TOLERANCE OF *Trichogramma chilonis* Ishii TO DIFFERENT INSECTICIDES

THESIS

Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
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By

SONAVANE SUVARNA BANSI

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY,
POST GRADUATE INSTITUTE, AKOLA
DR. PANJABRAO DESHMUKH KRISHI VIDYAPEETH,
KRISHINAGAR PO, AKOLA (MS) 444104

Enrolment Number - CC/762 2010

DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the Thesis entitled **"TOLERANCE OF *Trichogramma chilonis* Ishii TO DIFFERENT INSECTICIDES"**or part there of has neither been submitted for any other degree or diploma of any university, nor the data have been derived from any thesis / publication of any university or scientific organization. The source of materials used and all assistance received during the course of investigation have been duly acknowledged.

Place: Akola

Date: 31/ 5 /2010

(Sonavane Suvarna Bansi)

Enrolment No. CC/762

CERTIFICATE

This is to certify that the thesis entitled **"TOLERANCE OF *Trichogramma chilonis* Ishii TO DIFFERENT INSECTICIDES"** submitted in partial fulfilment of the requirement for the degree of **"Master of Science in Agriculture (Agricultural Entomology)"** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **Sonavane Suvarna Bansi** under my guidance and supervision.

The subject of the thesis has been approved by the Student's Advisory Committee.

Place: Akola

Date: 31 / 05/2010

(MS. Pradnya S. Kadam)
Chairman,
Advisory Committee

Countersigned

Associate Dean,
Post Graduate Institute, Akola
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE
INCLUDING EXTERNAL EXAMINER (AFTER VIVA-VOCE)

1. Chairman (Ms. Pradnya S. Kadam) ________
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6. External Member (Dr. G.K. Lande ________

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(D) Abbreviations

%	-	per cent
@	-	at the rate of
^0C	-	Degree Centigrade
Avg.	-	Average
a.i.	-	Active ingredient
BOD	-	Biological Oxygen Demand
Bt	-	*Bacillus thuringiensis*
CD	-	Critical difference
Cm	-	Centimeter
EC	-	Emulsified concentration
et al.	-	et alia (and others)
etc.	-	Etcetera
Fig.	-	Figure
g	-	Gram
HaNPV	-	*Helicoverpa armigera* polyhedrosis virus
hrs.	-	hours
i.e.	-	id est (that is)
IPM	-	Integrated pest management
ml	-	Milliliter
PDBC	-	Project Directorate of Biological Control
RH	-	Relative humidity
SC	-	Suspension concentration
S.E.(m)±	-	Standard error of mean
SG	-	Soluble granule
Sig.	-	Significant
SL	-	Soluble liquid
SP	-	Soluble powder
Spp.	-	Species
UV	-	Ultraviolet
Viz.,	-	Videlicet (namely)

(E) THESIS ABSTRACT

a. Title of the thesis	: **"TOLERANCE OF *Trichogramma chilonis* Ishii TO DIFFERENT INSECTICIDES"**
b. Name of student	: **Sonavane Suvarna Bansi**
c. Name and address of Major Advisor	: **Ms. Pradnya S. Kadam** Assistant Professor Section of Entomology Dr. Panjabrao Deshmukh Krishi Vidyapeeth,Akola (M.S.) – 444104.
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Head,
University Department of Agricultural Entomology,
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola

HEAD, Deptt. of Entomology, Dr. P.D.K.V., Akola

ABSTRACT

In order to screen relatively safer chemicals for an egg parasitoid *Trichogramma chilonis* the investigations entitled "Tolerance of *Trichogramma chilonis* Ishii to different insecticides" were carried out as a part of post graduate research work during academic year 2009-2010 in the laboratory at Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi

Vidyapeeth, Akola.

The experiment was conducted in CRD with a set of 12 treatments replicated thrice. Some newer insecticides and one biopesticide were bioassayed against the potential egg parasitoid, *T. chilonis*.

For determining the effect of newer insecticides on per cent parasitization, per cent adult emergence and longevity in days, card strip containing 100 *C. cephalonica* eggs each, treated with insecticides were exposed to *T. chilonis* @ 5:1 host : parasitoid ratio. Observations on parasitization were taken after 5th day of treatment. In this study, UV exposed and unexposed eggs of *C. cephalonica* were tested separately.

Results indicated significant differences among the treatments. The order of safetyness of insecticides on the basis of per cent parasitization was *Bacillus thuringiensis* 0.075% > Endosulfan 0.07% > Diflubenzuron 0.08% > Flubendiamide 0.025% > Acetamiprid 0.02% > Spinosad 0.01% > Profenophos 0.20% > Cypermethrin 0.005% > Indoxacarb 0.01% > Pyridalyl 0.20% > Fipronil 0.16%.

The order of safetyness on the basis of per cent adult emergence was *Bacillus thuringiensis* 0.075% > Endosulfan 0.07% > Diflubenzuron 0.08% > Acetamiprid 0.02% > Indoxacarb 0.01% > Cypermethrin 0.005% > Flubendiamide 0.025% > Profenophos 0.20% > Pyridalyl 0.20% > Spinosad 0.01% > Fipronil 0.16%.

The order of safetyness on the basis of longevity in days was *Bacillus thuringiensis* 0.075% > Endosulfan 0.07% > Diflubenzuron 0.08% > Acetamiprid 0.02% > Flubendiamide 0.025% > Indoxacarb 0.01% > Profenophos 0.20% > Cypermethrin 0.005% > Spinosad 0.01% > Pyridalyl 0.20% > Fipronil 0.16%.

Thus it can be concluded that *T. chilonis* preferred unirradiated *C. cephalonica* eggs as compared to irradiated ones for parasitization. *Bacillus thuringiensis* was found safer and Fipronil was found highly toxic to *T. chilonis*.

CHAPTER I
INTRODUCTION

1.1. Background Information

Integrated Pest Management strategy emphasizes concept of conservation and augmentation of naturally occurring biological control agents. As such, it is key component of Integrated Pest Management system. Pest suppression with natural enemy and applied biological control are amongst the valuable non-chemical plant protection methods as they have minimal impact on non-target organisms and safe to the environment.

Pesticides are considered to be the most effective tool for combating the pest problems inimical to the interest of man. They have dominated the field of pest control since long. Even today they are used on a large scale by most of the cultivators in their spray schedules, because of quick knock-down effects and noticeable results in controlling different pests, both in agriculture, forestry and public health sectors. However, extensive reliance on pesticides and their indiscriminate and intensive use, has lead to serious consequences like pest resistance to pesticides, resurgence of pests due to destruction of their natural enemies, soil, water and air pollution due to pesticide residue etc. Also, use of toxic chemicals have caused ill-effects to non-target organisms including human being (Dhawan et al., 1994 and Singh 1994).

1.2 Importance and Need of study

Destruction of natural enemies of the pests is a major concern for the entomologists as well as ecologists. The natural enemies co-exists with the pests in an ecosystem and are continuously engaged in control of insect-pests naturally, which is unnoticeable to man, as they often remain neglected due to their small size, silent role, lack of knowledge about them. Most of them being very tiny and delicate, and they are easily destroyed by toxic chemicals.

As the pesticides are dumped in the environment in the present context of Integrated Pest Management (IPM), it becomes highly essential to conserve the natural enemies either present naturally or release artificially (Geetalaxmi and Chandrasekaran, 2000). The insecticides because of their promising attributes, such as immediate knock-down effect, ease in availability and use, occupies a prominent place in IPM, and hence need arises to evaluate the pesticides that are harmful only to the insect pests but are equally safe to the natural enemies and human beings.

To reap the combine advantage of biological and chemical control, both must be compatible with each other, to use in Integrated Pest Management programme. This can be achieved by following two ways.

i. Developing specific, target oriented chemical pesticides, safer to non-target organisms.
ii. Screening / identifying pesticide resistant strains of natural enemies.

As a part of this approach, the safety of most commonly used insecticides in pest control needs to be evaluated (Ingle et al., 2004).

1.3 Objectives of study

Keeping in mind, the discussion made above, it becomes debatable aspect whether Trichogrammatids could be used safely with some commonly used pesticides for pest management? Inline with this a laboratory study was conducted on "Tolerance of *Trichogramma chilonis* Ishii to different insecticides" with following objectives.

i. To study the effect of newer insecticides on parasitization of corcyra eggs by *Trichogramma chilonis.*
ii. To ascertain the effect of some newer insecticides on per cent adult emergence and longevity of *T. chilonis*.

1.4 Scope and limitations of the study

Egg parasitoids belonging to the genus Trichogramma (Hymenoptera: Trichogrammatidae) are used world wide for innoculative and inundative release against lepidopteran pests (Smith and Sandy, 1996). This tiny wasps have a wide range of adaptability which is an important attribute of an effective natural enemy. Trichogrammatids inhabit almost all kinds of habitats from swampy marshlands to hot dry deserts and occur in low-lying or in strictly arboreal habitats (Sudha and Nagaraja, 1977).

Trichogrammatids have over 150 species, subspecies and strains used against more than 200 insect species belonging to 10 families and 8 insect orders in diversified habits, mostly on the lepidopteran pests of different crops. In India, about 26 species of Trichogrammatids are recorded of which *T. chilonis* (Ishii), *T. japonicum* (Ashmead), *T. achaeae* (Nagaraja and Nagarkatti), are the important ones. (Singh and Jalali, 1994).

Now, with the onset of Biointensive Pest Management systems, instead of using biocontrol agents alone, emphasis is given to integrate the use of bioagents such as Trichogramma with other pest control methods without reducing the efficacy of biocontrol agents (Tiwari and Khan 2004). Large number of insecticides have been screened for their comparative safety to natural enemies in different parts of the world. Number of studies have focused on the effect of pesticides on *Trichogramma spp.* (Paul and Agarwal, 1989; Malathi et al., 1999; Reddy and Manjunatha, 2000; Tiwari and Khan, 2001). Endusulfan resistant strain of *Trichogramma chilonis* called 'Endogram' has been developed by the Project Directorate of Biological Control (PDBC), Bangalore through artificial selection process (Anonymous, 2000).

Till now, we have discussed about the importance and scope for using biocontrol agents along with chemicals which are safer to them. Now, it is of prime importance to discuss the factors limiting the scope for integrated use of biological and chemical control. As stated earlier, not all the chemicals are harmful to the natural enemies but equally, not all are safer to them. It is some what time consuming and laborious process to identify or screen out the safer compounds for natural enemies as none of the chemicals hold effectiveness against particular pest for longer period because of development of resistance which in turn lead to development of large number of new pesticide molecules to be used for pest suppression. For testing the safety of pesticides, a well equipped laboratory with all the necessary facilities is a prerequisite. As there are so many differences in conditions maintained under laboratory and that existing in the environment the degree of safetyness of a chemical may changes under both the situations.

1.5 Hypothesis

Parasitoid release and insecticidal applications at a time can not work together. Therefore, it is imperative to conserve the natural enemies in agro-ecosystem by avoiding the use of deleterious insecticides. Application of chemical insecticides with temporal synchronization of parasitoid release at specified period is of vital importance for Integrated Pest Management Programme. Not all the pesticides are harmful to natural enemies, but there are safer and less hazardous to beneficial organisms (Shukla et al., 1988 and Brar et al., 1991). An almost safer or relatively safer insecticides to Trichogrammatids needs to be screened frequently in the process of recurring entry of new insecticides. Hence, the tolerance of Trichogramma to different insecticide become a debatable aspect.

CHAPTER II

REVIEW OF LITERATURE

Large number of insecticides have been tested for their safety to *Trichogramma chilonis*. Number of studies in this line have focussed on hazardous effect of pesticides on natural enemies of insect pests in different parts of the world and also revealed the urge for need based application of pesticides as a part of an integrated approach of pest management.

For planning the present research review of literature pertaining to these aspects was made and presented below under the suitable headings and subheadings.

