Pakistan J. Zool., vol. 47(5), pp. 1427-1432, 2015.

Insecticidal Susceptibility and Effectiveness of *Trichogramma chilonis* as Parasitoids of Tomato Fruit Borer, *Helicoverpa armigera*

Dilbar Hussain,[1] Hussain Ali,[2]* Muhammad Qasim[3] and Juma Khan[3]
[1]*Entomological Research Institute, Faisalabad 38000, Pakistan*
[2]*Entomology Section, Agricultural Research Institute, Tarnab, Peshawar 25000, Pakistan*
[3]*Department of Agricultural Entomology, University of Agriculture, Faisalabad 38000, Pakistan*

Abstract.- Tomato fruit borer, *Helicoverpa armigera* (Hübner) is a serious pest of many crops tomato, cotton and okra in Pakistan. Experiments were conducted to find out effectiveness of the *Trichogramma chilonis* against *Helicoverpa armigera* in field and effects of commonly used insecticide on *Trichogramma chilonis* under lab condition. Experiments were conducted with three replicated trials at Faisalabad for three years in different villages. Egg card of *Trichogramma* @ 300, 400, 500 and 600 eggs/card were used once. Percentage of effectiveness of *Trichogramma* against tomato fruit borer was calculated, which was increased with the increasing of card numbers 65.00% (2010), 48.09% (2011) and 83.51% (2012) after 4th release of *Trichogramma* @ 600 eggs/card, but it was least (00.00%) in control conditions during whole trial period. Similarly study of adult emergence of *T. chilonis* was also studied during 2010-11 at Entomological laboratory, Ayub Agricultural Research Institute, Faisalabad against frequently used field insecticides, Proclaim 1.9Ec, Steward 150 SC, Match 50EC, Talstar 10EC, Tracer 240SC, Advantage 20EC, Chlorpyrifos 40EC, Triflumuron 20SC, Imidacloprid 200SL and Abamectin 1.8EC. After one week adult emergence remained 42.50-63.50% during 2010 and 44.60-64.80% in 2011, which proved that Proclaim 1.9EC, Match 50EC, Triflumuron 20SC and Imidacloprid 200SL were found safe against *T. chilonis* adult emergence and can be used in fields with cards for management of *H. armigera.*

K**ey words:** Tomato, *Trichogramma chilonis, Helicoverpa armigera*.

INTRODUCTION:

Tomato (*Lycopersicon esculentum* Miller) is well known and second major vegetable crop of Pakistan, occupying an area of 63 thousand hectares during 2009-10 (Minfal, 2011). It is enriched with significant amount of the vitamin A and C (Mirza, 2007). Tomato production is greatly challenged by many factors, diseases and attack of some insect pests which significantly damaged the crop (Fry and Goodwin, 1997). Among the insects pests of tomato, tomato fruit borer *Helicoverpa armigera* (Hübner) is most serious and destructive pest. It is a multivoltine and polyphagous pest attacking many agricultural and vegetable crops throughout the world (Cunningham *et al.*, 1999).

Young larvae feed on foliage, buds and flowers, while older larvae feed on the fruits. Tomato is more susceptible to insect pests and diseases mainly due to their sensitiveness and softness as compared to other crops, mainly because of its tenderness and softness. Tomato yield was decreased up to 35 to 38% due to tomato fruit borer in India (Dhandapani *et al.*, 2003). On the other hand, $250 million losses were increased due to insecticide applications for management of *Helicoverpa* spp in USA alone (Anonymous, 1976; Johnson *et al.*, 1986).

Insecticides used for the management of insect pests of different crops, caused the resistance and resurgence development in insects as well as environmental and health hazards. Due to that, integrated pest management (IPM) trends replaced insecticidal management. Similarly, *H. armigera* populations were managed through host plant resistance along with other methods such as botanicals and insecticides application (Lukefahr, 1981). Parasitoids, *Trichogramma chilonis* are well known due to efficiency and multiplication (Parra and Zucchi, 2004), used to control *Neoleucinodes elegantalis* (Guenée) in tomato in Brazil (Blackmer *et al.*, 2001).

T. chilonis survives in wide range habitats and attacks insect pests at different stages responding to target species. It parasitizes

* Corresponding author: hussaintanha@yahoo.com
0030-9923/2015/0005-1427 $ 8.00/0

lepidopteron eggs and caterpillars of field crops, forests and fruits (Zucchi *et al.*, 2010).

