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Evaluation of safety of newer insecticides to immature stages of *Trichogramma japonicum*

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Abstract
An experiment was carried out to study the safety of some new insecticides namely chlorantraniliprole 18.5 SC, flubendiamide 20 WG, buprofezin 25 SC, lambda cyhalothrin 5 EC, thiamethoxam 25 WG, dinotefuran 20 SG, thiacloprid 21.7 SC and azadirachtin 5 % w/w on egg, larval and pupal stage of *Trichogramma japonicum* parasitizing UV irradiated and unirradiated *Corcyra cephalonica* eggs by evaluation of percent reduction in adult emergence of when treated after 1st, 3rd and 5th day of parasitisation which is during egg, larval and pupal stage of *Trichogramma* respectively. Lambda cyhalothrin adversely affected the emergence of *T. japonicum* during all the life stages of *T. japonicum*. However azadirachtin, buprofezin, chlorantraniliprole and flubendiamide least affected the per cent reduction in adult emergence than other insecticides. Thiamethoxam was found selective towards different life stages of *T. Japonicum.*

Keywords: *Trichogramma japonicum*, insecticides, adult emergence, mortality

Introduction
Insect egg parasitoid *Trichogramma* is the most important biological control agent which is commonly distributed worldwide. These are minute endoparasitoids of insect egg insects ranging size from 0.2 mm to 1.5 mm. The genus *Trichogramma* is one of the 80 genera in the family *Trichogrammatidae* which includes 145 described species worldwide. Whereas, 20 species of *Trichogramma* and 6 species of old world *Trichogrmmatoidea* have been recorded from India, of which *T. chilonis* (Ishii), *T. japonicum* (Ashmead), *T. achaeae* (Nagraja) are widely distributed (Singh, 1994) [22]. Amongst the various species of *Trichogramma*, *Trichogramma japonicum* (Ashmead) is an important egg parasitoid and the most promising natural enemy of lepidopteron pests in paddy crop (Rani *et. al*., 2007) [16] and is widely used in IPM of many important insect pest including yellow stem borer *Scirpohaga incertulus*, which is considered to be most important pest of rain fed, low land and flood prone rice ecosystem (Deka *et. al*., 2010) [5]. Though *T. japonicum* is the potential bio control agent in integrated pest management, but its effectiveness might be affected by use of various chemical insecticides. The use of *Trichogramma spp.* is potential key strategy in pest management but its effectiveness largely depends on the use of insecticide that does not interfere with parasitism and parasitoid viability (Moura *et. al*., 2004) [13].
Despite of the importance of biological control, the use of organic synthetic insecticides continues to be an important tool in integrated pest management system. The effectiveness of biological control practices can be improved by using insecticides in compatible manner without causing damage to bio control agents. Hence the knowledge of compatibility and the impact of insecticides on beneficial parasitoids species are of utmost importance for the effective integration of the chemical and biological management programmes. Some earlier studies reported negative effects on *Trichogramma*, whereas some studies showed that lethal and sub lethal insecticides are usually considered as high risk to beneficial species (Croft, 1990) [4]. Therefore the present study is of much importance to know the safety of new chemicals on the performance of parasitoid *Trichogramma japonicum* for sustainable pest management.

Materials and Methods
Mass multiplication of *Trichogramma japonicum* was done in the laboratory at Entomology Section, College of Agriculture, Nagpur during year 2017-2018.

The initial culture was obtained from the already established culture of *T. japonicum* in the laboratory and it was further multiplied on the factitious laboratory host, eggs of *Corcyra cephalonica* under room temperature and relative humidity ranging between 26 ± 2°C and 60 ± 5% respectively and commercial formulation of insecticides were obtained from the market.

