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Contact toxicity of different insecticides against egg parasitoid, *Trichogramma japonicum* Ashmead under laboratory condition

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Abstract
The present investigation was undertaken to evaluate the contact toxicity of seven different insecticides against female adult of *Trichogramma japonicum*. The results indicated that none of the insecticide was found safer except control treatment to the female of *T. japonicum* under contact toxicity trial during the present investigation. However, insecticides *viz.*, Flubendiamide 39.35 SC, chlorantraniliprole 18.5 SC and lambda-cyhalothrin 5 EC were considered as slightly harmful. Furthermore, thiamethoxam 25 WG and thiacloprid 21.7 SC were found moderately harmful to the female of *T. japonicum*. Moreover, fipronil 5 SC and quinalphos 25 EC were found detrimental and grouped as harmful to the female of *T. japonicum* by causing cent per cent adult mortality.

Keywords: *Trichogramma japonicum*, insecticides, contact toxicity

Introduction
Biological control agents are the most significant strategies in integrated pest management programme. Among the several biological control agents successfully adopted in the pest management strategies, Trichogrammatid wasps are one of the most dominant groups of bio-control agents with prominent attention for the management of lepidopteran pests throughout the world. Among the different genus of family Trichogrammatids, *Trichogramma* is the best-known genus in the family due to its use in the biological control programme. *Trichogramma sp*. (Hymenoptera; Trichogrammatidae) are tiny wasps that occur naturally in most terrestrial ecosystems. Worldwide, a total area of more than 32 million ha of agricultural and forest lands has been annually released *Trichogramma* spp. to control insect pests in 19 countries [24]. In India, about 28 Trichogrammatids are recorded against major insect pest [25]; among them, *Trichogramma chilonis* Ishii, *Trichogramma japonicum* Ashmead, and *Trichogramma acheae* Nagaraja and Nagarkatti are important species. Furthermore, *T. japonicum* is an important hymenopteran egg parasitoid used for the management of different pests *viz.*, rice stem borer, sugarcane borers' complex, etc. Despite the crucial role of the biological control agents in agriculture, synthetic chemical insecticides are still indispensable and these broad-spectrum insecticides significantly reduce the potential of the biocontrol agents in general and in particular to parasitic Hymenoptera that are often highly susceptible to insecticides than their hosts. Insecticides may affect the effectiveness of bio-control agents either by causing direct mortality or by altering their behaviour, reproductive potential, and movement [5, 23]. However, the adverse effect on biocontrol agents usually depends on the intrinsic relative toxicity of insecticides, formulation, and concentration of chemicals applied, timing, and special pattern used for application as well as environmental factors. Better results can be ascertained in the IPM programme by a judicious combination of the natural enemies and selective insecticides that will give effective management of the pest without causing much harm to natural enemies [10, 13]. Moreover, the efficacy of *Trichogramma* is diminishing due to the extensive use of insecticides, as they are sensitive to most of the pesticides [12]. Therefore, an attempt was made by considering the importance of *Trichogramma* spp. in general and *T. japonicum* in particular for their safety against different common and new generation insecticides during the present investigation.

Materials and Methods
The present investigation was undertaken at Bio-control Laboratory, Department of Entomology, N.M.C.A., Navsari Agricultural University, Navsari.

Insecticidal solutions of pre-decided concentrations (Table-1) were prepared in a glass beaker of 1 litre capacity and evaluated for their relative toxicity to the egg parasitoid, *T. japonicum* through contact toxicity.

Mass culture of *Corcyra cephalonica* and egg parasitoids, *T. japonicum*

The rice moth, *C. cephalonica* and *T. japonicum* were reared in Bio-control Laboratory, Department of Entomology, N.M.C.A., NAU, Navsari. Sterilized sorghum grains were used as feed for the factitious host, *C. cephalonica* and eggs of *Corcyra* were used for the culture of *T. japonicum*. The mass production of *C. cephalonica* under laboratory conditions was made as per the methodology suggested by Naganna and Shinde (2017) [16]. The eggs of Corcyra laid were collected and cleaned to remove the impurities *viz.*, scales and other body parts of the moths by rolling them on blotting paper. Cleaned eggs of *C. cephalonica* were exposed to Ultra Violet (U.V) radiation in a U.V chamber for 45 minutes at a height of 42 cm to kill the embryo [19]. These eggs were used for the preparation of Trichocards. One Cubic Centimetre (cc) eggs of *Corcyra* were sprinkled on each card smeared with a thin layer of diluted acacia gum with the help of a 5 ml plastic vial having a perforated lid. After proper drying, the individual egg card was introduced in a plastic jar (15 cm × 25 cm) having freshly emerged adults of *T. japonicum*. Adults of *T. japonicum* were fed with 5 per cent honey solution in the form of a fine streak on the inner wall of the bottle. Adults were allowed to parasitize *Corcyra* egg cards for 24 hours. The blackening of *Corcyra* eggs in the card indicated parasitization and these cards were kept as such for the emergence of adult parasitoids for further rearing during this investigation.