2.1 Effect of newer insecticides on per cent parasitization by *T. chilonis* Ishii

Varma et al. (1988) studied the effect of 15 insecticides on the susceptibility of *Trichogramma achaeae*. All the insecticides except fenvalerate gave 100 per cent mortality. Maximum parasitism was observed when the unparasitised eggs of *Corcyra cephalonica* were treated with permethrin, oxydemeton methyl and fenvalerate.

Malendez and Valencia (1990) reported that endosulfan was harmless while monocrotophos was moderately harmful to *T. semifumatum*

Varma et al. (1991) studied the effect of 15 insecticides on 1, 3, 5 and 7 days old eggs of *C. cephalonica* parasitized by *T. eldanae*. Parasitism and emergence were greatest (47.3 % and 38.3%, respectively) and least with oxydemeton methyl (0.06%)

Hohman (1993) reported less than 15 per cent parasitization when application of chlorpyriphos, deltamethrin and methomyl to host eggs (*Anagastra kuehniella*) 0.5 and 24 h before exposure to the parasitoid (*T. pretiosum*). Similar effects were noted when endosulfan and methyl parathion were applied to host eggs 30 minutes before exposure to *T. pretiosum* with the intervals of 24 and 72 h.

Klemm and Schmutterer (1993) reported that, neem treated host eggs were less parasitized by *Trichogramma sp.* in the laboratory as compared to untreated eggs (control). Further it was observed that after two successive treatments with neem, adults did not emerge from pupae.

Pili (1996) carried out studies for identifying the safer insecticides to *T. chilonis*. The insecticides were used at their recommended field doses and their respective half doses viz., endosulfan (0.06%), phosalone (0.05%), chlorpyriphos (0.05%), fenvalerate (0.0125%), sulphur (0.025%), coc (0.25%) and NSKE (5%). Results indicated that, NSKE, coc, endosulfan, monocrotophos alone and at their half doses in combination with NSKE were totally safe. Chlorpyriphos proved most detrimental to *T. chilonis*.

Murray and Uoyel (1997) reported that spinosad could play important role in IPM in cotton as it had minimal effect on activity of egg parasitoid which was similar to untreated plots.

Zhang (1998) tested the effect of 8 insecticides on *Trichogramma chilonis* in laboratory studies. Results indicated that parathion methyl was most toxic insecticide and *Bacillus thuringiensis* was on a par with the untreated control.

Jalali and Singh (1999) tested 10 insecticides for their toxicity, resistance and effect on parasitism of *Trichogrammatoidea armigera* Nagaraja, both under laboratory and field conditions. At field recommended doses phosalone was found moderately toxic to adults, whereas all the other insecticides viz. dimethoate, fenitrothion, monocrotophos, phosphamidon, endosulfan, cypermethrin, deltamethrin, fenvalerate and fluvalinate were found toxic to adults.

Malathi et al. (1999) evaluated seven ecofriendly insecticides viz. dipel, delfin, biobi, biolep, biosap (Bt formulations), green commandos (nematode formulations) for their effect on *T. chilonis* and found that they exhibited very little effect on parasitization of *T. chilonis* when exposed after parasitization as compared to when sprayed and exposed. The insecticide had little effect on ovipositional behaviour of *T. chilonis*, but not on further development and hence, resulted in successful adults emergence of *T.chilonis* whereas endosulfan was relatively toxic.

Sarode and Sonalkar (1999) reported that the insecticides belonging to pyrethroid and organophosphate groups showed toxic effects on parasitization of *Corcyra cephalonica* eggs by *T. chilonis,* whereas, neem seed extract and endosulfan were moderately safe to the parasitoid.

The toxicity of seven different insecticides viz., monocrotophos, endosulfan, quinalphos, cypermethrin, deltamethrin, fenvalerate and *Azadirachta indica* extract were evaluated against *T. chilonis* in a field experiment conducted by Asifulla et al. (2000). The release of *T. chilonis*, followed by insecticidal spraying, recorded higher parasitization rate 19% of cotton bollworm than insecticide spraying followed by release of *T. chilonis. A. indica* treatment resulted in the highest (26.40%) and quinalphos in the lowest mean parasitization rate (1.20%).

Dhawan (2000) studied the effect of new insecticides on natural enemy complex in cotton ecosystem. The results have shown that, all the insect growth regulators (IGR), delfin and spinosad were safer to *T. chilonis* followed by β – cyfluthrin and λ – cyhalothrin. Chlorpyriphos methyl and chlorpyriphos were found highly toxic to *T. chilonis* followed by quinalphos.

Rajendran and Gahukar (2000) studied four insecticides viz., endosulfan, quinalphos, monocrotophos and fenvalerate against *T. chilonis* and found endosulfan to be the safest among tested insecticides.

Borah et al. (2001)[a] studied the the effect of certain insecticides on the parasitization of the egg parasitoid, *T. japonicum* Ashmead. No parasitism was recorded for quinalphos. The *Bacillus thuringiensis* preparations, and the two *Azadirachta indica* products resulted in fairly high degree of parasitism. The parasitism in treatments with monocrotophos and fenvalerate was highest among the chemical pesticides.

Tawar (2001) evaluated some insecticides for their toxicity of an egg parasitoid, *T. chilonis* under laboratory conditions. Azadirachtin and endosulfan were found harmless while spinosad and imidacloprid were moderately toxic to *T. chilonis* as compared to other insecticides tested.

Singh and Gupta (2001) studied the toxicity of endosulfan, fenvalerate and acephate to *Trichogramma chilonis*. Minimum per cent parasitization was found in all concentrations of fenvalerate. Increase in concentration of all insecticides there was reduction in parasitization. Among all insecticides maximum parasitization (84.66%) was observed in 50 ppm dose of acephate.

Rao et al. (2002) tested the toxicity of newer insecticides to *Trichogramma chilonis* Ishii. Experimental results revealed that the per cent parasitization ranged from 0.0 to 50.33 in insecticidal treatments as compared to 95.67 per cent in untreated control. Maximum parasitism was recorded in neemgold at 0.015%, followed by nivar at 0.30%.

Tiwari and Khan (2002) studied the effect of fenbucarb and chlorpyriphos methyl on parasitization of *T. chilonis*.The results have shown that both the insecticides have an adverse effect on parasitization efficacy of *T. chilonis* at all the tested concentrations.

Ughade (2003) studied the relative safety of newer insecticides to *T. chilonis* Ishii under laboratory conditions. The results have shown that, endosulfan 0.06% was more safe to the parasitoid over the other insecticides.

Jalali and Singh (2003) studied the effect of nimbicidine, dipel 8 L and dispel on adults egg parasitoid and its immature stages inside the eggs of *Chilo partellus*. Slight reduction in parasitism and fecundity was observed in all products tested when compared to the untreated control. Studies indicated that all these products can be used in the field simultaneously with *T. chilonis* for suppression of *C. partellus* on maize.

Abida et al. (2004) studied the efficacy of different insecticides to *C. carnia* and *T. chilonis* under semifield conditions. Out of 9 insecticides tested, *Bacillus thuringiensis*, spinosad, thiodicarb and indoxacarb exhibited selectivity for beneficial insects, particularly for *C. carnia.* The beneficial insects damaged 19.667, 19.000, 18.000, 17.667 number of eggs out of the 20 eggs of *H. armigera*, when exposed to these insecticides, respectively. Chlorfenapyr, cypermethrin and endosulfan were also found selective for *C. carnea* but toxic for *T. chilonis*. Profenophos was found toxic to both beneficial insects.

Ingle et al. (2004) tested the susceptibility of four species of Trichogramma viz. *T. chilonis, T. japonicum, T. bactrae* and *T. pretiosum* to insecticides like carbaryl, deltamethrin, endosulfan and malathion. It was found *T. chilonis* was most tolerant strain amongst four and it may be genetically manipulated for endosulfan tolerance.

Nasreen et al. (2004) tested the toxicity of different insecticides against egg parasitoid *T. chilonis*. The results revealed that parasitism rate of *T. chilonis* was lowest (18%) in methamidophos and highest (100%) in buprofezin.

Tiwari and Khan (2004) conducted laboratory studies to evaluate the effect of different concentration of endosulfan on per cent parasitization by three species, *T. chilonis, T. polae* and *T. japonicum* on corcyra eggs. It was observed that, the insecticide concentration had reciprocal relationship with per cent parasitization. Among three species, lowest per cent parasitization was noted in *T. japonicum*

Bastos et al. (2005) tested the selectivity of pesticides to *Trichogramma. pretiosum*. Experimental results revealed that alpha-cypermethrin, carbosulfan, deltamethrin, endosulfan, profenophos and beta - cypermethrin were highly noxious to the pyrethroid, significantly reducing the per cent parasitism of *T. pretiosum.*

Senguttuvan et al. (2005) carried out safety test of botanicals against natural enemy *T. chilonis* Ishii by using a *Meli dubia* cav. products. The results showed that, use of Melia products under laboratory conditions posed no serious ill effects to the natural enemies and same can be expected under field conditions. Hence, neem products can safely be used for pest control practices.

Fund (2007) studied the selectivity of newer insecticides to *Trichogramma chilonis* Ishii under laboratory conditions. Results indicated that the highest per cent parasitization was recorded in HaNPV followed by Bt. However spinosad and imidacloprid were found moderately toxic for parasitization. Least parasitization was found in lambda-cyhalothrin followed by neem oil.

Goulart et al. (2009) tested the selectivity of pesticides to *T. pretiosum* and *T. exiguam* on *Anagastra kuehniella, Spodoptera frugiperda* and *Plutella xylostella* eggs. Results had shown that endosulfan was most harmful inhibiting the parasitism in all hosts. Endofenoprox showed low selectivity to parasitoid species when eggs of natural hosts were used.

Vianna et al. (2009) studied the effect of 9 insecticides used in tomato production on adults of *Trichogramma pretiosum* Riley. Result showed that *Bacillus thuringiensis*, lufenuron and triflumuron had lowest negative effect on parasitism. However, abamectin and pyrethroid insecticides reduced parasitism rates.

2.2 Effect of newer insecticides on per cent adult emergence of *T. chilonis* Ishii

Gupta et al. (1984) reported the toxicity of insecticidal spray of monocrotophos, endosulfan, malathion and quinalphos at recommended field rates to the egg parasitoid *T. japonicum* Ashmead . It was found that among insecticides tested endosulfan and monocrotophos were the least toxic giving more than 70 per cent emergence of parasitoid while malathion and quinalphos even at low doses were toxic giving only 39 per cent and 23 per cent parasitoid emergence.

Santaram and Kumarswami (1985) tested monocrotophos, endosulfan, phosalone and carbaryl at recommended field doses against *T. chilonis* reared on *Earias vitella* eggs to assess their effect on the emergence of the parasitoid *T. chilonis*. Carbaryl (0.1%) proved highly toxic in which minimum (10-30%) emergence was recorded. Endosulfan (0.035%) and monocrotophos (0.025%) gave maximum emergence similar to that of control (71.26%).

Dutt and Somchoudhary (1986) tested the toxicity of different insecticides on emergence and survival of *T. perkinsi* Girault and *T. australicum* Girault. The parasitized egg cards of *Corcyra cephalonica* containing 3rd instar larvae *of T. perkinsi* and *T. australicum* of similar age were dipped in different insecticidal concentrations and removed immediately in separate glass vials to record failure of emergence. For *T. perkinsi*, the descending order of relative toxicity of insecticides was parathion, malathion, carbaryl, endosulfan and diazinon. The order of susceptibility of different stages of the parasitoid was adult > pupa > larva.

Varma and Singh (1987) studied the effect of 9 insecticides on the emergence of *Trichogramma brasiliensis* Ashmead from the parasitized eggs of *Corcyra cephalonica* of different age groups. Results have shown that quinalphos and fenitrothion caused complete inhibition of emergence of the parasitoid from parasitized host eggs of all ages (1 to 7 days). However phosalone and fenvalerate were considered to be relatively safe to *T. brasiliensis*.