To obtain *Corcyra cephalonica* eggs throughout the experimental period, *Corcyra* culture was maintained on sorghum based artificial diet with following ingredients including crushed sorghum grains (2.5 kg), groundnut kernel powder (100 g), yeast powder (5 g), micronized wettable sulphur 80% (5 g) and streptomycin sulphate (5 g) in one plastic tub. Adult moths started emerging after 40 days of inoculation of nucleus egg culture of *C. cephalonica* (0.5 cc/ tub). Emerged adult moths were transferred to oviposition chamber and then freshly obtained Corcyra eggs were sieved and kept under UV irradiation for 45 minutes. Thus UV irradiated and unirradiated eggs of *C. cephalonica* were used for conducting the experiment. The treatment was given by following method suggested by Santharam and Kumaraswami (1985) [18].

Effect of newer insecticides on percent mortality (per cent reduction in adult emergence) of *Trichogramma japonicum*

UV irradiated and unirradiated eggs of *Corcyra cephalonica* were glued to the egg cards separately (@50 eggs per card strip) and were cut into strips of 5.0 x 2.0 cm size. These cards were exposed to the adults of *Trichogramma japonicum* (@ 5:1 host parasitoid ratio) for 24 hrs to obtain adequate parasitisation. After parasitoid release, the card strips were dipped in insecticide solution, as per the treatments, for 5 seconds on 1st, 3rd and 5th day after parasitoid release, for control water was used instead of insecticides. The cards were shade dried and kept in BOD for 24 hrs. Each treatment was replicated three times and the observations were recorded daily staring at 24 hrs after parasitoid release and were continued upto parasitoid emergence to record percent mortality based on percent emergence. The per cent reduction in adult emergence was considered as the percent mortality due to application of insecticides during different developmental stages of *T. japonicum.*

On the basis of per cent mortality/ per cent reduction in parasitisation /adult emergence, insecticides were classified in different categories as suggested by IOBC (International Organization for Biological Control) (Sterk *et al.*, 1999) [24].

Toxicity class	categorization	% mortality/reduction in adult emergence
Class 1	Harmless	<30
Class 2	Slightly harmful	30-79
Class 3	Moderately Harmful	80-99
Class 4	Harmful	>99

Result and Discussion

Effect of newer insecticides on per cent mortality (per cent reduction in adult emergence) of *Trichogramma japonicum*.

Effect on UV irradiated eggs of *Corcyra cephalonica* eggs treated after 1 day of parasitisation by *T. japonicum*

The data recorded in table 1 indicate per cent reduction in adult emergence of *T. japonicum* due to different insecticides tested after 1 day of parasitisation in UV irradiated *Corcyra cephalonica* eggs, in which lowest per cent reduction in adult emergence i.e least mortality was recorded from buprofezin followed by azadirachtin, chlorantraniliprole, and flubendiamide with 14.81, 20.35, 21.37 and 24.94 per cent reduction in adult emergence respectively, whereas maximum 47.79 per cent reduction was recorded under lambda cyhalothrin. However the per cent reduction in adult emergence under remaining insecticides with descending order of toxicity were 46.51, 42.29 and 29.50 per cent under dinotefuran, thiacloprid and thiamethoxam respectively when treated after 1 day post parasitisation.

The results indicated that buprofezin, azadirachtin and chlorantraniliprole favoured greater per cent of adult emergence followed by thiamethoxam and thiacloprid. However, maximum per cent reduction in adult emergence i.e. maximum per cent mortality as compared to other insecticides was recorded under lambda cyhalothrin and dinotefuran. The values recorded under both lambda cyhalothrin and dinotefuran were nearly similar.

