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Effect of insecticides on adult emergence from different developmental stages of *Trichogramma chilonis* (Ishii) (Hymenoptera: Trichogrammatidae) under laboratory condition

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Abstract
The present investigation was carried out in the biocontrol laboratory, entomology section, College of Agriculture, Nagpur during 2016-2017 to study the effect of insecticides *viz.* Chlorantraniliprole 18.5 SC, Diafenthiuron 50 WP, Cartap hydrochloride 50 SP, Spiromesifen 22.9 SC, Thiamethoxam 25 WG, Clothiandin 50 WDG, Flonicamid 50 WG, Azadirachtin 1500 ppm on the rate of adult emergence of *T.chilonis,* when applied during different developmental stages *i.e* egg, egg- larval and pupal stages. Amongst all the insecticides understudy, cartap hydrochloride was found most toxic causing the highest reduction in the emergence of adults, when applied after 1st, 3rd and 5th days after parasitization which coincide with the egg, egg- larval and pupal stage of Trichogramma. Whereas, diafenthiuron, was found least toxic upon application during egg and egg larval stage and azadirachtin during the pupal stage.

Keywords: Insecticide, *Trichogramma chilonis*, adult emergence, parasitization, developmental stages

1. Introduction
Trichogramma is a well- known egg parasitoid, that has been successfully used in biological control of a variety of pest. *Trichogramma* spp. parasitizes the eggs of over 400 species belonging to at least seven insect orders [1]. The life cycle of *Trichogramma chilonis* lasts for about 8-10 days. Whereas, egg, larval and pupal stages of *T. chilonis* were completed in about 1 day, 3-4 days and 4-5 days respectively [18]. In spite of the important role of the bio-agents in agriculture, chemical control is still indispensable. Various attempts to suppress the pest population by biological control measures have often failed because of the deleterious effects of chemicals on the beneficial insect [2]. A range of harmful effects of insecticide on *Trichogramma* spp. have been described by different workers [5, 19]. Trichogramma wasps are highly susceptible to most broad-spectrum insecticides.
The integration of biological and chemical control tactics requires a thorough understanding of the effects of insecticides on biological control agents. A stepwise assessment, moving from the laboratory to field, with proper consideration of both direct and sub-lethal effects is recommended in the screening of pesticides against biological control agents [3]. The present investigation was undertaken to study the selective toxicity of different insecticide towards the adult emergence of *Trichogramma chilonis;* when applied during different developmental stages of the wasp to search for comparatively less toxic insecticide against *Trichogramma chilonis* to be incorporated into IPM program.

2. Materials and Methods
The present investigation was carried out in the Biocontrol laboratory, Entomology Section, College of Agriculture, Nagpur, Maharashtra during June-Dec of 2016. The rearing of the host insect and parasitoid was done under controlled room temperature and relative humidity conditions ranging between 24 ± 2 ^{0} C and 60 ± 5%. Mass multiplication of Trichogramma was done in the laboratory to obtain a healthy culture of the test parasitoid.
To obtain the eggs of *Corcyra cephalonica* throughout the experimental period, the rearing of rice moth was done in the laboratory. The culture was maintained on a sorghum-based artificial diet. Ultraviolet irradiated eggs and fresh eggs (without UV irradiation) of *Corcyra cephalonica* were used for experimenting. The Corcyra eggs thus obtained from laboratory culture were sterilized by exposing to UV light (15 watts for half an hour) to kill the embryo.

Corcyra cephalonica eggs with and without UV irradiation were glued to the egg cards separately and were cut into strips of 5.0x 2.0 cm size (@50 eggs per card strip). Those cards were exposed to the adults of *Trichogramma chilonis* (@ 5:1 host-parasitoid ratio) for 24 hrs to obtain adequate parasitization. After parasitization, the card strips were dipped in insecticide solution, as per the treatments, for 5 seconds on the 1st, 3rd and 5th day of parasitoid release. For control, water was used instead of insecticide. The cards were shade dried and kept in BOD for 24 hours. Each treatment was repeated three times and the observations were recorded daily starting at 24 hours after parasitoid release and were continued up to parasitoid emergence to record percent mortality based on adult emergence. The percent reduction in adult emergence will be considered as the percent mortality due to the application of insecticide during different developmental stages of Trichogramma. The effect of the insecticides on adult emergence compared to the untreated was calculated by using the following formula [14].

E (%) = (1- Vt/Vc) x 100

Where,

E = Reduction in adult emergence

V_t= No. of adults emerged in the treatment

V_c= No. of adults emerged in control

The treatments were given by following the method suggested by Santharam and Kumaraswami (1985) [13]. The egg, egg-larval and pupal stages of *Trichogramma chilonis* coincide with 1st day, 3rd day and 5th day after parasitization.

Toxicity Class	Categorization	% mortality/ reduction either in parasitism or emergence
Class 1	Harmless	<30
Class 2	Slightly harmful	30-79
Class 3	Harmful	80-99
Class 4	Harmful	>99

On the bases of percent mortality/percent reduction in parasitization/adult emergence, insecticides were classified in different categories as suggested by IOBC/WPRS [16].

