological control agents for pest suppression in different crops.

Numerous laboratory and field studies have shown that *Trichogramma* spp. wasps are highly susceptible to most broad-spectrum insecticides (Bull and Coleman 1985). Consequently, use of insecticides and *Trichogramma* spp. has historically been considered incompatible. In an attempt to combat insecticide resistance, conserve arthropod natural enemies, and reduce health risks, several new insecticides (e.g., tebufenozide, methoxyfenozide, spinosad) have been developed and tested against *T. exiguum* (Duttle *et al*. 1997, Harrison *et al*. 1997). Studies were conducted to assess the effects of selected insecticides on *T. chilonis* preimaginal development in Biocontrol laboratory S.V.P. Uni. of Agric. & Tech., Meerut,

II. MATERIALS AND METHODS

Fresh *Corcyra cephalonica* eggs (less than 24 h. old) were glued onto Trichocards, each contained nearly 300 eggs. These cards were placed in glass tubes. Newly emerged *T. chilonis* adults were transferred to the glass tubes containing *Corcyra* egg-cards and kept for 24 hrs. The exposed eggs were divided into five groups; the 1st group was treated with the tested insecticides 1st day after parasitism, 2nd group was treated 48 h after parasitism, 3rd group was treated 3rd day after parasitism, 4th group

was treated 5th days after parasitism, while 5th group was treated 6 days after parasitism (one day before adult emergence), while the 6th group was treated with water after parasitism to serve as a control**.**

The insecticides treated eggs were dried on paper-sheets for 15 minutes. All the five groups of insecticides treated eggs of *T. chilonis* were kept in glass tubes and checked daily for emergence of the adult parasitoids. Droplets of honey were scattered on the inner surface of the tube's walls as food for the adult parasitoid.

$$Percent\ of\ emergence = \frac{No.\ of\ wasp\ emerged}{Total\ No.\ of\ eggs\ in\ one\ cm2} \times\ 100 \quad (1)$$

Observations were made on the percent parasitization the fresh eggs were provided to these parasitoid @ 6:1 ratio and the number of parasitized eggs were recorded after 24, 48 and 72 hours. The percent parasitization was worked out by the following formula

$$Parasitization\ percent\ = \frac{No.\ of\ parasitized\ eggs}{Total\ No.\ of\ Corcyra\ eggs} \times\ 100 \quad (2)$$

Observations were made on the mortality was parasitoid wasp at Ist, 2nd, 3rd, 5th and 6th day after application of different concentration of insecticides. The percent mortality was worked out by the following formula

$$Mortality\ Percent\ = \frac{Total\ No.\ of\ adults\ dead}{Total\ No.\ of\ wasps} \times\ 100 \quad (3)$$

2.1 Biological aspects of the emerged parasitoids:

The following biological aspects were studied for the parasitoids emerged from treated parasitized eggs: average number of black eggs (containing parasitoids' pupae), emergence rate, longevity of adults, and female percentage. Each group was tested for the ability of emerged females to parasitize new untreated host eggs, (second generation (2nd G), and the previous biological aspects were determined for the second generation (if any).

2.2 Statistical analysis:

The experiment was conducted in a completely randomized design with six treatments five insecticides and a control (3 replicates for each treatment and 100 eggs for each replicate). Statistical analysis was achieved using the SPSS Software.

III. RESULTS AND DISCUSSION

3.1 Endosulfan 35% EC:

Different concentration i.e. 0.009, 0.010, 0.020, 0.022 and 0.024% of endosulfan was found to have considerable detrimental effect on the development of parasitoid inside the treated host eggs. The recorded values for the number of black eggs were (75.67, 78.33, 71.33, 75.0 and 74.33 for the first generation and 45.67, 38.33, 33.0, 32.33 and 29.67 for 2nd generation, compared to 76.33 for the control) at 1 day after parasitization for the eggs treated at 1, 2, 3, 5 and 6 days post parasitization, respectively. The respective values of the emergence rate for second generation decreased compared to 1st generation and the control, the recorded values were 58, 59.33, 60.0%, 61.0 and 62.67% on 1, 2, 3, 5 and 6 days post parasitization at 0.009% concentration compared to 75.33, 79.0, 77.33 and 78.67% for the control. As for comparing different concentration of insecticides with each other there were non-significant differences for the numbers of black eggs but significant differences between each other for emergence rates in first generation but in 2nd generation it was different (Table 1).