Shukla et al. (1988) tested the contact toxicity of cypermethrin, fenvalerate, deltamethrin, endosulfan to *T. brasiliensis* and *T. pretiosum*. Results showed that more parasitoids emerged from eggs treated with endosulfan than from those treated with fenvalerate, cypermethrin or deltamethrin.

Varma *et al.* (1988) studied the effect of 15 insecticides on the emergence of *Trichogramma achaeae*. When the insecticides were tested on parasitized eggs, It was found that fenvalerate, permethrin, oxydemeton methyl, DDT, dimethoate, deltamethrin and phosphamidon were comparatively safe to the parasitoid. Emergence of parasitoid was significantly affected in 1 and 2 day old parasitized eggs.

No harmful effects were observed on emergence of *Trichogramma spp.* From eggs of *Sitotroga cerealella* treated with largest recommended dose of cypermethrin, deltamethrin, endosulfan, methyl-parathion, carbaryl, malathion, diflubenzuron and azinophosmethyl for the control of cotton pests (Broglion, 1991).

Brar et al. (1991) reported that oxydemetonmethyl at 0.06% caused lowest mortality, maximum parasitism and highest emergence of *T. chilonis* from the host of *C. cephalonica*. Emergence of parasites was above 60 per cent from corcyra eggs treated with dimethoate, monocrotophos, deltamethrin, cypermethrin, fenvalerate, permethrin and phosphamidon.

Hohman (1991) noted the lowest emergence rate of *T. pretiosum* from parasitized eggs of *Anagasta kuhniella* treated with methomyl, chlorpyriphos, deltamethrin, parathion methyl and monocrotophos. Highest emergence was reported from endosulfan treated cards.

Mandal and Somchaudhary (1992) studied the effect of six insecticides against the pupal stages of five ecotypes of *T.chilonis*. The findings of the investigation revealed the possibilities of utilizing different ecotypes of *T.chilonis* Ishii under variable insecticide stress situations.

Arora et al. (1993) tested diflubenzuron for its toxicity against eggs parasitized by *T.chilonis*. It was observed that treatment of host eggs with 0.1% diflubenzuron in the case of *T. chilonis* resulted in 17.6 to 34.4 per cent mortality, depending on the stage of application.

Kring and Smith (1995) evaluated the efficacy of *T. pretiosum* under Bt insecticide combination in laboratory as well as in the cotton field. Endosulfan showed little impact on parasitoid emergence than lambda cyhalothrin under laboratory condition.

Borah and Basit (1996) studied the effect of insecticides on the emergence of *Trichogramma japonicum* from eggs of *Corcyra cephalonica* treated on the 3rd and 6th days after parasitization. Result have shown that *B. thuringiensis* and neem products had the least effect on emergence of parasitoids of the other insecticides, Fenvalerate and monocrotophos had the least effect while quinalphos had the most. Adult emergence was relatively less when eggs sprayed on the 6th day after parasitization compared with when sprayed on the 3rd day after parasitization.

Fisho and Almeda (1997) conducted experiment on effect of insecticides on emergence of *T. pretiosum*. Deltamethrin was observed as the least selective insecticide as compared to endosulfan, diflubenzuron, monocrotophos and lamda cyhalothrin.

Rajendran and Hanifa (1997) reported that, the application of 2000 ppm of endosulfan and monocrotophos on sugarcane shoot borer decreased the emergence of *T. chilonis* than lowest doses (200 ppm).

Sohi et al. (1997) determined the effect of insecticides on emergence of *T. chilonis* adults. The spraying of insecticides was done in a cotton field where parasitized trichocards were stapled. After 30 minutes of spraying, the egg cards were removed from field and were brought to the laboratory for observing parasitoid emergence. All insecticides significantly affected the *T. chilonis* emergence, maximum emergence was recorded in the treatment of carbaryl followed by cypermethrin, endosulfan, fenvalerate and monocrotophos. Chlorpyriphos and quinalphos proved detrimental to the parasitoid.

Effect of imidacloprid, buprofezin and fenitrothion on reproduction of *T. japonicum* in laboratory was shown by Zhang et al. (1997). Fenitrothion had given greatest mortality of *T. japonicum* by affecting nerve transmission.

Radhika (1998) studied the effect of *Bacillus thuringiensis* on *Trichogramma spp.* Results have shown that *Bacillus thuringiensis* at 0.05, 0.10 and 0.20 per cent had a negligible effect on duration of the egg, larval and pupal stages, and adult emergence of *Trichogramma spp.* reared on eggs of *Corcyra cephalonica*, or on the rate of parasitization.

Effect of seven insecticides on *T.chilonis* adults were investigated by Abida et al. (2001). Tested pesticides were abamectin, Bt, chlorfenpyr, endosulfan , indoxacarb, profenophos and spinosad. Bt and indoxacarb caused 10 and 20 per cent mortality after 6h, respectively and 95 and 75 per cent, respectively after 24h. These were classified harmless for the first 6h of exposure but were categorized harmful and slightly harmful, respectively, after 24h. All the other preparations caused 100 % mortality after 24h.

Borah et al. (2001)[b] studied the effect of insecticides on the emergence of the egg parasitoid, *Trichogramma japonicum* Ashmead. Results showed that quinalphos completely inhibited the emergence of *T. japonicum*. The highest adult emergence was recorded for Biolep (71.07%) and Biosap (73.05%) treatments.

Prabal and Prameswaran (2001) studied the contact toxicity of different groups of chemicals. More than 90% emergence of *T. chilonis* was recorded from eggs treated with *B. thuringinsis* subsp. galleriae and neem azal. F and neem azal T/S followed by NSKE (89.80%) and buprofezin (82.60%) only 73.80 per cent of adult *T. chilonis* emerged from monocrotophos treated host eggs after parasitization.

Premchand et al. (2001) evaluated toxic effects of four commertially used insecticides viz. acephate, deltamethrin, endosulfan and malathion on egg parasitoid *T. chilonis*. Among the four insecticides, acephate was found safer for parasitoid emergence.

Balkrishnan et al. (2004) tested the efficacy of *Trichogramma chilonis* in combination with biopesticides against *Helicoverpa armigera* in rainfed cotton ecosystem. It was found the minimum larval population was observed in treatment having two releases of *Trichogramma chilonis* with two groups of B. t. K. followed by two releases of *Trichogramma chilonis* along with spray of HaNPV.

Saber et al. (2004) studied the effect of Azadirachtin / Neemazal on different stages and adult life table parameters of *Trichogramma cacoeciae*. The adults exposed to the insecticide at pupal stage yielded the lowest percentage of emergence followed by the eggs treated at larval and prepupal stages.

Bastos et al. (2005) tested the selectivity of pesticides to *Trichogramma pretiosum*. Experimental results revealed that lufenuron and monocrotophos had no effect on the parasitoid pupae while chlorfluazuron, diafenthiuron, diflubenzuron, fentin hydroxide, mepiquat chloride, novaluron, thiacloprid and triflumuron did not affect *T.*

pretiosum emergence when eggs of *S. cerealella* enclosing pupae of the wasps were surface treated.

Singh and Shenhmar (2008) tested five insecticides for their impact on some biological parameters of the *Trichogramma japonicum*. Result showed that endosulfan was found to be comparatively safe to the parasitoid with least effect on the emergence while malathion and chlorpyriphos were highly deleterious.

Garcia et al. (2009) studied the side effects of three insecticides and one fungicide on host eggs parasitized by *Trichogramma cordubensis*. Results revealed that both the pyrethroids reduced the emergence rate. The most toxic pyrethroid was lamda-cyhalothrin. *Bacillus thuringiensis* and basic copper sulphate had little or no adverse effect on adult emergence.

Sheng et al. (2009)[a] studied the toxicity of five insecticides on *Trichogramma evanescens*. Result showed that *Bacillus thuringiensis* and acetamiprid were non toxic to adult emergence. Lambda-cyhalothrin reduced emergence rate by approximately 92 per cent when applied during pre-mature stages.

2.3 Effect of newer insecticides on Longevity of *T.chilonis* Ishii

Garcia et al. (2009) studied the side effects of three insecticides and one fungicide on host eggs parasitized by *Trichogramma cordubensis*. Results revealed that lamda cyhalothrin negatively affected the longevity of pyrethroids cold stored for 60 days. *Bacillus thuringiensis* and basic copper sulphate had little or no adverse effect on longevity of *T. cordubensis*.

Sheng et al. (2009) studied the toxicity of five insecticides on *Trichogramma evanescens*. Result showed that *Bacillus thuringiensis* and acetamiprid had low effects on the longevity. Abamectin treatment in pre pupae and pupal stage severely reduced longevity.

CHAPTER III

MATERIAL AND METHODS

Success of Integrated Pest Management lies in the use of selective insecticides effective against the target pests, safeguarding the non targeted beneficials. In line with the objectives discussed in chapter I, present investigation was entitled "Tolerance of *Trichogramma chilonis* Ishii to different insecticides" carried out to screen relatively safer insecticides to an egg parasitoid *T. chilonis* so that, it would be safely used in the IPM programme. The experiment was conducted in laboratory of Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during the year 2009-2010.

The material and equipment used for conducting the research along with the sources from where they were procured and the methodology adopted for application of treatments and recording observations on various parameters under study are described in this chapter as below.

3.1 Material and equipment used.

The material for conducting the research included:-

i. Fresh eggs of *Corcyra cephalonica* (Both U.V. exposed and unexposed).
ii. Culture of *Trichogramma chilonis* Ishii.
iii. Chemicals.
    a. Insecticides for giving the treatments.
    b. Alcohol for disinfection of glass vials etc.
    c. Sodium hypochloride for sterilization.
iv. Glass wares.
    a. 50 glass vials of 15 X 2.5 cm size.
    b. Beakers of 100 ml, 250 ml capacity.
    c. Magnifying hand lens.
    d. Measuring cylinder.

v. Others

Trichocards, Polythene bags, Camel hair brush, Forceps, Gum Arabic, U pins, Needle, Scissor, Rubber bands, Razor.

Following laboratory equipments and instruments were used during the research work.

i. U.V chamber for sterilizing *C. cephalonica* eggs.
ii. Stereoscopic microscope for observing parasitized eggs.
iii. Micropipette for preparing insecticide dilution or spray liquids of desired concentrations.
iv. Refrigerator – For cold storage of insecticide dilutions.
v. BOD incubator – For maintaining required temperature and relative humidity.

All the above material and equipments were made available by the Head, Department of Agricultural Entomology, PGI, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola especially from Insect – Biocontrol laboratory and Entomology section, college of agriculture, Akola.