Trichogramma parasitism level fluctuate significantly in diverse habitats, plants or plant structures on which the host eggs are located. The Plant structure, plant chemistry, plant volatiles and plant color are considered as vital (Jorg *et al.*, 2005). The success behind the *Trichogrammma* is their dispersal. They rapidly dispersed in the field and attack the target organism (Jeffrey *et al.*, 2012).

Different species of *Trichogramma, T. evanescens, T. poliae and T. chilonis* are being reared in private or government laboratories and used as natural enemy of agricultural insect pests in the world (Li, 1994; Hoffmann *et al.*, 2001). Muhammad *et al*. (2008) reported that *T. chilonis* have high effectiveness if combined with other control strategies. Biocontrol Lab of NIAB, Biocontrol lab of Ramzan Sugar mills and Biocontrol lab of Madinah Sugar mills are some laboratories which are producing *Trichogramma* cards commercially.

This study was carried to determine 1. The efficiency of *T. chilonis* in field conditions against tomato fruit borer, *H. armigera* and 2. Effect of different insecticides on potential adult emergence of *T. chilonis* under laboratory condition.

MATERIALS AND METHODS

Field trials

Trials were conducted in different villages (Chak 72/GB and Chak 118/GB) and at Ayub Agricultural Research Station at Faisalabad, Pakistan between 2010-2012. The experiment was laid out in Randomized Complete Block Design (RCBD) replicated three times. Trials were conducted for three years, having a plot size of 15 × 10 m. *T. chilonis* @ 300, 400, 500 and 600 eggs/card were used, cards were obtained from Trichogramma Lab, Entomological Research Institute, Faisalabad. A buffer zone of 2 meter was maintained for treatments. Cards were installed weekly on pest appearance in the field and continued till crop maturity. Percent fruit infestation (*H. armigera*) was recorded from 10 randomly selected plants per plot at weekly interval.

Determination of comparatively safe insecticides against T. chilonis, *under laboratory conditions*

Experiment was laid out in CRD having eleven treatments with five repeats each for two years in laboratory at Entomological Department, Ayub Agricultural Research Institute, Faisalabad, Pakistan during 2010-2011. The insects were tested under laboratory conditions at 25±2°C and 70±5% RH. All treatment were applied under laboratory conditions. The applied insecticides were Proclaim 1.9EC (Emamectin benzoate, nerve poison), Steward 150 SC (Indoxacarb, nerve poison), Match 50EC (Lufenuron, nerve poison), Talstar 10EC (Bifenthrin, nerve poison), Tracer 240 SC (Spinosad, contact and nerve), Advantage 20EC (Carbosulfan, contact and nerve poison), Chlorpyrifos 40EC (Chlorpyrifos, nervous system, the cardiovascular system and the respiratory system), Triflumuron 20SC (triflumuron, *insect* growth regulator), Imidacloprid 200SL (Imidacloprid, nerve poison) and Abamectin 1.8EC (Avermectin, nerve poison). The insecticides were used at the field recommended doses. Developmental egg stages of *T. chilonis* were tested. Five randomly selected egg cards containing 100 host eggs were dipped into each treatment and data were recorded after 1st, 2nd, 4th, 5th and one week. Controls were left untreated for comparison. Data were recorded on the basis of adult emergence.

Statistical analysis

Analysis of variance (ANOVA) was carried out to determine effectiveness of *T. chilonis* against *H. armigera*, by using statistical program MSTAT-C. Similarly, least significant differences (LSD) were calculated with Duncan's Multiple Range test for adult emergence of *T. chilonis* against insecticidal exposures by using MSTAT-C at a significance level of $P<0.05$ (Freed *et al.*, 1989).

RESULTS AND DISCUSSION

Table I shows the percent effect of *T. chilonis* against *H. armigera* in 2010, 2011 and 2012. In the first week of 2010, maximum infestation was found in control (33.37%), which are not significantly different than other treatments. In 2nd, 3rd and 4th weeks significant differences were found among the

Table I.- Effectiveness of *Trichogramma chilonis* against *Helicoverpa armigera* in 2010, 2011, and 2012.