3.2 Monocrotophos 36 SL:

The number of black eggs of *T. chilonis* was slightly affected, but the emergence rate highly decreased compared to control. The recorded values on the emergence (31% and 23%) rate were for those treated one and two days post parasitism, while the emergence was recorded for those treated 3 and 5 days post parasitism compared to (78-85%) for the control. As for the second generation, the emergence rates were 39% and 40% when the treatment was one and two days post parasitism. It was noticed that in all the concentrations after 5th and 6th days of parasitization, number of adult emergence were maximum. As for the second generation, the emergence rates were only 30% and 31% when treatment was one and two days post parasitism at 0.009%, while at 0.024% conc. there was only 16-18% emergence recorded at 1st and 2nd day of parasitism (Table: 1). As for comparing different concentration of insecticides with each other there were non-significant differences for the numbers of black eggs but significant differences between each other for emergence rates in first generation, while in 2nd generation it was different (Table 1). At 1st, 2nd and 3rd day after parasitization of eggs there was found maximum deformities in second generation adults of *T. chilonis*, while at 5th and 6th day parasitized eggs had least. The maximum mortalities and deformities of adults were found highly concentrated doses of insecticides compared to the low concentrated.

TABLE: 1 (a)

NUMBER OF BLACK EGGS AND EMERGENCE RATE OF THE EGG PARASITOID *T. CHILONIS* TREATED WITH INSECTICIDES

Insecticides and Conc. (%)	Time of treatments after parasitism (days)											
	1st				2nd				3rd			
	No of black eggs		% Emergence		No of black eggs		% Emergence		No of black eggs		% Emergence	
	I st G	2nd G	I st G	2nd G	I st G	2nd G	I st G	2nd G	I st G	2nd G	I st G	2nd G
Endosulfan 35%EC												
0.009	75.67	45.67	58.00	33.33	70.00	50.33	59.33	36.00	69.67	51.33	60.00	39.67
0.010	78.33	38.33	51.33	31.00	69.33	44.33	56.00	33.33	72.67	47.67	52.33	37.00
0.020	71.33	33.00	45.33	29.33	80.67	37.67	47.33	30.33	83.00	43.00	47.33	33.33
0.022	75.00	32.33	38.67	25.00	68.67	34.00	40.33	27.33	80.67	36.33	41.00	32.00
0.024	74.33	29.67	32.67	19.33	71.67	30.00	35.67	21.33	72.00	32.67	37.00	27.33
Monocrotophos 36%SL												
0.009	79.33	38.67	49.67	30.00	74.33	39.67	50.00	31.67	79.33	44.00	52.00	39.33
0.010	69.67	36.67	46.67	25.00	69.67	37.33	48.33	29.00	75.00	39.33	48.33	36.00
0.020	72.67	34.33	40.67	19.00	71.00	34.00	42.33	24.33	82.33	36.67	42.33	33.00
0.022	73.33	29.67	33.33	18.33	76.33	30.33	40.00	20.00	77.00	39.00	40.00	29.67
0.024	73.33	27.33	26.33	16.67	76.33	28.67	33.67	18.00	72.00	29.33	33.67	26.67
Coragen												
0.009	80.33	39.00	52.33	33.00	77.33	40.00	58.00	31.00	78.67	52.33	55.67	41.00
0.010	72.67	35.33	47.33	31.00	75.33	37.00	53.00	32.33	78.33	48.33	52.67	34.33
0.020	81.00	33.33	40.67	26.00	76.00	32.33	46.00	31.00	75.33	41.00	46.33	31.33
0.022	71.67	31.33	36.33	18.67	74.67	30.33	39.33	28.33	74.00	35.33	39.67	27.67
0.024	77.00	27.00	33.33	18.00	80.67	24.33	33.33	25.00	73.67	30.33	33.67	23.33
Deltamethrin 1%+ Triazophos 35%EC												
0.009	70.00	0.00	4.00	0.00	76.67	0.00	2.00	0.00	73.33	0.00	2.00	0.00
0.010	74.67	0.00	1.00	0.00	76.00	0.00	0.67	0.00	75.67	0.00	1.00	0.00
0.020	73.67	0.00	0.00	0.00	76.00	0.00	0.00	0.00	66.67	0.00	0.00	0.00
0.022	70.00	0.00	0.00	0.00	78.67	0.00	0.00	0.00	71.00	0.00	0.00	0.00
0.024	68.00	0.00	0.00	0.00	72.67	0.00	0.00	0.00	74.67	0.00	0.00	0.00
Control												
Water spray	76.33	**76.33**	**77.67**	**73.33**	**73.33**	**74.67**	**75.33**	**75.67**	**73.33**	**75.33**	**79.00**	**77.33**
CD 5% SE (m)												