Table1. List of insecticides tested against *T. chilonis*

Sr. No.	Common name and Formulation	Chemical name	Trade name	Source/ manufacture
1	Diflubezuron 48 SC	1-[4- chlorophenyl 1-3-(2, 6-diflurobenzyol) urea	Dimilin	Dhanuka, pesticides Ltd, New Delhi
2	Indoxacarb 14.5 SC	(5)methyl,7chloro-2-5-dihydro-2 {(methoxy carbonyl,1) 4-flurometho xy-phenyl aminocarbonylindel-0} (1,2-0 (1,3,4 oxadiazine 4(a) (3H)-carboxylate	Avaunt	E. I. Dupont Pvt. Ltd., Mumbai
3	Fipronil 5 SC	[5-Amino-1[2,6dichloro-4-(trifluoromethyl) phenyl]-4-(1R,S)-(trifluoromethyl) sulfenyl] - 1H-pyrazole 3- carbnitrile]	Regent	Bayer Crop Science, Mumbai
4	Spinosad 45 SC	Natural fermentation product of soil actinomycetes, *Saccharopolyspora spinosa*	Tracer	DENOCIL Crop Protection Pvt. Ltd., Madras
5	Endosulfan 35 SC	6,7,0,9,10 hexachloro, 1,5,5,1,6.9,9a hexahydro, 6,9 methano, 2,4,3-benzacedioxthiepin-3 oxide	Thiodon	Bayer Crop Science, Ankleshwar, Gujrat
6	Acetamiprid 20 SP	(E)-N^1[(6 chloro-3-pyridyl) methyl]-N^2-cyano-N^1-methyl-acetamide	Pride	DENOCIL Ltd., Gaziabad (U.P.)
7	Profenophos 50 EC	O-4-Bromo-2-Chlorophenyl O-ethyl phosphorothrithioate	Pivot	Syngenta India Ltd., Mumbai
8	Flubendiamid e 480 SC	1,2-Benzenedicarboxamide,N_2 -[1,1dimethyl-2-(methylsulfonyl) ethyl]-3-iodo-N1-[2-methyl-4[1,2,2,2-tetrafluoro-1(trifluromethyl) ethyl] phenyl]-(9cl)	Fame	Bayer Crop Science Ltd., Sabarkanta, Gujrat
9	Cypermethrin 25 EC	Cyano-3-phenoxyl (+)- cis, trans 3-(2,2-dichlorovinyl)-2,2- dimethyl cychlopropane carboxylate	Cymbush	Bayer India Ltd., Mumbai
10	Pyridalyl 10 EC	2,6-dichloro-4-(3,3-dichloroallyloxy) phenyl 3-[5- (trifluoromethyl) -2- pyridyloxy] propyl ether	Sumipleo	Sumitomo Chemical Co. Ltd., Mumbai
11	*Bacillus thuringiensis*	*Bacillus thuringiensis* Var. Kurstaki	Dipel 8 L	Cheminova India Ltd.

3.2 Methodology used for research work.

3.2.1 Experimental Details.

Design – Completely Randomized Design (CRD)

Treatments – Twelve (12)

Replications – Three (3)

Number of Corcyra eggs per treatment –100 (for each replication)

Table 2 Treatment Details

Treatment No	Insecticides	Concentrations
T_1	Diflubezuron 48 SC	0.08%
T_2	Indoxacarb 14.5 SC	0.01 %
T_3	Fipronil 5 SC	0.16 %
T_4	Spinosad 45 SC	0.01 %
T_5	Endosulfan 35 SC	0.07 %
T_6	Acetamiprid 20 SP	0.02 %
T_7	Profenophos 50 EC	0.2 %
T_8	Flubendiamide 480 SC	0.025 %
T_9	Cypermethrin 25 EC	0.005 %
T_{10}	Pyridalyl 10 EC	0.2 %
T_{11}	*Bacillus thuringiensis*	0.075 %
T_{12}	Control (Water spray)	

3.2.2. Preparation of Insecticidal Spray liquid

Stock solutions of the different insecticides under study were prepared by using following formula

$$V = \frac{C X A}{\% a.i.}$$

Where,

V = volume of insecticides,

C = Concentration required,

A = Quantity of water,

% a. i. = Per cent active ingredient.

The concentrations of different insecticides were prepared on the day of bioassay treatment. The insecticides were applied at recommended field doses.

3.2.3 Method of application of treatments.

U.V.irradiated and unirradiated corcyra eggs for preparing trichocards were obtained from the Biocontrol Laboratory of the Entomology Department. The applications were made as per the method suggested by Santaram and Kumarswami (1985).

The insecticidal treatments were made by two ways as follows.

3.2.3.1 Application of insecticide to U.V. irradiated corcyra eggs and treated eggs exposed to *T. chilonis* at 1st, 3rd and 5th day of treatment.

a. Exposure of *T. chilonis* at 1st day of insecticide application to U. V. irradiated corcyra eggs.
b. Exposure of *T. chilonis* at 3rd day of insecticide application to U. V. irradiated corcyra eggs.
c. Exposure of *T. chilonis* at 5th day of insecticide application to U. V. irradiated corcyra eggs.

U. V. irradiated fresh eggs of *C. cephalonica* were glued to the egg cards separately (@ 100 eggs per card strip). The cards were cut into small strips (5.0 X 2.0 cm size) and were dipped in spray suspension of each treatment and the excess suspension was drained out. For control, water was used instead of insecticides. After thorough shade drying, the egg cards were kept separately in glass vials of 15.0 X 2.5 cm size @ one card strip per vial for each treatment and replication. Each treatment was then labeled properly with details such as name of treatment, concentration of insecticides, date and time of treatment application. The egg cards were kept in separate sets for exposure to gravid females of *T. chilonis* (@ 5:1 host parasitoid ratio) at 1st, 3rd and 5th days of treatment. Adults exposed for 24 hours for parasitization. Each treatment was replicated thrice and experiment was conducted at 27 $\pm$ 1°C temperature and 65 $\pm$ 5 % R.H.

3.2.3.2 Application of insecticide to U.V. unirradiated corcyra eggs and treated eggs exposed to *T.chilonis* at 1^{st} day of treatment.

same procedure was followed as in U.V. irradiated *C. cephalonica* eggs, only difference was that egg cards were exposed to the gravid female only at 1^{st} day of insecticide treatment.

3.2.4 Observations

Observations were recorded on the per cent egg parasitization, per cent adult emergence of *T. chilonis* and longevity in days, in both the methods.

The egg cards were examined for parasitization after 5^{th} day (on 6^{th} day) of parasitoid release and the number of parasitized eggs were counted.

$$\text{Per cent parasitization} = \frac{\text{Number of eggs of parasitized}}{\text{Total number of eggs exposed}} \text{X100}$$

Emergence of adult parasitoids was recorded by counting the total parasitized host eggs and the eggs from which the parasitoids emerged to work out per cent emergence of *T. chilonis*

$$\text{\% Adult emergence} = \frac{\text{Number of adult emerged}}{\text{Number of eggs parasitized}} \text{X100}$$

Longevity of adult parasitoids were recorded in days.

3.2.5. Exposure of *C. cephalonica* eggs to twenty gravid females of *T. chilonis* for parasitization.

As stated earlier in the methodology egg strips of *C. cephalonica* containing 100 eggs each were exposed to 20 gravid females of *T. chilonis* (@ 5:1host parasitoid ratio) for 24 hrs to obtain adequate parasitization.

For identification of female of *T. chilonis,* a strip of unparasitized corcyra eggs was placed in another separate vial in which a strip of parasitized trichocard containing newly emerged adults (4 to 8 hrs.) was inserted. After mating and lapse of waiting period, the females of *T. chilonis* were seen attracted towards the eggs of *Corcyra cephalonica* for parasitization. Such females were picked up immediately with a wet camel hair brush and 20 females were transferred into each vial containing the eggs of *Corcyra cephalonica* (Dadmal, 2003 and Budhwant, 2005)

3.2.6 Statistical Analysis

The data obtained on per cent parasitization, per cent adult emergence and longevity in days related to various parameters under study were subjected to statistical analysis, after appropriate transformation for interpretation of the results (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISSCUSION

The present investigations entitled "Tolerance of *Trichogramma chilonis* Ishii to different insecticides" were carried out with the following objectives.

i) To study the effect of newer insecticides on parasitization of corcyra eggs by *T. chilonis*.

ii) To ascertain the effect of some newer insecticides on per cent adult emergence and longevity of *T. chilonis*.

4.1 Effect of newer insecticides on per cent parasitization of *C. cephalonica* eggs by *T. chilonis* Ishii.

In the present study, per cent parasitization has been estimated by simply dividing the number of eggs parasitized by the total number of eggs exposed. The parasitized eggs were identified on the basis of their colour change from creamy white to dark brown/black under microscope. (Tiwari and Khan, 2004).

4.1.1 U.V. irradiated *C. cephalonica* eggs (Trichogramma adult release at 1st day of treatment)

Data presented in Table 3 are found statistically significant.

Among the various insecticides tested, along with microbial (Bt), the treatment of *Bacillus thuringiensis* 0.075% with 81.66 per cent parasitization resistered maximum parasitization after control (89%). This treatment was followed by a group of insecticides including , Endosulfan 0.07% (74.66%) , Diflubenzuron 0.08% (73.66%), Acetamiprid 0.02% (71.66%) , Flubendiamide 0.025% (71.33%) , all being at par with each other.

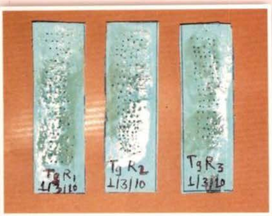

Plate 1. ***C. cephalonica*** **eggs parasitized by** ***T. chilonis***

Plate 2. Unparasitized ***C. cephalonica*** **egg**

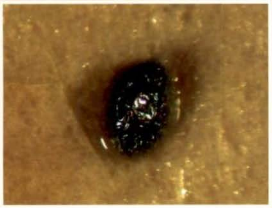

Plate 3. ***C. cephalonica*** **egg parasitized by** ***T. chilonis***

Plate 4. ***C. cephalonica*** **parasitized egg showing emergence of parasitoid**

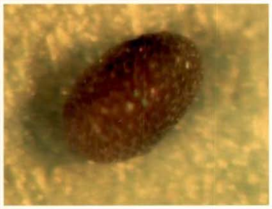

Plate 5. ***T. chilonis*** **died within parasitized egg due to insecticide treatment**

Plate 6. Adult of ***T. chilonis***

Table 3. Effect of newer insecticides on per cent parasitization of irradiated eggs (Trichogramma adult release at 1st day of treatment)

Treatment	Concen -tration	per cent parasitization of corcyra eggs			
		RI	RII	RIII	Mean
T_1 - Diflubenzuron 48SC	0.08%	73 (58.69)	77 (61.34)	71 (57.42)	73.66 (59.15)
T_2 - Indoxacarb 14.5SC	0.01%	54 (47.29)	56 (48.45)	57 (49.02)	55.66 (48.25)
T_3 - Fipronil 5SC	0.16%	34 (35.67)	31 (33.83)	32 (34.45)	32.33 (34.65)
T_4 - Spinosad 45SC	0.01%	64 (53.13)	56 (48.45)	68 (55.55)	62.66 (52.37)
T_5 - Endosulfan 35EC	0.07%	78 (62.03)	72 (58.05)	74 (59.34)	74.66 (59.80)
T_6 - Acetamiprid 20SP	0.02%	74 (59.34)	71 (57.42)	70 (56.79)	71.66 (57.85)
T_7 - Profenophos 50EC	0.20%	60 (50.77)	63 (52.53)	58 (49.60)	60.33 (50.96)
T_8 - Flubendiamide 480SC	0.025%	72 (58.05)	71 (57.42)	71 (57.42)	71.33 (57.63)
T_9 - Cypermethrin 25EC	0.005%	53 (46.72)	57 (49.02)	54 (57.29)	54.66 (51.01)
T_{10} - Pyridalyl 10EC	0.20%	42 (40.40)	46 (42.71)	43 (40.98)	43.66 (41.36)
T_{11} - *Bacillus thuringiensis*	0.075%	81 (64.16)	80 (63.44)	84 (66.42)	81.66 (64.67)
T_{12} - Control (Water spray)		87 (68.87)	86 (68.03)	94 (75.82)	89.00 (70.90)
'F' test					Sig.
S.E.(m)±					1.489
CD at 1%					4.42

(Figures in parentheses are arc sine values)

The next efficacious group included spinosad 0.01%, profenophos 0.20%, indoxacarb 0.01%, cypermethrin 0.005% with parasitization of 62.66 , 60.33, 55.66, 54.66 per cent, respectively and all were at par with each other.

The least parasitization was observed in fipronil 0.16% (32.33%) followed by pyridalyl 0.20% (43.66%)

Fund (2007) reported 77.33 per cent parasitization by *T. chilonis* when host eggs were sprayed with 0.075 per cent concentration of *Bacillus thuringiensis*. Hewa - Kapuge et al., (2003) reported minimal effect of indoxacarb on Trichogramma , which supports the present findings.