3. Statistical Analysis

The data so obtained on percent mortality during the present study were subjected to arcsine transformation and the transformed values were analyzed by using CRD through STPR.

4. Results and Discussion

The values of the percent reduction in adult emergence due to the application of insecticides after 1st, 3rd and 5th day of parasitization in both UV irradiated and unirradiated eggs are presented in table 1 and depicted in Fig 1 and Fig 2 respectively. Upon application of insecticides after 1st day of parasitization, the maximum reduction in adult emergence was recorded in cartap hydrochloride followed by clothianidin, spiromesifen, azadirachtin, flonicamid, thiamethoxam, chlorantraniliprole, and diafenthiuron respectively in both UV irradiated and unirradiated eggs. Based on the IOBC categorization of different insecticides concerning the reduction in adult emergence diafenthiuron and chlorantraniliprole were categorized as “harmless” whereas thiamethoxam, flonicamid and azadirachtin were found harmless to slightly harmful towards adult emergence. Further insecticides clothianidin and spiromesifen can be categorized as slightly harmful to moderately harmful. Amongst all insecticides, cartap hydrochloride showed maximum reduction and categorized as moderately harmful to harmful. The results obtained were in accordance with Hallapa *et al.* (2013), Preetha *et al.* (2010), Hussain *et al.* (2012), Ranjith *et al*. (2016), Costa *et al.* (2014), Takada *et al.* (2001), Patel and Pramanik (2012) and Lingathurai *et al*. (2015) [4, 10, 6, 11, 17, 9, 8].

Upon application of insecticides after 3rd day of parasitization in both UV irradiated and unirradiated eggs, the highest percent mortality was recorded in cartap hydrochloride and categorized as “Moderately harmful”. Whereas, Azadiracthin, Spiromesifen, flonicamid, thiamethoxam and clothiandin were found slightly harmful. However, Chlorantraniliprole and diafenthiuron equally favoured the adult emergence and were categorized as "Harmless" according to IOBC categorization. Similar findings were also obtained by Hallapa *et al*. (2013), Sattar *et al.* (2011), Hussain *et al.* (2012), Costa *et al.* (2014), Patel and Pramanik (2012), Takada (2001), Sabry *et al.* (2014) [4, 14, 6, 917, 12].

Application of insecticides to the egg cards after the 5th day of parasitization showed that the least reduction in adult emergence was recorded in Azadirachtin, chlorantraniliprole, and diafenthiuron and categorized as harmless, Whereas, Spiromesifen and flonicamid were found slightly harmful. Clothianidin and thiamethoxam were found moderately harmful. However, the highest reduction in adult emergence was recorded in Cartap hydrochloride and categorized as moderately harmful to harmful. Similar results were obtained in both UV irradiated and unirradiated eggs. Results obtained were in agreement with Hussain *et al.* (2012), Costa *et al.* (2014), Sattar *et al.* (2011), Khan *et al.* (2010), Sliva *et al.* (2015) [6, 14, 7, 15].

Table 1: Effect of insecticides on rate of adult emergence after application on 1st, 3rd and 5th day after parasitisation in UV irradiated and unirradiated eggs

T. No.	Treatment Name	Concentration	UV irradiated eggs (Per cent mortality/reduction in adult emergence)			UV unirradiated eggs (Per cent mortality/reduction in adult emergence)		
			1st DAP	3rd DAP	5th DAP	1st DAP	3rd DAP	5th DAP
T1	Chlorantraniliprole18.5SC	0.005%	25.14 (30.07)	25.89 (30.59)	14.36 (22.22)	21.71 (27.76)	22.52 (28.32)	12.98 (21.05)
T2	Diafenthiuron 50WP	0.06%	20.62 (26.99)	18.57 (25.55)	17.49 (24.73)	15.65 (23.26)	15.33 (23.03)	16.78 (24.20)
T3	Cartap hydrochloride 50SP	0.1%	91.72 (73.26)	92.20 (73.38)	90.91 (72.44)	90.87 (72.44)	90.81 (72.34)	86.75 (68.70)

T4	Spiromesifen 22.9 SC	0.03%	52.56 (46.43)	34.08 (35.73)	24.45 (29.60)	51.51 (45.86)	31.63 (34.20)	20.80 (27.13)
T5	Thiamethoxam 25WG	0.005%	32.72 (34.88)	47.15 (43.34)	55.54 (48.16)	29.93 (33.15)	40.03 (39.23)	56.06 (48.45)
T6	Clothiandin 50WDG	0.002%	52.78 (46.61)	51.41 (45.80)	58.26 (49.78)	51.56 (45.86)	49.64 (44.57)	48.31 (44.03)
T7	Flonicamd 50WG	0.015%	35.90 (36.81)	39.60 (39.00)	34.93 (36.21)	34.06 (35.67)	36.10 (36.93)	30.73 (33.65)
T8	Azadirachtin (1500ppm)	0.005%	43.28 (40.37)	30.03 (33.21)	7.67 (11.61)	39.41 (38.88)	29.71 (33.02)	7.11 (15.45)
T9	Control (water spray)	-	7.78 (16.22)	8.31 (16.74)	6.45 (14.65)	5.67 (13.81)	6.99 (15.23)	6.96 (15.23)
F test			Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.E.(m)			1.86	1.44	1.30	1.72	1.48	1.56
C.D at 5%			5.41	4.20	3.79	5.04	4.32	4.55

Values in parentheses are arc sine transformed values.
DAP- Days after parasitization.