**** Mean of three replications***

TABLE: 1 (b)

NUMBER OF BLACK EGGS AND EMERGENCE RATE OF THE EGG PARASITOID *T.CHILONIS* TREATED WITH INSECTICIDES

Insecticides and Conc. (%)	Time of treatments after parasitism (hours)							
	5th				6th			
	No of black eggs		% Emergence		No of black eggs		% Emergence	
	Ist G	2nd G	Ist G	2nd G	Ist G	2nd G	Ist G	2nd G
Endosulfan 35%EC								
0.009	69.67	53.67	61.00	44.33	71.00	56.67	62.67	45.33
0.010	72.00	46.00	52.33	40.33	80.33	55.33	54.33	41.33
0.020	75.67	44.67	47.33	35.33	75.67	47.67	51.33	37.00
0.022	75.00	37.00	45.00	32.33	81.00	40.00	48.00	33.00
0.024	71.00	32.00	38.67	29.00	67.67	34.33	41.67	31.00
Monocrotophos 36%SL								
0.009	82.33	47.67	54.33	39.67	70.33	51.33	55.33	42.67
0.010	66.67	45.33	49.33	36.67	76.33	48.33	51.67	40.33
0.020	77.00	40.00	46.00	33.67	66.33	42.33	47.67	36.00
0.022	74.67	35.67	43.00	30.33	75.00	38.67	44.67	30.67
0.024	79.33	29.67	38.67	26.33	75.00	30.67	39.00	26.67
Coragen								
0.009	69.33	53.00	58.00	39.67	78.33	55.67	59.00	39.33
0.010	80.67	46.00	54.00	36.00	80.00	51.33	54.67	35.33
0.020	68.67	40.67	47.67	32.00	76.67	44.33	49.00	29.33
0.022	75.33	36.00	41.00	29.33	69.67	39.33	42.00	27.00
0.024	75.00	33.00	34.33	24.00	69.67	34.67	35.00	25.67
Deltamethrin 1%+ Triazophos 35%EC								
0.009	82.33	0.00	2.00	0.00	78.00	0.00	2.00	0.00
0.010	77.00	0.00	0.67	0.00	76.00	0.00	1.00	0.00
0.020	69.33	0.00	0.00	0.00	68.33	0.00	0.00	0.00
0.022	71.00	0.00	0.00	0.00	75.67	0.00	0.00	0.00
0.024	72.67	0.00	0.00	0.00	75.33	0.00	0.00	0.00
Control								
Water spray	**70.00**	**70.00**	**77.33**	**72.33**	**74.67**	**67.00**	**78.67**	**76.00**
CD 5% SE (m)								