4.1.2 U.V. irradiated *C. cephalonica* eggs (Trichogramma adult release at 3rd day of treatment)

Data presented in Table 4 are found statistically significant. Maximum per cent parasitization was observed in treatment *Bacillus thuringiensis* 0.075 % (64.66%)

However, next group showing maximum parasitization includes flubendiamide 0.025%, endosulfan 0.07%, diflubenzuron 0.08% , spinosad 0.01%, acetamiprid 0.02% with parasitization 58.33 , 56.33 , 56.33 , 55.33 , 54.33 per cent, respectively and all being at par with each other. Cypermethrin 0.005% (44.66%) was found at par with profenophos 0.20% (46.66%). Cypermethrin was also found at par with indoxacarb 0.01% (40.66%)

Whereas, least parasitization was noticed in fipronil 0.16% (18.66%) followed by pyridalyl 0.20% (34.33%)

As no literature is available on per cent parasitization of *C. cephalonica* eggs by *T. chilonis* in Trichogramma adult release at 3rd day of treatment , hence could not be discussed.

Table 4. Effect of newer insecticides on per cent parasitization of irradiated eggs (Trichogramma adult release at 3rd day of treatment)

Treatment	Concen -tration	per cent parasitization of corcyra eggs			
		RI	RII	RIII	Mean
T_1 - Diflubenzuron 48SC	0.08%	53 (46.72)	59 (50.18)	57 (49.02)	56.33 (48.64)
T_2 - Indoxacarb 14.5SC	0.01%	43 (40.98)	39 (38.65)	40 (39.23)	40.66 (39.62)
T_3 - Fipronil 5SC	0.16%	20 (26.56)	19 (25.84)	17 (24.35)	18.66 (25.58)
T_4 - Spinosad 45SC	0.01%	57 (49.02)	54 (47.29)	55 (47.87)	55.33 (48.06)
T_5 - Endosulfan 35EC	0.07%	53 (46.72)	57 (49.02)	59 (50.18)	56.33 (48.64)
T_6 - Acetamiprid 20SP	0.02%	54 (47.29)	53 (46.72)	56 (48.45)	54.33 (47.48)
T_7 - Profenophos 50EC	0.20%	43 (40.98)	50 (45.00)	47 (43.28)	46.66 (43.08)
T_8 - Flubendiamide 480SC	0.025%	57 (49.02)	58 (49.60)	60 (50.77)	58.33 (49.79)
T_9 - Cypermethrin 25EC	0.005%	43 (40.98)	47 (48.28)	44 (41.55)	44.66 (41.93)
T_{10} - Pyridalyl 10EC	0.20%	36 (36.87)	32 (34.45)	35 (36.27)	34.33 (35.86)
T_{11} - *Bacillus thuringiensis*	0.075%	64 (53.13)	63 (52.53)	67 (54.94)	64.66 (53.53)
T_{12} - Control (Water spray)		78 (62.03)	74 (59.34)	69 (56.17)	73.66 (59.18)
'F' test					Sig.
S.E.(m)±					0.890
CD at 1%					2.64

(Figures in parentheses are arc sine values)

Table 5. Effect of newer insecticides on per cent parasitization of irradiated eggs (Trichogramma adult release at 5th day of treatment)

Treatment	Concen -tration	per cent parasitization of corcyra eggs			
		RI	RII	RIII	Mean
T_1 - Diflubenzuron 48SC	0.08%	32 (34.45)	34 (35.67)	39 (38.65)	35 (36.25)
T_2 - Indoxacarb 14.5SC	0.01%	22 (27.97)	23 (28.73)	20 (26.56)	22.66 (27.75)
T_3 - Fipronil 5SC	0.16%	14 (21.97)	16 (23.58)	12 (20.27)	14 (21.94)
T_4 - Spinosad 45SC	0.01%	25 (30.00)	32 (34.45)	36 (36.87)	31 (33.77)
T_5 - Endosulfan 35EC	0.07%	33 (35.06)	38 (38.06)	39 (38.65)	36.66 (37.25)
T_6 - Acetamiprid 20SP	0.02%	32 (34.45)	34 (35.67)	31 (33.83)	32.33 (34.65)
T_7 - Profenophos 50EC	0.20%	40 (39.23)	43 (40.98)	41 (39.82)	41.33 (40.01)
T_8 - Flubendiamide 480SC	0.025%	30 (33.21)	35 (36.27)	37 (37.47)	34 (35.65)
T_9 - Cypermethrin 25EC	0.005%	30 (33.21)	24 (29.33)	22 (27.97)	25.33 (30.17)
T_{10} - Pyridalyl 10EC	0.20%	20 (26.56)	22 (27.97)	24 (29.33)	22 (27.95)
T_{11} - *Bacillus thuringiensis*	0.075%	40 (39.23)	41 (39.82)	38 (38.06)	39.66 (39.03)
T_{12} - Control (Water spray)		50 (45.00)	48 (43.85)	42 (40.40)	46.66 (43.08)
'F' test					Sig.
S.E.(m)±					1.140
CD at 1%					3.38

(Figures in parentheses are arc sine values)

4.1.3 U.V. irradiated *C. cephalonica* eggs (Trichogramma adult release at 5th day of treatment)

Data presented in Table 5 are found statistically significant.

Maximum per cent parasitization was observed in group of insecticides including, *Bacillus thuringiensis* 0.075%, (39.66%), endosulfan 0.07% (36.66%), diflubenzuron 0.08% (35%), flubendiamide 0.025% (34%), acetamiprid 0.02% (32.33%). Amongst these five treatments, the first four (*Bacillus thuringiensis*, endosulfan, diflubenzuron, flubendiamide) as well as the last four (endosulfan, diflubenzuron, flubendiamide, acetamiprid) treatments were found statistically similar. However the last three treatments were found statistically similar with Spinosad 0.01% (31%).

Whereas minimum per cent parastitzation were observed in treatments cypermethrin 0.005%, pyridalyl 0.20%, fipronil 0.16%, recorded parsitization 25.33, 22, 14 per cent, respectively and also found statistically similar.

No literature is available on per cent parasitization of *C. cephalonica* eggs by *T. chilonis* in Trichogramma adult release at 5th day of treatment, hence could not be discussed.

4.1.4 U.V. unirradiated *C. cephalonica* eggs (Trichogramma adult release at 1st day of treatment).

Data presented in Table 6 are found statistically significant.

Maximum per cent parasitization was observed in *Bacillus thuringiensis* 0.075% (83.66%). The next safer group included endosulfan 0.07% , diflubenzuron 0.08%, flubendiamide 0.025%, acetamiprid 0.02% recorded per cent parasitization 79, 78.66, 76 and 74.33 per cent, respectively. Amongst these four treatments, the first three as well as last two treatments were found statistically similar.

However, the treatment spinosad 0.01%, (71.66%) was also found at par with acetamiprid. Treatments including profenophos 0.20%, cypermethrin 0.005%, indoxacarb 0.01% recorded parasitizaton 64.66, 62.33 and 58.66 per cent, respectively. Amongst these three treatments, first two (profenophos and cypermethrin)as well as last two (cypermethrin and indoxacarb) treatments were found statistically equal.

Table 6. Effect of newer insecticides on per cent parasitization of unirradiated eggs (Trichogramma adult release at 1st day of treatment)

Treatment	Concen -tration	per cent parasitization of corcyra eggs			
		RI	RII	RIII	Mean
T_1 - Diflubenzuron 48SC	0.08%	79 (62.72)	77 (61.34)	80 (63.44)	78.66 (62.50)
T_2 - Indoxacarb 14.5SC	0.01%	56 (48.45)	62 (51.94)	58 (49.60)	58.66 (49.99)
T_3 - Fipronil 5SC	0.16%	42 (40.40)	44 (41.55)	36 (36.87)	40.66 (39.60)
T_4 - Spinosad 45SC	0.01%	70 (56.79)	74 (59.34)	71 (57.42)	71.66 (57.85)
T_5 - Endosulfan 35EC	0.07%	82 (64.90)	75 (60.00)	80 (63.44)	79 (62.78)
T_6 - Acetamiprid 20SP	0.02%	76 (60.67)	74 (59.34)	73 (58.69)	74.33 (59.56)
T_7 - Profenophos 50EC	0.20%	64 (53.13)	63 (52.53)	67 (54.94)	64.66 (53.53)
T_8 - Flubendiamide 480SC	0.025%	75 (60.00)	77 (61.34)	76 (60.67)	76 (60.67)
T_9 - Cypermethrin 25EC	0.005%	60 (50.77)	63 (52.53)	64 (53.13)	62.33 (52.14)
T_{10} - Pyridalyl 10EC	0.20%	54 (47.29)	49 (44.43)	50 (45.00)	51 (45.57)
T_{11} - *Bacillus thuringiensis*	0.075%	85 (67.21)	84 (66.42)	82 (64.90)	83.66 (66.17)
T_{12} - Control (Water spray)		97 (80.02)	96 (78.46)	98 (81.87)	97 (80.11)
'F' test					Sig.
S.E.(m)±					0.904
CD at 1%					2.687

(Figures in parentheses are arc sine values)

Whereas, the least parasitizaton was observed in Pyridalyl 0.20% (51%) followed by Fipronil 0.16% (40.66%)

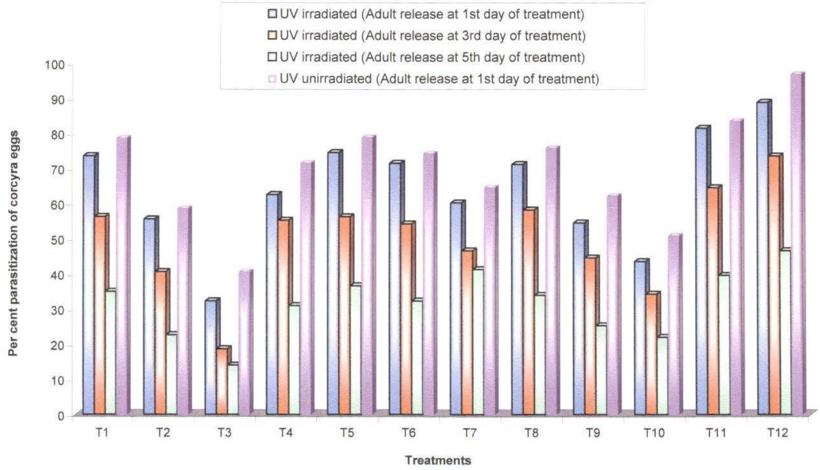

Fig. 1. Effect of newer insecticides on per cent parasitization of *C. cephalonica* eggs by *T. chilonis*

Pili (1996) has reported 76.23 per cent parasitization of *C. cephalonica* eggs by *T. chilonis* exposed to 0.06 per cent Endosulfan. Tiwari and Khan. (2002) recorded 60.16 per cent parasitization by *T. chilonis* when exposed to 0.1 per cent endosulfan.

Fund (2007) reported that 82.67 per cent parasitization was observed in *C. cephalonica* eggs by *T. chilonis* when eggs were treated with Bt 0.075%. Thus, the present findings corroborate with previous findings.

4.2 Effect of Newer insecticides on per cent adult emergence of *T. chilonis* in *C. cephalonica* eggs.

In present study, per cent adult emergence has been estimated by dividing the number of eggs from which parasitoid has emerged out by total number of parasitized eggs treated with the insecticides. The adult emergence was observed on the basic of the exit holes on parasitized eggs observed under microscope (Fund, 2007).

4.2.1 U.V. irradiated *C. cephalonica* eggs (Trichogramma adult release at 1st day of treatment).

Data presented in Table 7 are found statistically significant.

Among the different insecticidal treatments, *Bacillus thuringiensis* 0.075% (86.66%) giving maximum adult emergence after control (92.33%). The next safer treatments were endosulfan 0.07% (80.66%) followed by diflubenzuron 0.08% (77.66%). However, both were found statistically equal.