The findings of present study are in accordance with results recorded by previous workers. Amongst Narendra *et al*., (2013)[14] reported that insecticides tested showed different degrees of toxicity to egg, larval and pupal stage of development of *Trichogramma*, where azadirachtin (1ml/L) recorded relatively safe to egg stage of *Trichogramma* with 79.74 per cent adult emergence. Gogoi *et al*., (2013) [7] reported maximum per cent adult emergence with 65.3 per cent under nimbecidin (0.03%). However Ko *et al*., (2015) [11] reported 12.0 and 8.8 per cent reduction in adult emergence under thiamethoxam and buprofezin respectively and reported both insecticides as 'Harmless' to egg stage. Chao *et al*., (2008) [3] reported thiamethoxam selective to different life stages of *T. japonicum* and "Harmless" to egg stage of development of *T. japonicum*, which is in line with the result of present study. Preetha *et al*., (2010) [15] recorded 98.73 per cent adult emergence under thiamethoxam. Shoeb, (2010)[21] found emergence rate highly decreased under lambda cyhalothrin with 31 and 23 per cent emergence of *T. evanescens* wasps after 1 and 2 days after parasitisation respectively. Khan *et al*., (2017) [10] reported significant reduction in adult emergence when treated with dinotefuran during egg stage of *Trichogramma*. Hussain *et al*., (2012) [8] recorded 17.8 per cent emergence of *T.chilonis* under chlorantraniliprole which increased upto 70.00 per cent after 8 days of treatment. Sattar *et al*., (2011) [19] found 27 and 14 per cent reduction in adult emergence under flubendiamide and neem oil respectively and categorized both insecticides as "Harmless" to egg stage of *Trichogramma*.

Effect on UV unirradiated *Corcyra cephalonica* eggs treated after 1 day after parasitisation by *T. japonicum*

The data presented in table 1 represent the per cent reduction in adult emergence of *T. japonicum* parasitizing UV unirradiated *C. cephalonica* eggs treated after 1 days of parasitisation with different insecticides. However lowest reduction in adult emergence 5.41per cent were recorded from control (water spray) followed by buprofezin, azadirachtin and chlorantraniliprole with 13.58, 18.99 and 20.00 per cent respectively, whereas the ascending order of toxicity towards adult emergence recorded as flubendiamide<thiamethoxam<thiacloprid<dinotefuran<lamb

da cyhalothrin with 21.47, 29.25, 39.29, 43.25 and 44.75 per cent reduction in adult emergence respectively. Among the insecticides tested lambda cyhalothrin recorded maximum per cent reduction in adult emergence of *T. japonicum* in UV unirradiated *C. cephalonica* eggs treated 1 day post parasitisation.

According to the IOBC categorization, the insecticides under present study were classified into different categories of toxicity towards per cent reduction in adult emergence on the basis of results recorded. Among them buprofezin (0.05%), azadirachtin (0.002%) and chlorantraniliprole (0.005%) showed lowest toxicity with minimum per cent reduction in adult emergence and hence classified under the category "Harmless", similarly per cent mortality i.e. per cent reduction in adult emergence under flubendiamide (0.005%) and thiamethoxam (0.005%) were recorded less than 30 per cent hence both the insecticides were categorized as "Harmless". However thiacloprid (0.021%), dinotefuran (0.006%) and lambda cyhalothrin (0.003%) were categorized as "Slightly harmful" towards rate of adult emergence of *T. japonicum*, when treatment was given 1 day post parasitisation i.e. during egg stage of *Trichogramma*.

Table 1: Effect of newer insecticides on per cent mortality (per cent reduction in adult emergence) of *Trichogramma japonicum* in UV irradiated and unirradiated *Corcyra cephalonica* eggs treated after 1 day of parasitisation.

Treatment No.	Treatment Name	Concentration	Per cent reduction in adult emergence.		Score
			UV irradiated eggs	UV unirradiated eggs	
T_1	Chlorantraniliprole 18.5 SC	0.005%	21.37 (27.49)	20.00 (26.57)	Harmless
T_2	Flubendiamide 20 WG	0.005%	24.94 (29.93)	21.47 (27.56)	Harmless
T_3	Buprofezin 25 SC	0.05%	14.81 (22.63)	13.58 (21.56)	Harmless
T_4	Lambda cyhalothrin 5 EC	0.003%	47.79 (43.68)	44.75 (41.96)	Slightly harmful
T_5	Thiamethoxam 25 WG	0.005%	29.50 (32.90)	29.25 (32.71)	Harmless
T_6	Dinotefuran 20 SG	0.006%	46.51 (42.99)	43.25 (41.09)	Slightly harmful
T_7	Thiacloprid 21.7 SC	0.021%	42.29 (40.51)	39.29 (38.76)	Slightly harmful
T_8	Azadirachtin 5% w/w	0.002%	20.35 (26.78)	18.99 (25.77)	Harmless
T_9	Control (Water)	-	5.44 (13.44)	5.41 (13.44)	-
'F test'			Sig.	Sig.	
S.E.(m)			1.18	0.98	
C.D. at 5%			3.45	2.86	