**** Mean of three replications***

TABLE (2)

LONGEVITY (H) OF MALE AND FEMALE OF THE EGG PARASITOID *TRICHOGRAMMA CHILONIS* TREATED WITH FIVE INSECTICIDES. (n =20)

Insecticides and Conc. (%)	Time of treatments after parasitism (day)																			
	1st				2nd				3rd				5th				6th			
	Ist G		2nd G		Ist G		2nd G		Ist G		2nd G		Ist G		2nd G		Ist G		2nd G	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Endosulfan 35%EC																				
0.009	5	7	3	5	5	7	3	5	5	7	3	5	5	7	3	5	5	7	3	5
0.010	5	7	3	4	5	7	3	4	5	7	3	4	5	7	3	4	5	7	3	4
0.020	4	6	3	4	5	7	3	4	4	7	3	4	5	7	3	4	5	7	3	4
0.022	4	6	3	4	4	6	3	4	4	6	3	4	4	6	3	4	4	6	3	4
0.024	3	5	3	4	4	6	3	4	3	5	3	4	4	6	3	4	4	6	3	4
Monocrotophos 36%SL																				
0.009	4	6	4	5	4	6	4	5	4	6	4	5	5	7	4	5	5	7	3	5
0.010	4	5	3	5	4	6	3	5	4	6	3	5	4	6	3	5	4	7	3	4
0.020	3	5	3	5	4	5	3	5	4	6	3	5	4	6	3	5	4	6	3	4
0.022	3	5	4	5	3	5	4	5	3	5	3	4	4	5	3	4	3	5	3	4
0.024	-	-	-	-	3	5	-	-	3	5	-	-	3	5	-	-	3	5	-	-
Coragen																				
0.009	5	7	4	6	5	7	4	6	4	7	4	6	4	7	4	6	5	7	4	6
0.010	5	7	3	5	4	7	3	5	4	7	3	5	4	7	3	5	5	7	3	5
0.020	4	6	3	5	4	6	3	5	4	6	3	5	4	6	3	5	5	7	3	5
0.022	4	6	4	6	3	5	4	6	3	6	4	6	3	6	4	6	4	6	4	6
0.024	3	5	3	5	3	5	3	5	3	5	3	5	3	5	3	5	4	6	3	5
Deltamethrin 1%+ Triazophos 35%EC																				
0.009	3	4	-	-	4	6	-	-	5	7	-	-	4	7	-	-	4	6	-	-
0.010	3	4	-	-	4	5	-	-	4	6	-	-	4	6	-	-	3	6	-	-
0.020	3	4	-	-	3	5	-	-	4	6	-	-	4	5	-	-	3	5	-	-
0.022	-	-	-	-	3	5	-	-	4	6	-	-	4	5	-	-	4	6	-	-
0.024	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Control																				
Water spray	5	7	5	6	5	7	5	7	5	6	5	6	5	7	5	6	5	7	5	7

3.3 Coragen:

The emergence rate of *T. chilonis* on all concentration of coragen was very low (3-5%) and the emerged adults died within 6-12 hrs after emergence. It was noticed that all the five concentrations of coragen affects the egg parasitoid *T. chilonis* adult. Statistical analysis, showed highly significant differences of black eggs between the control and all the studied insecticides at 2nd generation but non-significant difference in 1st generation. As for comparing insecticides with each other there were non-significant differences for the numbers of black eggs (77-80) as well as emergence (52.33, 47.33, 40.67, 36.33 and 33.33) rates at 0.009, 0.01, 0.020, 0.022 and 0.024% concentration (Table 1). The respective values for the emergence rate for 2nd generation decreased compared to 1st generation and the control. In second generation, the emergence rate was 33% and 31% on one and two days post parasitism at 0.009% concentration, while at 0.024% conc. there was only 18-25% emergence recorded at 1st and 2nd day of parasitism (Table: 1). At 1st, 2nd and 3rd day after parasitization of eggs there was found maximum deformities in second generation adults of *T. chilonis*, while at 5th and 6th day parasitized eggs had least. The maximum deformities and mortality of adult wasps were found in highly concentrated doses of insecticides compared to the low concentrated.