Whereas, indoxacarb 0.01% (72.23%) was found at par with acetamiprid 0.02% (68.33%) and cypermethrin 0.005% (60.66%) was found at par with flubendiamide 0.25% (58.33%).

Least adult emergence were observed in treatments pyridalyl 0.20% (39.00%), fipronil 0.16% (35.66%) spinosad 0.01% (34.33%).

Table 7. Effect of newer insecticides on per cent adult emergence of *T. chilonis* in irradiated eggs (Trichogramma adult release at 1st day of treatment)

Treatment	Concen-tration	per cent adult emergence of *T. chilonis*			
		RI	RII	RIII	Mean
T_1 - Diflubenzuron 48SC	0.085%	76 (60.67)	79 (62.72)	78 (62.03)	77.66 (61.80)
T_2 - Indoxacarb 14.5SC	0.01%	72 (58.05)	70 (56.79)	75 (60.00)	72.33 (58.28)
T_3 - Fipronil 5SC	0.16%	40 (39.23)	34 (35.67)	33 (35.06)	35.66 (36.65)
T_4 - Spinosad 45SC	0.01%	34 (35.67)	36 (36.87)	33 (35.06)	34.33 (35.86)
T_5 - Endosulfan 35EC	0.07%	84 (66.42)	80 (63.44)	78 (62.03)	80.66 (63.96)
T_6 - Acetamiprid 20SP	0.02%	68 (55.55)	70 (56.79)	67 (54.94)	68.33 (55.76)
T_7 - Profenophos 50EC	0.20%	53 (46.72)	57 (49.02)	51 (45.57)	53.66 (47.10)
T_8 - Flubendiamide 480SC	0.025%	61 (51.35)	58 (49.60)	56 (48.45)	58.33 (49.80)
T_9 - Cypermethrin 25EC	0.005%	60 (50.77)	63 (52.53)	59 (50.18)	60.66 (51.16)
T_{10} - Pyridalyl 10EC	0.20%	39 (38.65)	38 (38.06)	40 (39.23)	39.00 (38.64)
T_{11} - *Bacillus thuringiensis*	0.075%	89 (70.63)	87 (68.87)	84 (66.42)	86.66 (68.64)
T_{12} - Control (Water spray)		92 (73.57)	93 (74.66)	92 (73.57)	92.33 (73.93)
'F' test					Sig.
S.E.(m)±					0.873
CD at 1%					2.59

(Figures in parentheses are arc sine values)

Malathi et al., (1999) who reported that Dipel and Delfin (Bt formulation) 0.075 per cent concentration gave 82.66 and 82.00 per cent parasitoids (*T. chilonis*) emergence when *C. cephalonica* eggs first parasitized and then sprayed. Also, the toxic effect of Spinosad was reported against *T. exiguam* where its adverse effect was found on Trichogramma emergence (suh et al., 2004). These reports supports the present findings.

Table 8. Effect of newer insecticides on per cent adult emergence of *T. chilonis* in irradiated eggs (Trichogramma adult release at 3rd day of treatment)

Treatment	Concen -tration	per cent adult emergence of *T. chilonis*			
		RI	RII	RIII	Mean
T_1 - Diflubenzuron 48SC	0.08%	61 (51.35)	58 (49.60)	63 (52.53)	60.66 (51.16)
T_2 - Indoxacarb 14.5SC	0.01%	50 (45.00)	45 (42.13)	52 (46.15)	49 (44.42)
T_3 - Fipronil 5SC	0.16%	23 (28.66)	21 (27.28)	26 (30.66)	23.33 (28.86)
T_4 - Spinosad 45SC	0.01%	29 (32.58)	30 (33.21)	32 (34.45)	30.33 (33.41)
T_5 - Endosulfan 35EC	0.07%	70 (56.79)	62 (51.94)	58 (49.60)	63.33 (52.77)
T_6 - Acetamiprid 20SP	0.02%	62 (51.94)	54 (47.29)	56 (48.45)	57.33 (49.22)
T_7 - Profenophos 50EC	0.20%	42 (40.40)	32 (34.45)	40 (39.25)	38 (38.03)
T_8 - Flubendiamide 480SC	0.025%	40 (39.23)	42 (40.40)	44 (41.55)	42 (40.39)
T_9 - Cypermethrin 25EC	0.005%	42 (40.40)	41 (39.82)	43 (40.98)	42 (40.40)
T_{10} - Pyridalyl 10EC	0.20%	23 (28.66)	28 (31.95)	31 (33.83)	27.33 (31.83)
T_{11} - *Bacillus thuringiensis*	0.075%	69 (56.17)	72 (58.05)	68 (55.55)	69.66 (56.59)
T_{12} - Control (Water spray)		70 (56.79)	74 (59.34)	73 (58.69)	72.33 (58.27)
'F' test					Sig.
S.E.(m)±					1.196
CD at 1%					3.55

(Figures in parentheses are arc sine values)

4.2.2 U.V. irradiated *C. cephalonica* eggs (Trichogramma adult release at 3rd day of treatment)

Data presented in Table 8 are statistically significant.

Among the different insecticidal treatments, *Bacillus thuringiensis* 0.075% (69.66%) gave maximum adult emergence and was at par with untreated control (72.33%). The next safer treatment was endosulfan 0.07% (63.33%) followed by diflubenzuron 0.08% (60.66%), acetamiprid 0.02% (57.33%), all being at par with each other.

The least adult emergence was observed in fipronil 0.16% (23.33%) followed by pyridalyl 0.20% (27.33%), spinosad 0.01% (30.33%). Amongst these three treatments, first two and last two treatments were found statistically similar.

As no literature is available on per cent adult emergence of *T. chilonis* in Trichogramma release at 3rd day of treatment, hence could not be discussed.

4.2.3 U.V. irradiated *C. cephalonica* eggs (Trichogramma adult release at 5th day of treatment)

Data presented in Table 9 are found statistically significant.

Among the different insecticidal treatments, *Bacillus thuringiensis* 0.075% (52.66%) giving maximum adult emergence after control (58.66%). The next safer treatments were endosulfan 0.07% (42.66%), diflubenzuron 0.08% (42.33%), acetamiprid 0.02% (41.66%) , indoxacarb 0.01% (41.00%), all being at par with each other.

However, the treatments profenophos 0.20% (25.33%), cypermethrin 0.005% (24%), spinosad 0.01% (23.33%), flubendiamide 0.025% (23.33%), all being at par with each other.

The least adult emergence was observed in fipronil 0.16% (14.00%) followed by pyridalyl 0.20% (20%)

No literature is available on per cent adult emergence of *T. chilonis* in Trichogramma release at 5th day of treatment, hence could not be discussed.

Table 9. Effect of newer insecticides on per cent adult emergence of *T. chilonis* in irradiated eggs (Trichogramma adult release at 5th day of treatment)

Treatment	Concen -tration	per cent adult emergence of *T. chilonis*			
		RI	RII	RIII	Mean
T_1 - Diflubenzuron 48SC	0.08%	42 (40.40)	43 (40.98)	42 (40.40)	42.33 (40.59)
T_2 - Indoxacarb 14.5SC	0.01%	40 (32.23)	42 (40.40)	41 (39.82)	41.00 (39.81)
T_3 - Fipronil 5SC	0.16%	15 (22.79)	14 (21.97)	13 (21.13)	14.00 (21.96)
T_4 - Spinosad 45SC	0.01%	23 (28.66)	24 (29.33)	23 (28.66)	23.33 (28.88)
T_5 - Endosulfan 35EC	0.07%	42 (40.40)	45 (42.13)	41 (39.82)	42.66 (40.78)
T_6 - Acetamiprid 20SP	0.02%	43 (40.98)	42 (40.40)	40 (39.23)	41.66 (40.20)
T_7 - Profenophos 50EC	0.20%	23 (28.66)	24 (29.33)	29 (32.58)	25.33 (30.19)
T_8 - Flubendiamide 480SC	0.025%	21 (27.28)	25 (30.00)	24 (29.33)	23.33 (28.87)
T_9 - Cypermethrin 25EC	0.005%	23 (28.66)	28 (31.95)	21 (27.28)	24 (29.29)
T_{10} - Pyridalyl 10EC	0.20%	19 (25.84)	18 (25.10)	23 (28.66)	20 (26.53)
T_{11} - *Bacillus thuringiensis*	0.075%	54 (47.29)	53 (46.72)	51 (45.57)	52.66 (46.52)
T_{12} - Control (Water spray)		58 (49.60)	60 (50.77)	58 (49.60)	58.66 (49.99)
'F' test					Sig.
S.E.(m)±					0.753
CD at 1%					2.238

(Figures in parentheses are arc sine values)

4.2.4 U.V. unirradiated *C. cephalonica* eggs (Trichogramma adult release at 1st day of treatment)

Data presented in Table 10 are statistically significant.

Table 10. Effect of newer insecticides on per cent adult emergence of *T. chilonis* in unirradiated eggs (Trichogramma adult release at 1st day of treatment)

Treatment	Concen -tration	Per cent adult emergence of *T. chilonis*			
		RI	RII	RIII	Mean
T_1 - Diflubenzuron 48SC	0.08%	86 (68.03)	84 (66.42)	83 (65.66)	84.33 (66.70)
T_2 - Indoxacarb 14.5SC	0.01%	72 (58.05)	82 (64.90)	78 (62.03)	77.33 (61.66)
T_3 - Fipronil 5SC	0.16%	40 (30.23)	38 (38.06)	46 (42.71)	41.33 (40.00)
T_4 - Spinosad 45SC	0.01%	38 (38.06)	36 (36.87)	40 (39.23)	38 (38.05)
T_5 - Endosulfan 35EC	0.07%	92 (73.57)	90 (71.56)	91 (72.54)	91 (72.54)
T_6 - Acetamiprid 20SP	0.02%	75 (60.00)	74 (59.34)	77 (61.34)	75.33 (60.22)
T_7 - Profenophos 50EC	0.20%	54 (47.29)	58 (49.60)	55 (47.87)	55.66 (48.25)
T_8 - Flubendiamide 480SC	0.025%	57 (49.02)	53 (46.72)	64 (53.13)	58 (49.62)
T_9 - Cypermethrin 25EC	0.005%	63 (52.53)	64 (53.13)	68 (55.55)	65 (53.73)
T_{10} - Pyridalyl 10EC	0.20%	49 (44.43)	47 (43.28)	53 (46.72)	49.66 (44.81)
T_{11} - *Bacillus thuringiensis*	0.075%	94 (75.82)	92 (73.57)	91 (72.54)	92.33 (73.97)
T_{12} - Control (Water spray)		99 (84.26)	98 (81.87)	98 (81.87)	98.33 (82.66)
'F' test					Sig.
S.E.(m)±					1.116
CD at 1%					3.317

(Figures in parentheses are arc sine values)

Among the different insecticidal treatments, maximum adult emergence was observed in *Bacillus thuringiensis* 0.075% (92.33%) followed by Endosulfan 0.07% (91%) both were at par with each other.