Table 1: Details of insecticidal treatment used against *T. japonicum* under laboratory condition

Treat No.	Name of insecticide	Formulation	Concentration (%)	Dose /1L of Water
T_1	Flubendiamide	39.35 SC	0.005	0.12 ml
T_2	Chlorantraniliprole	18.5 SC	0.003	0.16 ml
T_3	Fipronil	5 SC	0.007	1.4 ml
T_4	Thiacloprid	21.7 SC	0.01	0.46 ml
T_5	Quinalphos	25 EC	0.025	1.0 ml
T_6	Lambda- cyhalothrin	5 EC	0.0005	0.1 ml
T_7	Thiamethoxam	25 WG	0.003	0.12 g
T_8	Control (Treated with water)	--	--	--

Contact toxicity of various insecticides against *T. japonicum*

Contact toxicity of various insecticides (Table-1) was determined as per methodology suggested by Jalali and Singh [7] with slight modifications. A transparent plastic container (6.5 cm × 5 cm) with a tight lid was converted into a pesticide - testing unit by cutting a small window on two sides and closing them with the fine muslin cloth, glued with waterproof glue to avoid the fumigant effect of insecticides and to provide aeration. The prepared solutions of various insecticides were sprayed on all inner sides of the respective container and lid with an atomizer and both were then air-dried thoroughly under a ceiling fan for about 15-20 minutes. In the control treatment, only water spray was made during the present investigation. Thereafter, twenty newly emerged females were introduced inside each vial and exposed to the treated surface freely. Five per cent honey solution was also provided in the form of the fine streak as adult food. Observation on the adult mortality was recorded at 0 (after 2 hours), 12, 24, 48 and 72 hours after constant exposure. The moribund adults were considered as dead. Thus, the data obtained on per cent adult mortality were subjected to arcsine transformation and analyzed by using Split-Plot Completely Randomized Design for interpretation of results during the present investigation. For the laboratory screening of different insecticides to test their safety to adults, the response of toxicant exposure to *Trichogramma* adult female was categorized based on per cent adult mortality and further scores were assigned as follows (Anonymous, 1994) [2].

Sr. No.	Category	Adult mortality (%)	Toxicity score
1	Harmless	<50	1
2	Slightly harmful	50 to 79	2
3	Moderately harmful	80 to 99	3
4	Harmful	>99	4

Results and Discussion

The contact toxicity of seven promising insecticides was tested against female *T. japonicum* at laboratory condition. The data in terms of per cent adult mortality recorded at 0 hrs (2 hrs), 12, 24, 48 and 72 hours after insecticide treatment (HAT) are presented in Table-02 and depicted in Figure-01 and discussed as hereunder.

The data obtained at 0 hrs (2 hrs) after treatment revealed that no adult mortality was recorded in control (water spray), flubendiamide 39.35 SC, chlorantraniliprole 18.5 SC and lambda-cyhalothrin 5 EC. The perusal of the mortality data recorded at 12 hrs after insecticide treatment indicated that control treatment (0.00%) had nil adult mortality. Afterward, the treatment of flubendiamide39.35 SC recorded least adult mortality (32.50%) and found safer for the parasitoid adult at 12 hrs after treatment. Moreover, the treatment of insecticides *viz.*, fipronil 5 SC, thiacloprid 21.7 SC and quinalphos 25 EC caused cent per cent adult mortality and these were found harmful to female parasitic wasp at 12 hrs after treatment.