(Figures in parentheses are arc sine values)

Effect on UV irradiated eggs of *Corcyra cephalonica* eggs treated after 3rd day of parasitisation by *T. japonicum*

The values recorded on per cent reduction in adult emergence of *Trichogramma japonicum* in UV irradiated *Corcyra cephalonica* eggs treated with insecticides after 3 days of parasitisation are represented in table 2, where all the insecticides showed various degrees of toxicity towards reduction in adult emergence i.e. per cent mortality as compare to control with 5.11 per cent reduction. However maximum reduction in adult emergence was observed under lambda cyhalothrin (57.62 %) whereas the descending order of toxicity towards per cent mortality i.e. reduction in adult emergence followed by lambda cyhalothrin was dinotefuran, thiacloprid, thiamethoxam, azadirachtin, flubendiamide and buprofezin with 55.86, 45.29, 38.30, 31.73, 23.26 and 18.29 per cent respectively, whereas minimum 17.64 per cent reduction in adult emergence amongst the insecticides was recorded under chlorantraniliprole.

Thus from the result recorded it was observed that chlorantraniliprole favoured the maximum per cent of emergence when treated after 3 days of parasitisation. However lambda cyhalothrin mostly affected the rate of emergence of *T. japonicum* over other insecticides.

The results recorded under present study were found in line with earlier works observed under different insecticides on adult emergence when applied after 72 hours of parasitisation. Among them Fand *et al*., (2009) [6] recorded effect of lambda cyhalothrin and neem oil (1%) on per cent mortality when treated after 3 days of parasitisation and recorded 58.67 per cent and 25.33 per cent mortality of *T. chilonis* respectively, whereas Saha *et al.*, (2017) [17] recorded 7.87 per cent pupal mortality under neemazal 1% EC (0.002%). However Kalaiselvi *et al*., (2007) [9] reported that reduction in adult emergence due to lambda cyhalothrin was 55.8 initially which increased up to 71.8 per cent which is in conformity with present result. Whereas Bastos *et al*., (2006) [2] reported 50 per cent reduction in adult emergence under thiacloprid. Chao *et al.*, (2008) [3] reported that buprofezin was "Harmless" to all immature stages of *Trichogramma japonicum*. However Ko *et al*., (2015) [11] reported thiamethoxam as "Slightly harmful" when treated at larval stage of *Trichogramma* with 33.2 reduction in adult emergence and also recorded 22.3 per cent reduction when treated with buprofezin after four days (larval stage) of parasitisation. Abdulhay *et al*., (2014) [1] observed thiacloprid as slightly harmful with 60.75 per cent reduction in adult emergence due to larvicidal and ovicidal activity with weaker adulticidal activity towards *Trichogramma minutum*. Madhusudhanan *et al*., (2014) [12] studied toxicity of flubendiamide 20 WG at 50, 60 and 70 g a.i. ha^{-1} dose and reported 89.70, 87.30 and 82.91 per cent emergence of *Trichogramma chilonis* respectively at 72 hours post parasitisationand also recorded 81.78 per cent emergence under chlorantraniliprole 18.5 SC. Hussain *et al*., (2012) [8] recorded 61.5 per cent adult emergence under flubendiamideand 37.4 per cent emergence under chlorantraniliprole treated 3 days post parasitisation which gradually increased up to 70 per cent after 8 days post parasitisation. Whereas Khan *et al*., (2017) [10] recorded effect of two different formulations of dinotefuran (SL-soluble liquid and SG- soluble granules) on late larval stage of *Trichogramma* and reported that both the formulations of dinotefuran significantly reduced the per cent of adult emergence. Whreas sattar *et al*., (2011) [19] categorised flubendiamide as "Harmless" with 26.00 per cent reduction in adult emergence when treated at larval stage of *Trichogramma* and also reported 35 per cent reduction under neem oil (1%) treatment and recorded neem oil as slightly harmful to larval stage than egg and pupal stage of *Trichogramma* which is again in accordance with result of present study.

