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

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DOI: [https://doi.org/10.22271/chemi.2020.v8.i3j.9297](https://doi.org/10.22271/chemi.2020.v8.i3j.9297)

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 *Trichogrammatoidea* have been recorded from India, of which *T. chilonis* (Ishii), *T. japonicum* (Ashmead), *T. acaecae* (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 *Scirpophaga incertulas*, 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 Kumaraswamini (1985)\[^{18}\].

| 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 percent 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)\[^{10}\] 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. Shobe, (2010)\[^{22}\] 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 of 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 day of parasitisation with different insecticides. However lowest reduction in adult emergence 5.41 per 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<dinitefuran<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%), dinofeturan (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 | UV irradiated eggs | UV unirradiated eggs | Per cent reduction in adult emergence | Score |
|---------------|----------------|---------------|--------------------|----------------------|--------------------------------------|-------|
| T1            | Chlorantraniliprole 18.5 SC | 0.005%         | 25.33 (27.49)      | 20.00 (26.57)        | Harmless                             |       |
| T2            | Flubendiamide 20 WG        | 0.05%          | 24.94 (29.93)      | 21.47 (27.56)        | Harmless                             |       |
| T3            | Buprofezin 25 SC          | 0.05%          | 14.81 (22.63)      | 13.58 (21.56)        | Harmless                             |       |
| T4            | Lambda cyhalothrin 5 EC   | 0.03%          | 47.79 (43.68)      | 44.75 (41.96)        | Slightly harmful                      |       |
| T5            | Thiamethoxam 25 WG        | 0.005%         | 29.50 (32.90)      | 29.25 (32.71)        | Harmless                             |       |
| T6            | Dinofeturan 20 SG         | 0.006%         | 46.51 (42.99)      | 43.25 (41.09)        | Slightly harmful                      |       |
| T7            | Thiacloprid 21.7 SC       | 0.021%         | 42.29 (40.51)      | 39.29 (38.76)        | Slightly harmful                      |       |
| T8            | Azadirachtin 5% w/w       | 0.002%         | 20.35 (26.78)      | 18.99 (25.77)        | Harmless                             |       |
| T9            | Control (Water)           | -              | 5.44 (13.44)       | 5.41 (13.44)         | -                                    |       |

(Tables in parentheses are arc sin 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 dinofeturan, thiacloprid, thiamethoxan, 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 neemazai 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) [3] 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) [15] 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) [11] 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 parasitisation and 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 flubendiamide at 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 dinofeturan (SL-soluble liquid and SG- soluble granules) on late larval stage of *Trichogramma* and reported that both the formulations of dinofeturan 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 5th day of parasitisation by *T. japonicum*

The data on per cent reduction in adult emergence of *Trichogramma japonicum* in UV unirradiated *Corcyra cephalonica* eggs treated with different insecticides at 3 days post parasitisation recorded in table 2 revealed that larval pre-pupal stage reduction in per cent adult emergence is recorded from dinotefuran and lambda cyhalothrin with 55.86 and 71.8 per cent respectively. Maximum 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 5 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   |
|---------------|---------------------------|---------------|--------------------------------------|---------|
| T1            | Chlorantraniliprole 18.5 SC | 0.005%        | 17.64 (24.80) 15.53 (23.18)         | Harmless|
| T2            | Flubendiamide 20 WG        | 0.005%        | 23.26 (28.79) 21.07 (27.27)         | Harmless|
| T3            | Buprofezin 25 SC           | 0.05%         | 18.29 (25.25) 17.88 (24.95)         | Harmless|
| T4            | Lambda cyhalothrin 5 EC    | 0.003%        | 57.62 (49.37) 54.03 (47.29)         | Slightly harmful|
| T5            | Thiamethoxam 25 WG         | 0.005%        | 38.30 (38.23) 35.34 (36.45)         | Slightly harmful|
| T6            | Dinotefuran 20 SG          | 0.006%        | 55.86 (48.33) 53.03 (46.72)         | Slightly harmful|
| T7            | Thiacloprid 21.7 SC        | 0.021%        | 45.29 (42.25) 41.54 (40.11)         | Slightly harmful|
| T8            | Azadirachtin 5% w/w        | 0.002%        | 31.73 (34.27) 30.74 (33.65)         | Slightly harmful|
| T9            | Control (Water)            |               | 5.11 (13.05) 5.04 (12.92)           |         |

(‘F test’ Sig.  S.E.(m) C.D at 5%)

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 larval 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 buprofezins 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*.
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 lowermost 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.

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       |
|---------------|------------------------------|---------------|---------------------------------------|-------------|
| T1            | Chlorantraniliprole 18.5 SC  | 0.005%        | 12.97 (21.05)                         | Harmless    |
| T2            | Flubendiamide 20 WG          | 0.005%        | 17.01 (24.35)                         | Harmless    |
| T3            | Buprofezin 25 SC             | 0.05%         | 26.62 (31.05)                         | Harmless    |
| T4            | Lambda cyhalothrin 5 EC     | 0.003%        | 63.47 (52.77)                         | Slightly harmful |
| T5            | Thiamethoxam 25 WG           | 0.005%        | 35.01 (36.27)                         | Slightly harmful |
| T6            | Dinotefuran 20 SG            | 0.006%        | 52.10 (46.20)                         | Slightly harmful |
| T7            | Thiacloprid 21.7 SC          | 0.021%        | 32.15 (34.51)                         | Slightly harmful |
| T8            | Azadirachtin 5% w/w          | 0.002%        | 10.50 (18.91)                         | Harmless    |
| T9            | Control (Water)              |               | 4.74 (12.52)                          | -           |

*F* test: Sig. S.E.(m) C.D. at 5%

|       | Sig. | 1.58  | 1.08  |
|-------|------|-------|-------|
| C.D.  | 4.61 | 3.16  |       |

(Figures in parentheses are arc sine values)

From the data represented in table 1, 2 and 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.

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.

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