Table 2: Contact toxicity of different insecticides against adult female of *T. japonicum* under laboratory condition

Treat. No.	Treatments	Conc. (%)	Adult mortality (%) at different intervals					Treatment mean	Toxicity score
			0 (2 HAT)	12 HAT	24 HAT	48 HAT	72 HAT		
T_1	Flubendiamide 39.35 SC	0.005	6.42* (0.00)	34.74 (32.50)	59.20 (73.75)	83.58 (100.00)	83.58 (100.00)	53.50 (61.25)	2
T_2	Chlorantraniliprole 18.5 SC	0.003	6.42 (0.00)	69.39 (87.50)	83.58 (100.00)	83.58 (100.00)	83.58 (100.00)	65.31 (77.50)	2
T_3	Fipronil 5 SC	0.007	83.58 (100.00)	83.58 (100.00)	83.58 (100.00)	83.58 (100.00)	83.58 (100.00)	83.58 (100.00)	4

T_4	Thiacloprid 21.7 SC	0.01	50.04 (58.75)	83.58 (100.00)	83.58 (100.00)	83.58 (100.00)	83.58 (100.00)	76.87 (91.75)	3
T_5	Quinalphos 25 EC	0.025	81.96 (97.81)	83.58 (100.00)	83.58 (100.00)	83.58 (100.00)	83.58 (100.00)	83.26 (99.75)	4
T_6	Lambda- cyhalothrin 5EC	0.0005	6.42 (0.00)	48.60 (56.25)	83.58 (100.00)	83.58 (100.00)	83.58 (100.00)	61.15 (71.25)	2
T_7	Thiamethoxam 25 WG	0.003	27.34 (21.25)	64.61 (81.25)	83.58 (100.00)	83.58 (100.00)	83.58 (100.00)	68.54 (80.50)	3
T_8	Control (water)	--	6.42 (0.00)	6.42 (0.00)	6.42 (0.00)	29.85 (25.00)	38.44 (38.75)	17.51 (12.75)	1
Period mean			33.58 (34.73)	59.31 (69.69)	70.89 (84.22)	76.86 (90.63)	77.94 (92.34)		

	S. Em ±	C.D. at 5%	C.V. (%)
Treatment	0.40	1.17	2.81
Period	0.29	0.81	2.53
T × P	0.81	2.26	--

* Figures outside the parentheses are arc sine transformed values while those inside the parentheses are original values.
HAT = Hours after Treatment

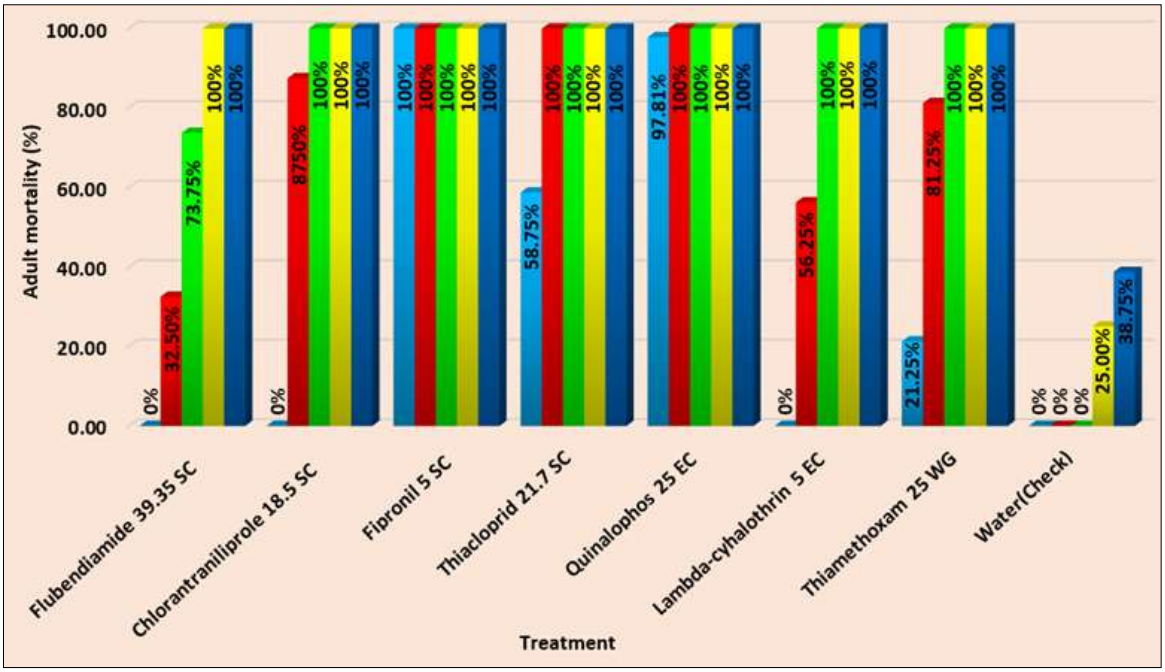

Fig 1: Contact toxicity of different insecticides against adult female of *T. japonicum* under laboratory condition