Effect on UV unirradiated eggs of *Corcyra cephalonica* eggs treated after 3rd day of parasitisation by *T. japonicum*

The values of the per cent reduction in adult emergence of *T. japonicum* in UV unirradiated *Corcyra cephalonica* eggs treated with different insecticides at 3 days post parasitisation recorded in table 2. The lowermost reduction in adult emergence (maximum emergence) was recorded from control (water spray) with 5.04 per cent followed by 15.53, 17.88 and 21.07 per cent reduction in adult emergence under chlorantraniliprole, buprofezin and flubendiamide respectively. Further reduction in adult emergence were recorded with 30.74 and 35.34 per cent from azadirachtin and thiamethoxam respectively, whereas maximum per cent reduction in adult emergence with ascending order of toxicity were recorded from thiacloprid, dinotefuran and lambda cyhalothrin with 41.54, 53.03,and 54.03 per cent reduction respectively.

The data recorded in table 2 indicated that maximum increase in reduction per cent of emergence i.e. maximum mortality observed due to treatment lambda cyhalothrin. Similar results were recorded by Fand *et al*., (2009) [6] with 61.33 per cent mortality of *Trichogramma* under lambda cyhalothrin treated after 3 days of parasitisation in UV unirradiated eggs. However in present study minimum reduction in adult emergence were recorded under chlorantraniliprole and buprofezin when treated at 3 days post parasitisation i.e. during larval stage of *T. japonicum*.

Hence according to IOBC categorisation, the insecticides under present study were classified, where chlorantraniliprole (0.005%), buprofezin (0.05%) and flubendiamide (0.005%) favoured maximum emergence of *T. japonicum* with per cent reduction in adult emergence less than 30 per cent hence categorized as "Harmless", whereas azadirachtin (0.002%) slightly affected the emergence rate when treated after 3 days of parasitisation hence categorized as "Slightly harmful". However thiamethoxam (0.005%), thiacloprid (0.021%), dinotefuran (0.006%) and lambda cyhalothrin (0.003%) caused significant damage towards adult emergence with per cent reduction in adult emergence greater than 30 per cent hence categorized as "Slightly harmful".

Table 2: Effect of newer insecticides on per cent mortality (per cent reduction in adult emergence) of *Trichogramma japonicum* in UV irradiated and unirradiated *Corcyra cephalonica* eggs treated after 3 days of parasitisation.

Treatment No.	Treatment Name	Concentration	Per cent reduction in adult emergence		Score
			UV irradiated eggs	UV unirradiated eggs	
T_1	Chlorantraniliprole 18.5 SC	0.005%	17.64 (24.80)	15.53 (23.18)	Harmless
T_2	Flubendiamide 20 WG	0.005%	23.26 (28.79)	21.07 (27.27)	Harmless
T_3	Buprofezin 25 SC	0.05%	18.29 (25.25)	17.88 (24.95)	Harmless
T_4	Lambda cyhalothrin 5 EC	0.003%	57.62 (49.37)	54.03 (47.29)	Slightly harmful
T_5	Thiamethoxam 25 WG	0.005%	38.30 (38.23)	35.34 (36.45)	Slightly harmful
T_6	Dinotefuran 20 SG	0.006%	55.86 (48.33)	53.03 (46.72)	Slightly harmful
T_7	Thiacloprid 21.7 SC	0.021%	45.29 (42.25)	41.54 (40.11)	Slightly harmful
T_8	Azadirachtin 5% w/w	0.002%	31.73 (34.27)	30.74 (33.65)	Slightly harmful
T_9	Control (Water)		5.11 (13.05)	5.04 (12.92)	
'F test'			Sig.	Sig.	
S.E.(m)			1.17	1.20	
C.D. at 5%			3.42	3.50	