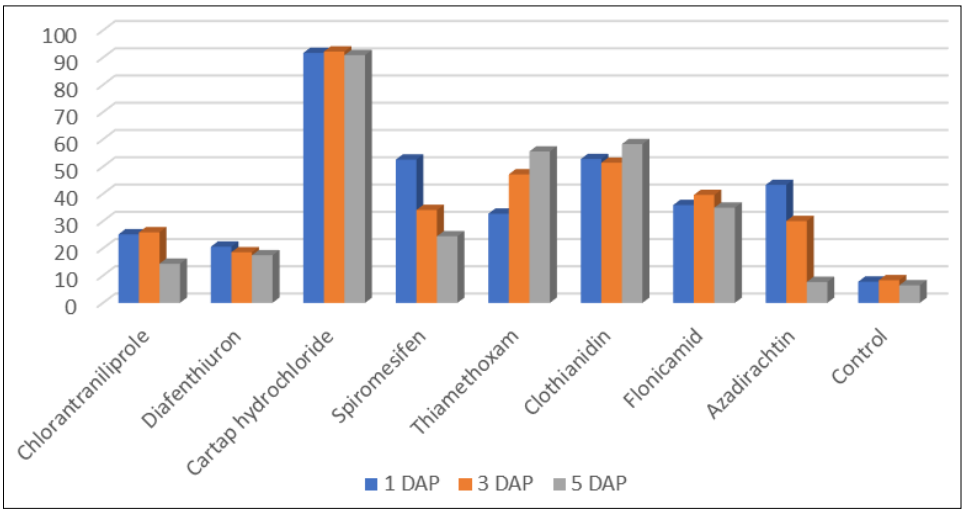

Fig 1: Effect of insecticides on rate of adult emergence after application on 1st, 3rd and 5th day after parasitisation in UV irradiated eggs

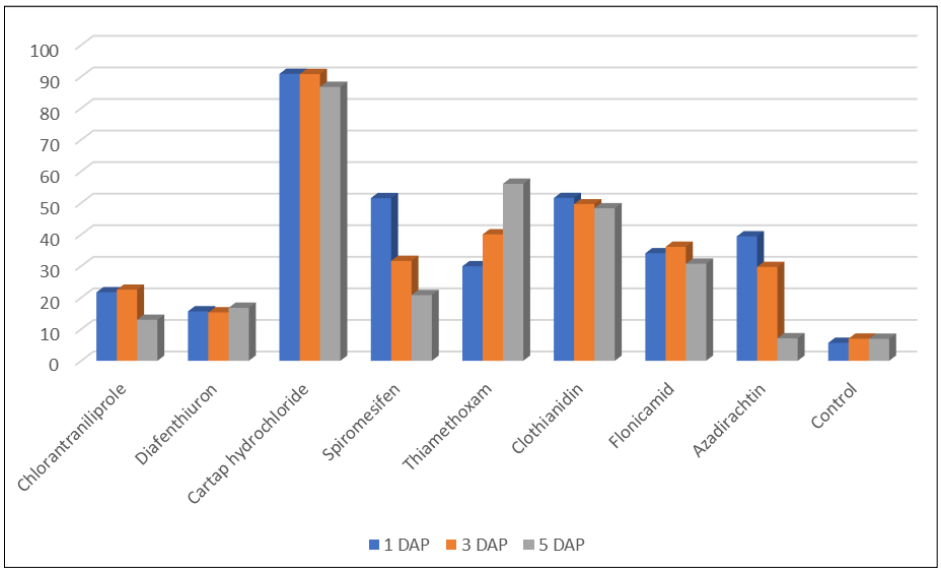

Fig 2: Effect of insecticides on rate of adult emergence after application on 1st, 3rd and 5th day after parasitisation in UV unirradiated eggs

5. Conclusion

Chlorantraniliprole was observed slightly harmful to harmless towards adult emergence during all the developmental stages. Whereas, diafenthiuron was found safe towards adult emergence when applied during egg to the egg-larval stage. Azadirachtin was found most safe at par with control during the adult emergence from the pupal stage. However, the emergence of adults from the azadirachtin treated larval stage was affected to some extent. It might be due to the antifeedant and oviposition deterrent nature of this botanical. Clothianidin, flonicamid and spiromesifen were found slightly harmful during all the developmental stages. Thiamethoxam

was found safe towards adult emergence when applied during egg and larval stages but it severely curtailed the adult emergence when applied during the pupal stage. Cartap hydrochloride was found most harmful and caused the highest mortality, upon application to all the developmental stages. Considering eco-friendliness, it can be concluded that insecticides chlorantraniliprole and diafenthiuron were found most safe towards adult emergence causing the least mortality and can be incorporated successfully during the IPM programs.

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