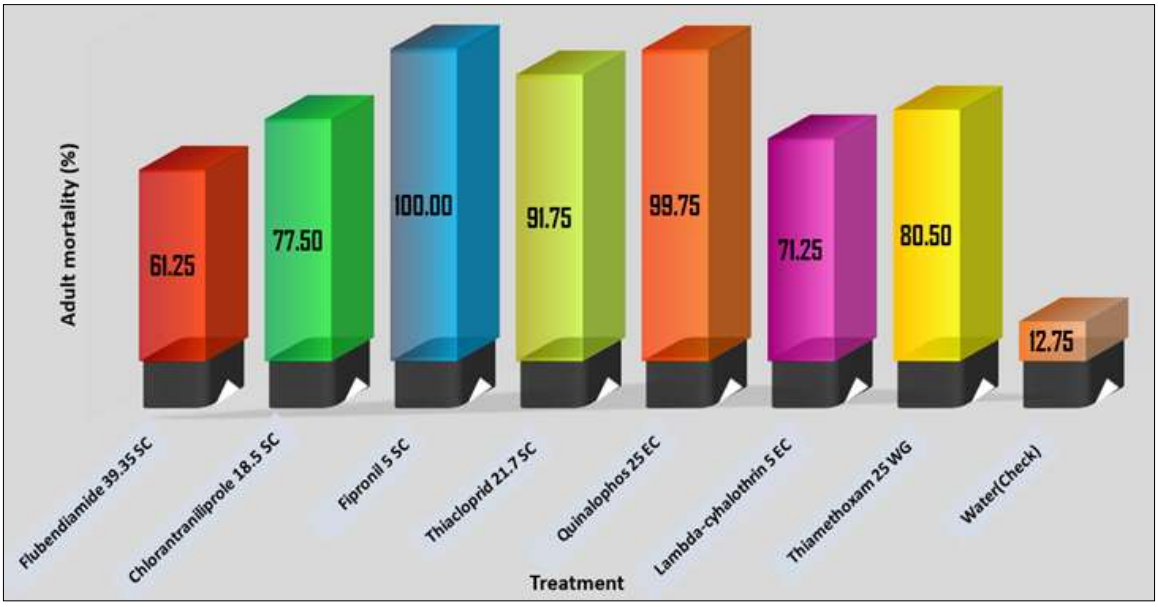

Fig 2: Contact toxicity of different insecticides against adult female of *T. japonicum* under laboratory condition (Based on treatment mean)

It can be seen from the data obtained at 24 hrs after treatment that no adult mortality was observed with control treatment whereas the treatment of insecticides *viz*, chlorantraniliprole 18.5 SC, fipronil 5 SC, thiacloprid 21.7 SC, quinalphos 25 EC, lambda-cyhalothrin 5 EC and thiamethoxam 25 WG caused cent percent mortality of parasitoid adult and were considered as harmful to adults of *T. japonicum* at 24 hrs after treatment. The data on adult mortality at 48 hrs after treatment indicated that exposure of all insecticides *viz*, flubendiamide39.35 SC, chlorantraniliprole 18.5 SC, fipronil 5 SC, thiacloprid 21.7 SC, quinalphos 25 EC, lambda-cyhalothrin 5 EC and thiamethoxam 25 WG were found

harmful to the female wasp showing cent per cent adult mortality at 48 hrs after treatment.

At 72 hrs after exposure, control treatment had 38.75 per cent adult mortality while all the tested insecticides were found detrimental to *T. japonicum* female and categorized under harmful to the female at 72 hrs after treatment.