(Figures in parentheses are arc sine values)

Effect on UV irradiated eggs of *Corcyra cephalonica* eggs treated after 5th day of parasitisation by *T. japonicum*

The data on per cent reduction in adult emergence of *Trichogramma japonicum* in UV irradiated eggs of *C. cephalonica* treated after 5 days of parasitisation presented in table 3 revealed that lower most reduction in per cent adult emergence recorded from control (water spray) with 4.74 per cent reduction followed by azadirachtin which recorded 10.50 per cent reduction in adult emergence. Further reduction in adult emergence was recorded in ascending order of toxicity with 12.97, 17.01, 26.62, 32.15 and 35.01 per cent reduction under the treatments, chlorantraniliprole, flubendiamide, buprofezin, thiacloprid and thiamethoxam respectively. However maximum reduction in per cent emergence over control was recorded from dinotefuran and lambda cyhalothrin with 52.10 and 63.47 per cent respectively.

The data clearly indicated that azadirachtin, chlorantraniliprole, flubendiamide favoured greater per cent of adult emergence when treated after 5 days of parasitisation i.e. during pupal stage of development similarly the results recorded by earlier workers were found in line with the results under present study. Where Chao *et al*., (2008) [3] reported that buprofezinas harmless to all stages of *Trichogramma japonicum* and Saha *et al*., (2017) [17] recorded 7.81 per cent mortality of *Trichogramma* at pupal stage under neemazal 1% EC. However Souza *et al*., (2014) [23] reported that lambda cyhalothrin and thiamethoxam more toxic to pupal stage than egg-larval and pre-pupal stage towards per cent reduction in adult emergence, hence categorized as "Slightly harmful". Whereas Kalaiselvi *et al*., (2007) [9] reported that lambda cyhalothrin caused maximum per cent reduction of adult emergence with 55.8 – 71.8 per cent reduction. However Khan *et al*., (2017) [10] reported that dinotefuran adversely affected immature and pre-emergent adults of *Trichogramma*. Narendra *et al*., (2013) [14] in his studies found azadirachtin (1 ml/L) was safer to pupal stage with 69.45 per cent emergence. However Shanmugha *et al* (2016) [20] reported maximum adult emergence 94.1 per cent under NSKE 5%. Ko *et al*., (2015) [11] classified buprofezin as harmless and thiamethoxam as slightly harmful to pre-pupal stage with 14.2 and 37.2 per cent reduction in adult emergence under buprofezin and thiamethoxam respectively, treated after 6 days of parasitisation. However Hussain *et al*., (2012) [8] reported 64.0 per cent emergence under flubendiamide and 44.2 per cent emergence under chlorantraniliprole when treated after 5 days of parasitisation which increased up to 70 per cent after 8 days of parasitisation. Sattar *et al*., (2011) [19] recorded 10 per cent reduction in adult emergence under flubendiamide and 12 per cent reduction under neem oil treated at pupal stage of development of *T. chilonis* and both insecticides were classified as harmless to pupal stage.

Effect on UV unirradiated eggs of *Corcyra cephalonica* eggs treated after 5th day of parasitisation by *T. japonicum*

The findings on per cent reduction in adult emergence of *Trichogramma japonicum* in UV unirradiated *C. cephalonica* eggs due to application of different insecticides over control after 5 days of parasitisation presented in table 3 revealed that the lower most 4.79 per cent reduction in adult emergence recorded under control (water spray) followed by azadirachtin which caused least reduction in emergence rate with 8.35 per cent reduction and per cent emergence of *T. japonicum* with ascending order of toxicity towards emergence were recorded as chlorantraniliprole, flubendiamide, buprofezin, thiacloprid, thiamethoxam, dinotefuran and lambda cyhalothrin with 10.25, 16.53, 22.45, 30.93, 33.30, 50.31 and 62.00 per cent respectively.