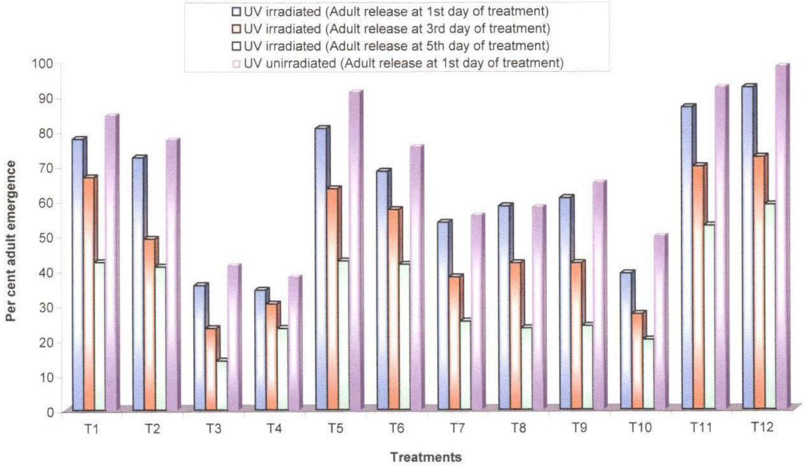

Fig. 2. Effect of newer insecticides on per cent adult emergence of *T. chilonis* in *C. cephalonica* eggs

The next safer treatments were diflubenzuron 0.08% (84.33%), indoxacarb 0.01% (77.33%), acetamiprid 0.02% (75.33%). Amongst these three treatments the last two treatments were found statistically equal. flubendiamide 0.025% (58%) and profenophos 0.20% (55.66%) was found at par with each other.

Whereas, the least adult emergence was observed in spinosad 0.01% (38%) followed by fipronil 0.16% (41.33%) and was found at par with each other.

Endosulfan has been reported safer to Trichogramma by some earlier workers, wherein about 88.4 per cent adult emergence was observed by Gupta et al. (1984) when parasitized host eggs were treated with endosulfan @ 0.075 per cent. Whereas about 81.42 per cent adult emergence has been observed by Pili (1996) with the treatment of endosulfan 0.06 per cent. These reports support present findings.

4.3 Effects of newer insecticides on longevity of *T. chilonis* in days.

In the present study, longevity has been estimated by, counting number of days from adult emergence to the death of Trichogramma adult.

4.3.1. U.V. irradiated *C. cephalonica* eggs (Trichogramma adult release at 1st day of treatment)

Data presented in Table 11 are found statistically significant.

Among the various insecticides tested along with microbial (Bt), the treatment *Bacillus thuringiensis* with longevity 3.41 days gave more longevity after control (3.91 days). This treatment was followed by a group of insecticides including , endosulfan 0.07% (2.66 days), diflubenzuron 0.08% (2.63 days), acetamiprid 0.02% (2.51 days), flubendiamide 0.025% (2.33 days), indoxacarb 0.01% (1.77 days). Amongst these five treatments, first four and last three were statistically equal. Profenophos 0.2% (1.77 days) was also found at par with indoxacarb and cypermethrin 0.005% (1.58 days) was also found at par with profenophos.

Table 11. Effect of newer insecticides on longevity of *T. chilonis* in days in irradiated eggs (Trichogramma adult release at 1st day of treatment)

Treatment	Concen -tration	Longevity of *T. chilonis* in days			
		RI	RII	RIII	Mean
T_1 - Diflubenzuron 48SC	0.08%	2.50	2.75	2.66	2.63
T_2 - Indoxacarb 14.5SC	0.01%	2.00	2.33	2.00	2.11
T_3 - Fipronil 5SC	0.16%	1.00	1.00	1.00	1.00
T_4 - Spinosad 45SC	0.01%	1.33	1.00	1.66	1.33
T_5 - Endosulfan 35EC	0.07%	2.75	2.75	2.50	2.66
T_6 - Acetamiprid 20SP	0.02%	2.50	2.75	2.33	2.51
T_7 - Profenophos 50EC	0.20%	1.66	2.00	1.66	1.77
T_8 - Flubendiamide 480SC	0.025%	2.33	2.00	2.66	2.33
T_9 - Cypermethrin 25EC	0.005%	1.66	1.75	1.33	1.58
T_{10} - Pyridalyl 10EC	0.20%	1.00	1.25	1.33	1.19
T_{11} - *Bacillus thuringiensis*	0.075%	3.25	3.00	4.00	3.41
T_{12} - Control (Water spray)		4.00	3.75	4.00	3.91
'F' test					Sig.
S.E.(m)±					0.143
CD at 1%					0.427

Whereas, less longevity was observed in treatments, fipronil 0.16% (1.00 day), pyridalyl 0.2% (1.19 days), spinosad 0.01% (1.33 days), cypermethrin 0.005% (1.58 days). Amongst these four treatments, first three and last three treatments were found statistically equal.

The present findings were supported by Sheng et al. (2009), who reported that *Bacillus thuringiensis* and acetamiprid had low effects on longevity.

4.3.2. U.V. irradiated *C. cephalonica* eggs (Trichogramma adult release at 3rd day of treatment)

Data presented in Table 12 are found statistically significant.

Table 12. Effect of newer insecticides on longevity of *T. chilonis* in days in irradiated eggs (Trichogramma adult release at 3rd day of treatment)

Treatment	Concen -tration	Longevity of *T. chilonis* in days			
		RI	RII	RIII	Mean
T_1 - Diflubenzuron 48SC	0.08%	2.00	2.66	2.33	2.33
T_2 - Indoxacarb 14.5SC	0.01%	2.00	2.00	2.00	2.00
T_3 - Fipronil 5SC	0.16%	1.25	1.00	1.33	1.19
T_4 - Spinosad 45SC	0.01%	1.00	1.33	1.33	1.22
T_5 - Endosulfan 35EC	0.07%	2.75	2.50	2.33	2.52
T_6 - Acetamiprid 20SP	0.02%	2.00	2.33	2.50	2.27
T_7 - Profenophos 50EC	0.20%	1.66	1.50	1.33	1.49
T_8 - Flubendiamide 480SC	0.025%	2.00	2.33	2.00	2.11
T_9 - Cypermethrin 25EC	0.005%	1.66	1.00	1.33	1.33
T_{10} - Pyridalyl 10EC	0.20%	1.00	1.25	1.00	1.08
T_{11} - *Bacillus thuringiensis*	0.075%	3.33	3.25	3.50	3.36
T_{12} - Control (Water spray)		3.75	3.50	3.75	3.66
'F' test					Sig.
S.E.(m)±					0.119
CD at 1%					0.437

Among the different insecticidal treatments, more longevity was observed in *Bacillus thuringiensis* 0.075% (3.36 days) was found at par with untreated control (3.75 days). Next efficacious group was endosulfan 0.07% (2.52 days) followed by diflubenzuron 0.08% (2.33 days) were found at par with each other. Flubendiamide 0.025% (2.11 days) was also found at par with diflubenzuron.

Whereas, the less longevity was observed in treatments, profenophos 0.2% (1.49 days), cypermethrin 0.05% (1.33 days), spinosad 0.01% (1.22 days), fipronil 0.16% (1.19 days), pyridalyl 0.2% (1.08 days), all being at par with each other.

No literature is available on longevity of *T. chilonis* in adult release at 3rd day of treatment, hence could not be discussed.

4.3.3 U.V. irradiated *C. cephalonica* eggs (Trichogramma adult release at 5th day of treatment)

The data presented in Table 13 are found statistically significant.

Table 13. Effect of newer insecticides on longevity of *T. chilonis* in days in irradiated eggs (Trichogramma adult release at 5th day of treatment)

Treatment	Concen -tration	Longevity of *T. chilonis* in days			
		RI	RII	RIII	Mean
T_1 - Diflubenzuron 48SC	0.08%	2.00	2.33	2.00	2.11
T_2 - Indoxacarb 14.5SC	0.01%	1.66	2.00	1.50	1.72
T_3 - Fipronil 5SC	0.16%	1.00	1.00	1.25	1.08
T_4 - Spinosad 45SC	0.01%	1.00	1.00	1.33	1.11
T_5 - Endosulfan 35EC	0.07%	2.25	2.33	2.00	2.19
T_6 - Acetamiprid 20SP	0.02%	2.50	2.00	2.00	2.16
T_7 - Profenophos 50EC	0.20%	1.33	1.66	1.66	1.55
T_8 - Flubendiamide 480SC	0.025%	2.00	2.00	2.00	2.00
T_9 - Cypermethrin 25EC	0.005%	1.33	1.00	1.25	1.19
T_{10} - Pyridalyl 10EC	0.20%	1.00	1.00	1.00	1.00
T_{11} - *Bacillus thuringiensis*	0.075%	2.66	3.00	3.50	3.05
T_{12} - Control (Water spray)		4.00	3.00	3.25	3.41
'F' test					Sig.
S.E.(m)±					0.147
CD at 1%					0.439

Among the different insecticidal treatments, more longevity was found in *Bacillus thuringiensis* 0.075% (3.05 days) was found at par with untreated control (3.41 days)

This traetment followed by the group of insecticides included, endosulfan 0.07%, acetamiprid 0.02%, diflubenzuron 0.08%, flubendiamide 0.025%, indoxacarb 0.01% with longevity 2.19 days , 2.16 days , 2.11 days, 2.00 days, 1.72 days , respectively. Amongst these five treatments, first four and last three treatments were found stastitically equal. Indoxacarb was also found at par with profenophos 0.2% (1.55 days). Profenophos was found at par with cypermethrin 0.005% (1.19 days)

Whereas, the less longevity were observed in treatments cypermethrin 0.005%, spinosad 0.01%, fipronil 0.16%, pyridalyl 0.2% with longevity 1.19 days , 1.11 days , 1.08 days , 1 day , respectively, all being at par with each other.

No literature is available on longevity of *T. chilonis* in adult release at 5th day of treatment , hence could not be discussed.

4.3.4. U.V. unirradiated *C. cephalonica* eggs (Trichogramma adult release at 1st day of treatment)

The data presented in Table 14 are found statistically significant.

More longevity was observed in *Bacillus thuringiensis* 0.075% (3.52 days) after untreated control (4.00 days). Next group of insecticides giving more longevity were endosulfan 0.07%, diflubenzuron 0.08%, acetamiprid 0.02%, indoxacarb 0.01% , flubendiamide 0.025% with longevity 2.72 days , 2.55 days , 2.49 days , 2.49 days , 2.44 days respectively and all beings at par with each other. Profenophos 0.20% with longevity 2.22 days was also found at par with last four treatments. Cypermethrin 0.005% (1.80 days) was found at par with profenophos. Spinosad 0.01% (1.44 days) was also at par with cypermethrin.

Whereas , the less longevity were observed in treatments spinosad 0.01% , pyridalyl 0.2%, fipronil 0.16% with longevity 1.44 days , 1.19 days , 1.00 days , respectively and all being at par with each other.

Garcia et al. (2009) reported that Bt had little or no adverse effect on longevity of *T. cordubensis*, which supports the present findings.