Looking to the overall mean data on the per cent adult mortality at 0 (2 hrs), 12, 24, 48 and 72 hrs after treatment presented in Table-02 and depicted graphically in Figure-02, the results revealed that significantly lowest adult mortality of female of *T. japonicum* was recorded with control treatment (12.75%). This was followed by flubendiamide39.35 SC (61.25%) and lambda-cyhalothrin 5 EC (71.25%). Further, fipronil 5 SC showed cent per cent adult mortality of parasitic wasp and it was considered as deadly harmful to the adult of *T. japonicum.* Moreover, the toxicity of remaining insecticides was intermediate in action *viz.*, quinalphos 25 EC (99.75%), thiacloprid 21.7 SC (91.75%), chlorantraniliprole 18.5SC (77.50%) and thiamethoxam 25 WG (80.50%).Thus, based on the above results, it can be concluded that the contact toxicity of different treatments to the *T. japonicum* adults in ascending order were control (water) < flubendiamide39.35 SC < lambda-cyhalothrin 5 EC < chlorantraniliprole 18.5% SC < thiamethoxam 25 WG < thiacloprid 21.7 SC < quinalphos 25 EC < fipronil 5 SC. Based on the above results, the ranking of the various insecticides was made and presented hereunder.

Toxicity score	Category	Perceived insecticides
1	Harmless (<50% mortality)	Nil
2	Slightly harmful (50 to 79% mortality)	Flubendiamide39.35 SC Chlorantraniliprole 18.5 SC Lambda-cyhalothrin 5 EC
3	Moderately harmful (80 to 99% mortality)	Thiacloprid 21.7 SC Thiamethoxam 25 WG
4	Harmful (>99% mortality)	Fipronil 5 SC Quinalphos 25 EC

From all the above results, it is ascertained that none of the insecticide was found safer except control treatment to the adults of *T. japonicum* under contact toxicity trial during the present investigation. However, insecticides *viz.*, Flubendiamide 39.35 SC, chlorantraniliprole 18.5 SC and lambda-cyhalothrin 5 EC were considered as slightly harmful. Furthermore, thiamethoxam 25 WG and thiacloprid 21.7 SC were found moderately harmful to the adults of *T. japonicum*. Moreover, fipronil 5 SC and quinalphos 25 EC were found detrimental and grouped as harmful to adults of *T. japonicum* (Figure-03). The present investigation demonstrated that a high degree of variation with respect to effect was found among the tested insecticides and various insecticides possessed significantly different risks to the adults of *T. japonicum*, which could provide the useful information for integration of biological control with chemical control. The present findings are corroborated with the results reported by Sun *et al.* (2008) [21] who noticed that fipronil and thiamethoxam had detrimental effect on survival of adult *T. japonicum* and found harmful to adult wasp. Later on, Pawar *et al.* (2020) [16] classified thiamethoxam as moderately harmful to adults of *T. japonicum* whereas Khan (2019) [9] showed that fipronil caused cent per cent mortality of *T. chilonis* within 24 hrs of exposure to 1-day old pesticide residue and categorized as harmful insecticide. Furthermore, Preetha *et al.* (2009) [17] and Ko *et al.* (2015) [11] reported that thiamethoxam was most toxic to adults of *T. chilonis* among all the investigated insecticides. Cheng *et al.* (2018) [4] reported that thiamethoxam was found moderately harmful to adults of *T. dendrolimi* and *T. ostriniae* and slightly toxic to the adultsof *T. chilonis*. The result further noted that cyhalothrin was considered as slightly harmful to adult wasp of *T. dendrolimi* and *T. ostriniae* while it was found moderately harmful to the adults of *T. chilonis* which is more or less in accordance with the present findings. In contrast to above scientists, Uma *et al.* (2014) [22] categorized thiamethoxam and fipronil as slightly harmful to *T. japonicum* adults. Further, according to Zhao *et al.* (2012) [26], the fipronil, thiacloprid and lambda-cyhalothtrin was found harmless to the adults of *T. japonicum* whereas thiamethoxam was considered as slightly harmful to adult wasp during the investigation which again differs with the present investigation. Jiang *et al.* (2019) [8] reported that thiacloprid and thiamethoxam were found slightly harmful to the adults of all three tested trichogramma parasitoid *viz.*, *T. dendrolimi*, *T. ostriniae* and *T. confusum* which disagrees with the present investigation.