Treatment eggs/ card	Pre-treatment infestation (%)	Percentage effectiveness after release of *T. chilonis*							
		1st Week		2nd Week		3rd Week		4th Week	
		Infestation	Effectiveness	Infestation	Effectiveness	Infestation	Effectiveness	Infestation	Effectiveness
2010									
Control	28.37	33.37 a	00.00	44.09 a	00.00	43.96 a	00.00	43.56 a	00.00
300	29.05	30.56 a	00.00	22.68 b	22.00	10.85 c	44.00	19.45 b	33.00
400	28.19	32.18 a	00.00	19.51 b	31.00	15.75 b	45.00	17.07 bc	40.00
500	26.71	32.12 a	00.00	18.80 b	30.00	12.80 b	52.00	12.87 cd	65.00
600	28.63	32.17 a	00.00	18.39 b	37.00	10.48 c	64.00	10.18 d	65.00
LSD 5%		3.55		4.15		3.77		6.22	
2011									
Control	21.86	21.92 a	00.00	22.66 a	00.00	24.99 a	00.00	24.31 a	00.00
300	17.26	17.97 a	00.00	14.23 b	17.50	13.79 b	20.11	12.86 b	25.40
400	15.58	16.83 a	00.00	13.97 b	10.59	11.38 b	26.90	9.78 b	37.20
500	16.10	18.34 a	00.00	11.67 b	27.50	10.71 b	33.40	8.85 b	45.00
600	17.03	16.95 a	00.00	12.61 b	25.90	11.82 b	30.48	9.61 b	43.00
LSD 5%		7.21		6.43		8.67		7.59	
2012									
Control	20.71	23.18 a	0.00	25.71 a	0.00	27.04 a	0.00	30.34 a	0.00
300	19.63	22.91 a	0.00	8.79 b	55.67	12.70 b	35.96	13.47 b	32.07
400	26.90	27.01 a	0.00	6.01 b	77.65	13.51 b	49.77	12.78 b	52.49
500	27.45	30.19 a	0.00	5.37 b	80.43	8.14 b	70.34	6.19 c	77.45
600	25.96	26.17 a	0.00	6.21 b	76.07	7.33 c	71.36	4.28 c	83.51
LSD 5%		7.34		9.35		8.11		4.19	

Means followed by the same letters within each column are not significantly different at 5 % level of probability.

control and treatments. Maximum infestation was found in control while minimum was found in plot treated with 600 eggs/card and maximum effectiveness was also found. Plots having 500 and 600 eggs/card showed maximum effectiveness (65%).

In the year 2011 no significant differences among the treatments and control in 1st week, however a significant differences can be found in the next three weeks. Control has maximum infestation, 22.66%, 24.99% and 24.31% for 2nd, 3rd and 4th week respectively. Minimum infestation was found in treated plots. All the treated plots showed significant effectiveness as compared with control.

In 2012 experiment some promising results were found (Table I). The treatments were not effective against the borer in the first week of application. Effectiveness started from 2nd week till 4th week with significant differences among the control and treatments. Minimum infestation was recorded in all treated plots compare with control in 2nd week. In third week plot treated with 600 eggs/card showed minimum infestation (7.33%) and maximum effectiveness (71.36%). In 4th week maximum effectiveness were found in plots treated with 500 and 600 eggs/card.

Tables II and IV showed the results of *in vitro* experiments for the year 2010 and 2011. From the tables it is clear that some insecticides have very negative affect and can reduce the percent adult emergence while some pesticides showed less toxicity and maximum adult emergence was found. Insecticides in which a relatively good and satisfied adult results were Proclaim 1.9EC, Match 50EC, Triflumuron 20SC and Imidacloprid 200SL with adult emergence of *T. chilonis*, more than 50% emergence during laboratory application. Insecticides like Steward 150EC, Talstar 10EC, Tracer 240SC, Advantage 20EC, Chlorpyrifos 40EC and

Table II.- Percent adult emergence of *T. chilonis* at different treatment intervals under laboratory conditions in the year 2010 and 2011.