3.4 Deltamethrin 1%+Triazophos 35%:

All the doses of Deltamethrin 1%+Triazophos 35% were significantly toxic to *T. chilonis*. The higher doses of chemical insecticide caused a highly decrease in the emergence rate, the recorded values were 0% - 2% compared to 77.33-77.67% for the control (Table: 1). Also this chemical caused death of the emerged adults within few hours post emergence (0–1 day) compared to (4–7 days) for the control so no data were recorded for the second generation. It is therefore, this chemical was recorded highly toxic to the *T. chilonis*. There was no mortality in untreated check.

IV. DISCUSSION

These findings are closely related to the findings of Chares *et al.* (2000), who reported that spinosad and prophenofos were the most toxic compounds to *T. exiguum* adults, followed by lambda cyhalothrin, cypermethrin, and thiodicarb. Plewka *et al.* (1975), also reported that some insecticides did not penetrate the host egg-chorion (*Sitotroga cerealella*), and *Trichogramma* spp. were affected only upon emergence from the eggs.

Adult *T. exiguum* emergence from *H. zea* eggs was significantly affected by insecticide treatment. Overall, parasitized eggs exposed to profenophos yielded the lowest percent emergence. Although insecticides are generally considered toxic to adult *Trichogramma*, preimaginal stages developing within host eggs appear to be well protected from many insecticides (Bull and House 1983, Bull and Coleman 1985, Li *et al*. 1986, Singh and Varma 1986, Brar *et al*. 1991, Coˆnsoli *et al*. 1998). Pyrethroids generally had a slight to moderate effect, whereas insect growth regulators and other selective compounds generally appeared to have no effect on emergence. For some insecticides, the effect on emergence appeared to be related to the progression of preimaginal development at time of exposure (Varma and Singh 1987, Coˆnsoli *et al*. 1998). Varma and Singh (1987) reported that in general, the disruptive effect of insecticides on *T. brasiliensis* Ashmead emergence decreased as parasitoids advanced in development.

The timing of insecticide exposure relative to preimaginal development (larval, prepupal, and pupal stages) did not have a significant impact on emergence for any of the insecticides tested. Profenophos (organophosphate) completely inhibited emergence and both pyrethroids (lambda cyhalothrin and cypermethrin) severely affected emergence for all three stages of exposure.

Possible explanations may be related to the species of *Trichogramma* and host eggs used as well as insecticide concentrations tested in each of the studies. The quality and overall fitness of *Trichogramma* heavily depends on the size of the host and the number of conspecifics that emerge with it (Bai *et al*. 1992)

We could found no published data concerning the effect of coragen on *Trichogramma* development or survival. However, Navarajan and Agarwal (1989) reported that the pyrethroids tested in their study (cypermethrin, fenvalerate, and deltamethrin) had relatively low residual toxicity to *T. brasiliensis* Ashmead while carbaryl (carbamate) had the highest residual activity.

V. CONCLUSION

Preliminary studies indicated that endosulfan and coragen had less adverse effect on preimaginal development or adult survival, indicating that these compounds are compatible with *T. exiguum* wasps. In response to the adverse effect of insecticides on preimaginal development in our study, it should be noted that eggs were completely drenched with an insecticide solution. Consequently, eggs received the maximum possible dose in our study. However, further research should focus on the impact of

insecticide exposure on *Trichogramma* parasitism and overall effectiveness under field conditions to determine the compatibility of *Trichogramma* wasps and insecticides. More emphasis should be placed on conserving or enhancing naturally occurring populations of *Trichogramma* as well as other natural enemies in field condition

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