Lateron, Pawar *et al.* (2020) [16] who discovered that lambda-cyhalothrin caused cent per cent mortality of adult *T.Japonicum* and classified as harmful to adult wasp while thiacloprid was categorized as slightly harmful to adults of *T. japonicum.* The findings of present investigation disagree with Abdulhay and Rathi (2014) [1] who demonstrated that thiacloprid listed as slightly harmful to the adult of *T. evanescens* and Carvalho *et al.* (2006) [3] who reported that thiamethoxam, thiacloprid and lambda-cyhalothrin were categorized as harmless, slightly harmful and moderately harmful to the adult of *T. pretiosum*, respectively.The present investigation showed that flubendiamide and chlorantraniliprole were slightly harmful to the *T. japonicum* adults which is in line of the findings of past workers *viz.*, Uma *et al.* (2014) [22] and Pawar *et al.* (2020) [16] who found that flubendiamide was categorized as slightly harmful to adults of *T. japonicum* and Hussain *et al.* (2012) [6] who revealed that flubendiamide and chlorantraniliprole showed toxic effect on the adults of *T. chilonis* after 24 hrs of exposure with 14 and 8 per cent adult survival, respectively. Moreover, Sattar *et al.* (2011) [18] recorded that flubendiamide was categorized as harmless with 28 per cent mortality of *T. chilonis* adult after 24 hours of exposure. A number of workers such as, Khan (2019) [9] and Preetha *et al.* (2009) [17] listed chlorantraniliprole was harmless to *T. chilonis* while, Uma *et al.* (2014) [22] and Pawar *et al.* (2020) [16] recorded chlorantraniliprole was harmless to adult *T. japonicum*. The findings of Singh and Varma (1986) [20] also support the present investigation that quinalphos caused cent per cent mortality of adults of *T. brasiliensis* at 24 hrs after treatment. In contrast to this, Uma *et al.* (2014) [22] reported that quinalphos was slightly harmful to adults of *T. japonicum.* Furthermore, findings of some workers disagree with the present findings. This discrepancy in contact toxicity of various insecticides against female of *T. japonicum* might be due to doses of insecticides used, tested insecticides and methodology adopted for their investigation.

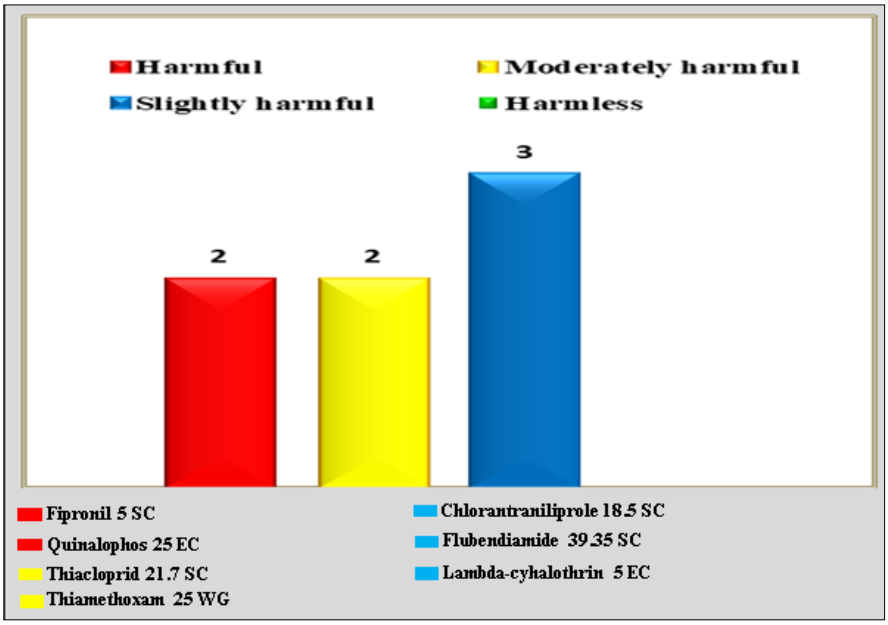

Fig 3: Classification of different insecticides based on their contact toxicity against adult female of T. japonicum under laboratory condition

Conclusion

The present investigation indicated that there was no insecticide under testing found totally safer to the *T. japonicum*. Hence, the use of moderately harmful and harmful insecticides should be avoided upto 72 hrs after release of parasitoid as well as during the peak activity period of parasitoid under field condition. Moreover, keeping the view of possible detrimental effect of the tested insecticides, the integration of these insecticides should be considered with utmost care during the implementation of IPM programme in agro-ecosystem.

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