As per IOBC categorization, different insecticides under present study were classified, out of which azadirachtin (0.002%), chlorantraniliprole (0.005%), flubendiamide (0.005%) and buprofezin (0.05%) caused least reduction in rate of emergence when treated after 5 days of parasitisation i.e. during pupal stage of *T. japonicum* hence classified as "Harmless", whereas thiacloprid (0.021%), thiamethoxam (0.005%), dinotefuran (0.006) and lambda cyhalothrin (0.003%) recorded significant reduction in rate of emergence hence classified as "Slightly harmful". Among all other insecticides maximum reduction in adult emergence were recorded under lambda cyhalothrin treated at 5 days post parasitisation.

Table 3: Effect of newer insecticides on per cent mortality (per cent reduction in adult emergence) of *Trichogramma japonicum* in UV irradiated and unirradiated *Corcyra cephalonica* eggs treated after 3 days of parasitisation.

Treatment No.	Treatment Name	Concentration	Per cent reduction in adult emergence		Score
			UV irradiated eggs	UV unirradiated eggs	
T_1	Chlorantraniliprole 18.5 SC	0.005%	12.97 (21.05)	10.25 (18.63)	Harmless
T_2	Flubendiamide 20 WG	0.005%	17.01 (24.35)	16.53 (23.97)	Harmless
T_3	Buprofezin 25 SC	0.05%	26.62 (31.05)	22.45 (28.25)	Harmless
T_4	Lambda cyhalothrin 5 EC	0.003%	63.47 (52.77)	62.00 (51.94)	Slightly harmful
T_5	Thiamethoxam 25 WG	0.005%	35.01 (36.27)	33.30 (35.24)	Slightly harmful
T_6	Dinotefuran 20 SG	0.006%	52.10 (46.20)	50.31 (45.17)	Slightly harmful
T_7	Thiacloprid 21.7 SC	0.021%	32.15 (34.51)	30.93 (33.77)	Slightly harmful
T_8	Azadirachtin 5% w/w	0.002%	10.50 (18.91)	8.35 (16.74)	Harmless
T_9	Control (Water)		4.74 (12.52)	4.79 (12.52)	-
'F test'			Sig.	Sig.	
S.E.(m)			1.58	1.08	
C.D. at 5%			4.61	3.16	

(Figures in parentheses are arc sine values)

From the data represented in table 1, table 2 and table 3, it can be observed that the order of selectivity of insecticides towards per cent reduction in adult emergence during each day of treatment i.e. during 1, 3 and 5 days post parasitisation in both UV irradiated and unirradiated eggs were almost same. However the toxicity of insecticides towards rate of adult emergence was relatively greater in UV irradiated eggs as compare to UV unirradiated eggs under respective insecticide treatments.

Conclusion

Azadirachtin was found safer to adult emergence during pupal stage whereas slightly affected the adult emergence when treated at larval stage of *Trichogramma japonicum*, buprofezin which is an insect growth regulator found safer, chlorantraniliprole and flubendiamide did not show any adverse effect where thiacloprid was recorded slightly harmful towards all the stages of *T. japonicum*. Thiamethoxam was found selective during present study, where it was found harmless when treated at egg stage of development (1 day after parasitisation), whereas rate of emergence was slightly affected during larval and pupal stage. Dinotefuran and lambda cyhalothrin were more harmful than most of other insecticides used during the present study, thus use of these insecticides should be avoided before and just after the release of parasitoid.

Considering the ecofriendliness, it can be stated that the insecticides viz. azadirachtin, buprofezin, chlorantraniliprole and flubendiamide were found safe in present study. Hence these insecticides can be included in IPM programmes without any or less adverse effect on bio control agents.

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