Treatment	Percentage adult emergence				
	1st day	2nd day	4th day	5th day	After week
2010					
Proclaim 1.9EC	72.00 b	59.901 b	61.00 b	66.50 b	63.50 b
Steward 150SC	00.00 d	00 e	0.50 d	1.50 c	00 d
Match 50EC	17.00 c	17.50 d	60.50 b	73.50 b	63.00 b
Talstar 10EC	00.00 d	0.00 e	1.50 d	0.00 c	1.00 d
Tracer 240 SC	00.50 d	4.50 e	2.00 d	5.00 c	1.50 d
Advantage 20EC	00.00 d	0.00 e	0.50 d	0.00 c	1.00 d
Chlorpyrifos 40EC	00.00 d	0.00 e	1.00 d	1.00 c	1.50 d
Triflumuron 20SC	89.50 a	42.50 c	69.90 b	75.50 b	57.00 b
Imidacloprid 200SL	66.83 b	18.52 d	19.50 c	68.00 b	42.50 c
Abamectin 1.8EC	00.00 d	0.50 e	4.50 d	00 c	0.00 d
Control	92.00 a	89.50 a	88.00 a	98.50 a	92.50 a
LSD 5%	9.54	7.99	6.90	11.69	8.89
2011					
Proclaim 1.9EC	63.50 a	53.00 a	49.50 b	61.80 a	55.00 b
Steward 150SC	0.50 e	0.00 e	0.00 d	1.10 d	0.00 d
Match 50EC	34.30 c	32.60 c	56.30 b	47.70 b	64.80 b
Talstar 10EC	10.30 d	1.70 e	11.40 c	0.00 d	0.00 d
Tracer 240 SC	0.00 e	12.30 d	3.30 d	7.90 c	3.50 d
Advantage 20EC	0.00 e	0.00 e	0.00 d	0.00 d	0.00 d
Chlorpyrifos 40EC	0.00 c	00.00 e	0.00 d	1.20 d	2.81 d
Triflumuron 20SC	36.90 c	38.90 c	65.00 a	73.00 a	59.00 b
Imidacloprid 200SL	53.40 b	41.00 b	11.00 c	60.70 a	44.60 c
Abamectin 1.8EC	0.00 e	0.00 e	0.00 d	00.00 d	0.00 d
Control	62.50 a	57.00 a	68.50 a	68.60 a	74.30 a
LSD 5%	7.83	6.94	10.07	7.65	8.82

Means followed by the same letters within each column are not significantly different at 5 % level of probability

Abamectin 1.8 EC were found more toxic and significantly less adult emergence was recorded during the two years. Highly mortality and less emergence were found in more toxic insecticides while in less toxic less mortality and high emergence were recorded.

It is revealed from our results that the *Trichogramma* cards are very good in managing *H. armigera* in field conditions as it controlled the pest population. The reasons are that *H.armigera* is a preferable food for *T. chilonis* and when suitable stage of the pest is available then results are promising. These results are in similarity with those of (Davies *et al.*, 2011) who reported the efficiency of *Trichogramma westwood* on *H. armegera* in cotton crop and suggested that *Trichogramma* alone can also give good result but if it combined with other control strategy so the efficiency will be increased, an integrated pest management (IPM) strategy was used. Cabello *et al.* (2012) used *Trichogramma* cards in green house for management of another lepidopterous borer (South American tomato pinworm) and found it very effective.

Effectiveness was increased with passage of time along with each release up to one month. But, with no more than single release infestation was boasted again in 4th week. Similar observation was found by Usman *et al.* (2012) who released 300 eggs/card and also combined with other methods such as in combination with *Chrysoperla carnea* and neem seed extract. They found that 300 eggs/card can also gave good results as compare with control but in a small area (8 x 5 m), further they recorded increase in the yield. Ayvaz *et al.* (2008) reported that *Trichogramma* is one of the

best biological control for management of many crop pest and specially *H. armigera* in many crops as the cost is less as compare to pesticides and safe to the environment.

The success is because of their dispersal ability and parasitizing performance. In first week of all three years there were no significant reduction in infestation and effectiveness but at 4th week infestation was reduced and effectiveness became high. These results are in line with those of Reddy and Manjunatha (2000) and Ayvaz *et al.* (2008) they observed significant decrease after 20 days of application in *H. armigera* in different crops such as cotton tomato. Further they noted that more than one application with proper interval can gave better management of *H. armigera* in different crop fields.

Among the ten applied insecticides some were found were toxic and cause minimum adult emergence, while some found to be safe compared with toxic one. Minimum adult emergence less than (5%) were found in Steward 150EC, Talstar 10EC, Tracer 240SC, Advantage 20EC, Chlorpyrifos 40EC and Abamectin 1.8 EC. Similar observation were found by Hewa-Kapuge *et al.* (2003), who recorded that some insecticides can cause 95% mortality with direct application. Some other studies showed that insecticides reduces egg hatching/adult emergence in *T. chilonis* and insecticides application can cause 70% mortality (Consoli *et al.*, 2001; Saber, 2011). Less adult emergence was found in cards treated with Tracer 240SC and Abamectin 1.8 EC after one week which confirms the finding of Hussain *et al.* (2012) and Vianna *et al*. (2009).

Similarly adult emergence was checked in laboratory but not much affected due to application of Proclaim 1.9 EC, Match 50EC, Triflumuron 20SC and Imidacloprid 200SL, showing more than 50% adult emergence. Some studies resulted that not all insecticides are toxic to *T. chilonis* and can used with this biological control agent in Integrated Pest Management (IPM) programs (Nasreen *et al.*, 2004). Our results also supports Hussain *et al.* (2012) as his observation that Proclaim 1.9 EC, Match 50EC and Imidacloprid 200SL to be safe and having little effect on adult emergence of *T. chilonis* under laboratory conditions. Vianna *et al.* (2009) also reported that Match 50EC and Triflumuron 20SC had lowest negative effects on parasitism and viability of individuals of *Trichogramma pretiosum* populations. It is concluded that *T. chilonis* can be used for management of fruit borer alone but more promising result can be obtained and if it combined with other management strategy for integrated pest management approach of *H. armigera*.

REFERENCES

ANONYMOUS, 1976. Agricultural Research Service. ARS. Nalt. *Heliothis* Planning Conf. New Orleans. La, US. Department of Agriculture. Washington D.C. p. 36.

AYVAZ, A., KARASU, E., KARABORKLU, S. AND YILMAZ, S., 2008. Dispersal ability and parsitizion performance of egg parasitoid *Trichogramma evanescene* Westwood (Hymenoptera: Trichogrammatidae) in field and storage conditions. *Turk. J. Biol*., **32**: 27-33.

BLACKMER, J.L., EIRAS, A.E. AND SOUZA, C.L.D., 2001. Oviposition preference of *Neoleucinodes elegantalis* (Guenée) (Lepidoptera: Crambidae) and rates of parasitism by *Trichogramma pretiosum* Riley (Hymenoptera: Trichogrammatidae) on *Lycopersicon esculentum* in São José de Ubá, RJ, Brazil. *Neot. Ent.*, **30**: 89-95.

CABELLO, T., GALLEGO, J.R., FERNANDEZ, F.J., GAMEZ, M., VILA, E., PINO, M.D. AND HERNANDEZ, S.E., 2012. Biological control strategies for the South American tomato moth (Lepidoptera: Gelechiidae) in greenhouse tomatoes. *J. econ. Ent*., **105**: 2085-2096.

CONSOLI, F., BOTELHO, P. AND PARRA, J., 2001. Selectivity of insecticides to the egg parasitoid *Trichogramma galloi* Zucchi, 1988, (Hymenoptera: Trichogrammatidae). *J. appl. Ent.*, **125**: 37-43.

CUNNINGHAM, J., ZALUCKI, M. AND WEST, S., 1999. Learning in *Helicoverpa armigera* (Lepidoptera: Noctuidae): a new look at the behaviour and control of a polyphagous pest. *Bull. entomol. Res.*, **89**: 201-208.

DAVIES, A.P., CARR, C.M., SCHOLZ, B.C. AND ZALUCKI, M.P., 2011. Using *Trichogramma* Westwood (Hymenoptera: Trichogrammatidae) for insect pest biological control in cotton crops: an Australian perspective. *Aus. J. Ent.*, **50**: 424-440.

DHANDAPANI, N., SHELKAR, U.R. AND MURUGAN, M., 2003. Bio-intensive pest management (BIPM) in major vegetable crops: an Indian perspective. *J. Fd. Agric. Environ.*, **1**: 330-339.

FREED, R.D., EVERSON, E.H., WEBER, M., PAUL, E. AND ISLEIB, D., 1989. *MSTAT-c user's guide: A microcomputer program for the design, management, and analysis of agronomic research experiments.* Michigan State University, East Lansing.

FRY, W.E. AND GOODWIN, S.B., 1997. Re-emergence of

potato and tomato late blight in the United States. *Pl. Dis.,* **81**: 1349-1357.

HEWA-KAPUGE, S., MCDOUGALL, S. AND HOFFMANN, A.A., 2003. Effects of methoxyfenozide, indoxacarb, and other insecticides on the beneficial egg parasitoid *Trichogramma nr. brassicae* (Hymenoptera: Trichogrammatidae) under laboratory and field conditions. *J. econ. Ent.,* **96**: 1083-1090.

HOFFMANN, M.P., ODE, P.R., WALKER, D.L., GARDNER, J., VAN NOUHUYS, S. AND SHELTON, A.M., 2001. Performance of *Trichogramma ostriniae* (Hymenoptera: Trichogrammatidae) reared on factitious hosts, including the target host, *Ostrinia nubilalis* (Lepidoptera: Crambidae). *Biol. Cont.,* **21**:1-10.

HUSSAIN, D., ALI, A., MUSHTAQ-UL-HASSAN., M., ALI S., SALEEM, M. AND NADEEM, S., 2012. Evaluation of toxicity of some new insecticides against egg parasitoid *Trichogramma chilonis* (Ishii) (Hymenoptera: Trichogrammitidae). *Pakistan. J. Zool*., **44:** 1123-1127.

JEFFREY, G., WRIGHT, M.G., THOMAS, P.K., SYLVIE, A.P. AND MICHAEL, P. H., 2012. Dispersal of *Trichogramma ostriniae* in field corn. *Biol. Sci. Tech*., **22**: 1221-1233.

JOHNSON, S.J., KING, E. AND BRADLEY, J.R., 1986. Theory and tactics of Heliothis population management: I-Cultural and biological control. *South. Coop. Ser. Bull*., **316**: 161-162.

JORG, R., DIRK, B., FELIX, L.W. AND THOMAS, G.S., 2005. Habitat and plant specificity of *Trichogramma* egg parasitoids underlying mechanisms and implications. *Basic appl. Ecol.* **6**:215-236.

LI, L.Y., 1994. *Worldwide use of* Trichogramma *for biological control on different crops: A survey. Biological control with egg parasitoids*. CAB International, pp. 37-53.

LUKEFAHR, M., 1981. *A review of the problems, progress, and prospects for host-plant resistance to* Heliothis *species.* International Workshop on *Heliothis* Management. ICRISAT, India. *Heliothis* Management, pp. 223-231.

MINFAL, 2011. *Agricultural statistics of Pakistan. 2009-10*. Govt. of Pakistan, Ministry of Food, Agriculture and Livestock. Food, Agri. and Livestock Div. (Economic Wing) Islamabad. 84-85.

MIRZA, I., 2007. *Tomato paste plant to be set up at Killa Saifullah*. Available at http://www.pakissan.com/ english/news/ news Detail.php?newsid = 15041.

MUHAMMAD, S., ASHFAQ, M., HASAN, M. AND RANA, S.A., 2008. Integration of some bio pesticides and *T. chilonis* for the sustainable management of rice leaf folder, *Cnaphalocrocis Medinalis* (Guenee) (Lepidoptera: Pyralidae). *Pakistan J. agric. Sci.*, **45:** 69-74.

NASREEN, A., MUSTAFA, G., ASHFAQ, M, AND SALEEM, M.A., 2004. Combined effect of *Chrysoperla carnea* Stephen (Neuroptera: Chrysopidae) and *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae) on *Helicoverpa armigera* eggs in the presence of insecticides. *Pakistan. J. Zool.,* **36**: 189-192.

PARRA, J.R. AND ZUCCHI, R.A., 2004. *Trichogramma* in Brazil: feasibility of use after twenty years of research. *Neo. Ent*., **33**: 271-281.

REDDY, G.V.P AND MANJUNATHA, M., 2000. Laboratory and field studies on the integrated pest management of *Helicoverpa armigera* in cotton, based on performance trap catch threshold level. *J. appl. Ent.,* **125**: 212-216.

SABER, M., 2011. Acute and population level toxicity of imidacloprid and fenpyroximate on an important egg parasitoid, *Trichogramma cacoeciae* (Hymenoptera: Trichogrammatidae). *Ecotoxicology,* **20**: 1476-1484.

USMAN, M., INAYATULLAH, M., USMAN, A., SOHAIL, K. AND SHAH, S.F., 2012. Effect of egg parasitoid, *Trichogramma chilonis*, in combination with *Chrysoperla carnea* and neem seed extract against tomato fruitworm, *Helicoverpa armigera*. *Sarhad J. Agric.*, **28:** 253-257.

VIANNA, U.R., PRATISSOLI, D., ZANUNCIO, J.C., LIMA, E.R., BRUNNER, J., PEREIRA, F.F. AND SERRAO, J.E., 2009. Insecticide toxicity to *Trichogramma pretiosum* (Hymenoptera: Trichogrammatidae) females and effect on descendant generation. *Ecotoxicology*, **18**: 180-186.

ZUCCHI, R.A., QUERINO, R.B. AND MONTEIRO, R.C., 2010. *Diversity and hosts of* Trichogramma *in the new world, with emphasis in South America. Egg parasitoids in agroecosystems with emphasis on* Trichogramma. Springer, pp. 219-236.

(Received 3 January 2015, revised 9 April 2015)