Table 14. Effect of newer insecticides on longevity of *T. chilonis* in days in unirradiated eggs(Trichogramma adult release at 1st day of treatment)

Treatment	Concen -tration	Longevity of *T. chilonis* in days			
		RI	RII	RIII	Mean
T_1 - Diflubenzuron 48SC	0.08%	2.66	2.50	2.50	2.55
T_2 - Indoxacarb 14.5SC	0.01%	2.66	2.33	2.50	2.49
T_3 - Fipronil 5SC	0.16%	1.00	1.00	1.00	1.00
T_4 - Spinosad 45SC	0.01%	1.66	1.33	1.33	1.44
T_5 - Endosulfan 35EC	0.07%	2.66	2.50	3.00	2.72
T_6 - Acetamiprid 20SP	0.02%	2.50	2.33	2.66	2.49
T_7 - Profenophos 50EC	0.20%	3.00	1.66	2.00	2.22
T_8 - Flubendiamide 480SC	0.025%	2.66	2.33	2.33	2.44
T_9 - Cypermethrin 25EC	0.005%	1.66	1.75	2.00	1.80
T_{10} - Pyridalyl 10EC	0.20%	1.33	1.00	1.25	1.19
T_{11} - *Bacillus thuringiensis*	0.075%	3.75	3.50	3.33	3.52
T_{12} - Control (Water spray)		4.00	4.00	4.00	4.00
'F' test					Sig.
S.E.(m)±					0.148
CD at 1%					0.440

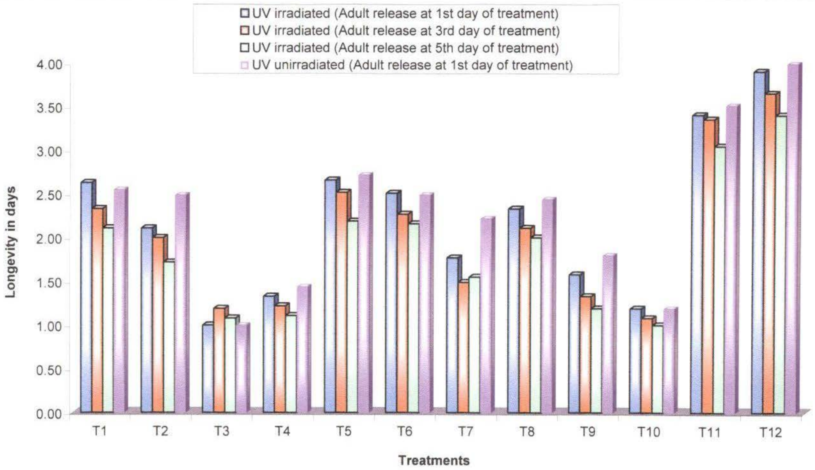

Fig. 3. Effect of newer insecticides on longevity of *T. chilonis* in days

CHAPTER V

SUMMARY AND CONCLUSIONS

The present investigation involved evaluation of some newer insecticides for their study against a very potent egg parasitoid, *T. chilonis*. The insecticides tested were diflubenzuron 48 SC (0.08%), indoxacarb 14.5 SC (0.01%), fipronil 5 SC (0.16%), spinosad 45 SC (0.01%), endosulfan 35 EC (0.07%), acetamiprid 20 SP (0.02%), profenophos 50 EC (0.20%), flubendiamide 480 SC (0.025%), cypermethrin 25 EC (0.005%), pyridalyl 10 EC (0.20%), *Bacillus thuringiesis* (0.075%).

The observations on per cent parasitization of *C. cephalonica* eggs, per cent adult emergence and longevity of *T. chilonis* were taken separately for U.V. exposed (Trichogramma adult release at 1st, 3rd and 5th day of treatment) and unexposed host eggs. For recording effect of the insecticides on these observations, egg strips each containing 100 *C. cephalonica* eggs, were treated with respective insecticidal spray suspensions and were exposed to adults of *T. chilonis* @ 5:1 host - parasitoid ratio. The observations on parasitization and adult emergence were recorded under stereoscopic microscope.

5.1 Effect of newer insecticides on per cent parasitization of *C. cephalonica* eggs by *T. chilonis* Ishii.

5.1.1. U.V. exposed *C. cephalonica* eggs (Trichogramma adult release at 1st day of treatment)

Maximum parasitization was observed in untreated control (89%) which was significantly superior to all the treatments. It was followed by *Bacillus thuringiensis* 0.075% (81.66%). This treatment followed by a group of insecticides including, endosulfan 0.07%, (74.66%), diflubenzuron 0.08% (73.66%), acetamiprid 0.02% (71.66%), flubendiamide 0.025% (71.33%) , all being at par with each other. The next efficacious group included spinosad 0.01%, profenophos 0.20%, indoxacarb 0.01%, cypermethrin 0.05% with parasitazation of 62.66, 60.33, 55.66, 54.66 per cent, respectively and all being at par with each other. Least parasitization was observed in Fipronil 0.16% (32.33%) followed by Pyridalyl 0.20% (43.66%).

5.1.2 U.V. exposed *C. cephalonica* eggs (Trichogramma adult release at 3rd day of treatment)

Maximum per cent parasitization was observed in treatment *Bacillus thuringiensis* 0.075% (64.66%). Next group of showing maximum parasitization was flubendiamide 0.025%, endosulfan 0.07%, diflubenzuron 0.08%, spinosad 0.01%, acetamiprid 0.02% with parasitization 58.33, 56.33, 56.33, 55.33, 54.33 per cent, respectively and all being at par with each other. Least parasitization was found in fipronil 0.16% (18.66%) followed by pyridalyl 0.20% (34.33%).

5.1.3 U.V. exposed *C. cephalonica* eggs (Trichogramma adult release at 5th day of treatment)

In present study, maximum per cent parasitization was observed in group of insecticides including, *Bacillus thuringiensis* 0.075% (39.66%), endosulfan 0.07% (36.66%), diflubenzuron 0.08% (35%), flubendiamide 0.025% (34%) , acetamiprid 0.02% (32.33%). Amongst these five treatments, the first four as well as the last four treatments were found statistically similar. However the last three treatments were found statistically similar with spinosad 0.01% (31%). Minimum per cent parasitization were observed in treatments cypermethrin 0.005%, pyridalyl 0.20%, fipronil 0.16%, recorded parasitization 25.33, 22, 14 per cent, respectively and also found statistically equal.

5.1.4 U.V. unexposed *C. cephalonica* eggs (Trichogramma adult release at 1st day of treatment).

Maximum per cent parasitization was found in *Bacillus thuringiensis* 0.075% (83.66%). The next safer group included endosulfan 0.07%, diflubenzuron 0.08%, flubendiamide 0.025%, acetamiprid 0.02% recorded parasitization 79, 78.66, 76, 74.33 per cent, respectively. Amongst these four treatments, the first three as well as last two treatments were found statistically similar. Whereas the least parasitization was observed in fipronil 0.16% (40.66%) followed by pyridalyl 0.20% (51%).

5.2. Effect of newer insecticides on per cent adult emergence of *T. chilonis* in *C. cephalonica* eggs.

5.2.1 U.V. exposed *C. cephalonica* eggs (Trichogramma adult releae at 1st day of treatment)

Among the different insecticidal treatments, *Bacillus thuringiensis* 0.075% (86.66%) giving maximum adult emergence after control (92.33%). The next safer treatments were endosulfan 0.07% (80.66%) followed by diflubenzuron 0.08% (77.66%), both were found statistically equal. Least adult emergence was observed in treatments, pyridalyl 0.20 % (39.00%), fipronil 0.16% (35.66%), spinosad 0.01%(34.33%)

5.2.2 U.V. exposed *C. cephalonica* eggs (Trichogramma adult releae at 3rd day of treatment)

Maximum adult emergence was found in *Bacillus thuringiensis* 0.075% (69.66%) was also found at par with control (72.33%). The next safer treatment was endosulfan 0.07% (63.33%) followed by diflubenzuron 0.08% (60.66%), acetamiprid 0.02% (57.33%), all being at par with each other. Whereas, least adult emergence was observed in fipronil 0.16% (23.33%) followed by pyridalyl 0.20% (27.33%), spinosad 0.01% (30.33%).

5.2.3 U.V. exposed *C. cephalonica* eggs (Trichogramma adult release at 5th day of treatment)

Maximum adult emergence was found in *Bacillus thuringiensis* 0.075% (52.66%) after control (58.66%). The next safer treatments were endosulfan 0.07% (42.66%), diflubenzuron 0.08% (42.33%), acetamiprid 0.02% (41.66%), indoxacarb 0.01% (41.00%), all being at par with each other. Whereas, the least adult emergence was observed in fipronil 0.16% (14.00%) followed by pyridalyl 0.20% (20%).

5.2.4 U.V. unexposed *C. cephalonica* eggs (Trichogramma adult release at 1st day of treatment)

Maximum adult emergence was observed in *Bacillus thuringiensis* 0.075% (92.33%) followed by endosulfan 0.07% (91%) both were at par with each other. The next safer treatments were diflubenzuron 0.08% (84.33%), indoxacarb 0.01% (77.33%), acetamiprid 0.02% (75.33%). Whereas, least adult emergence was observed in spinosad 0.01% (38%) followed by fipronil 0.16% (41.33) and was found at par with each other.

5.3 Effect of newer insecticides on longevity of *T. chilonis* in days

5.3.1 U.V. exposed *C. cephalonica* eggs (Trichogramma adult release at 1st day of treatment)

The treatment *Bacillus thuringiensis* 0.075% (3.41days) gave more longevity after control (3.91days). This treatment followed by a group of insecticides including, endosulfan 0.07% (2.66days), diflubenzuron 0.08% (2.63days), acetamiprid 0.02% (2.51 days), flubendiamide 0.025% (2.33 days), indoxacarb 0.01% (1.77 days). Amongst these five treatments, first four and last three treatments were statistically equal. Whereas less longevity was observed in treatments, fipronil 0.16% (1.00day), pyridalyl 0.2% (1.19 days), spinosad 0.01% (1.33 days), cypermethrin 0.005% (1.58days).

5.3.2 U.V. exposed *C. cephalonica* eggs (Trichogramma adult release at 3rd day of treatment)

More longevity was observed in *Bacillus thuringiensis* 0.075% (3.36 days) and was found at par with untreated control (3.75 days). The next efficacious group was endosulfan 0.07% (2.52 days) followed by diflubenzuron 0.08% (2.33 days) were found at par with each other. Whereas, the less longevity were observed in treatments, profenophos 0.2% (1.49 days), cypermethrin 0.05% (1.33 days), spinosad 0.01% (1.22 days), fipronil 0.16% (1.19 days) pyridalyl 0.2% (1.08 days), all being at par with each other.

5.3.3 U.V. exposed *C. cephalonica* eggs (Trichogramma adult release at 5th day of treatment)

More longevity was found in *Bacillus thuringiensis* 0.075% (3.05 days) was found at par with control (3.14 days). The next safer treatments were endosulfan 0.07%, acetamiprid 0.02%, diflubenzuron 0.08%, flubendiamide 0.025%, indoxacarb 0.01% with longevity 2.19 days, 2.16 days, 2.11 days, 2 days, 1.72 days, respectively. Amongst these five treatments first four and last three treatments were found statistically equal. Whereas, the less longevity were observed in treatments cypermethrin 0.005%, spinosad 0.01%, fipronil 0.16%, pyridalyl 0.2% with longevity 1.19 days, 1.11 days, 1.08 days, 1 day, respectively, all being at par with each other.

5.3.4 U.V. unexposed *C. cephalonica* eggs (Trichogramma adult release at 1st day of treatment)

More longevity was found in *Bacillus thuringiensis* 0.075% (3.52 days) after control (4.00 days). The next safer treatments were endosulfan 0.07%, diflubenzuron 0.08%, acetamiprid 0.02%, indoxacarb 0.01%,flubendiamide 0.025% with longevity 2.72 days, 2.55 days, 2.49 days, 2.49 days, 2.44 days, respectively, all being at par with each other. Whereas, the less longevity were observed in treatments spinosad 0.01%, pyridalyl 0.2%, fipronil 0.16%, with longevity 1.44 days, 1.19 days, 1.00 day, respectively and all being at par with each other.

CONCLUSIONS

1) U.V. irradiation of eggs reduces the parasitization by *T. chilonis* to the extent of 6% as compared to U.V. unirradiated eggs.
2) *T. chilonis* prefers unirradiated *C. cephalonica* eggs as compared to irriadiated ones for parasitization.
3) *Bacillus thuringiensis*, being a biopesticide, confirmed as safer insecticide to *T. chilonis.*
4) Among the chemical insecticides, Endosulfan followed by Diflubenzuron were found to be safer to *T. chilonis*.
5) Fipronil was found detrimental to *T. chilonis* with reduced parasitization and adult emergence.
6) Spinosad was found moderately toxic for parasitization and toxic for adult emergence.
7) Indoxacarb was found safer for emergence and moderately safer for parasitization.
8) Trichogramma can be released immediately either before or after spraying of *Bacillus thuringiensis* as it was found to be compatible with each other.

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VITA

1. Name of Student : Sonavane Suvarna Bansi

2. Date of Birth : 19.05.1987

3. Name of College : Post Graduate Institute,
Dr. PDKV, Akola

4. Residential Address : At Post - Virgaon
Tal - Akole
Dist - Ahmednagar
Pin – 422601

5. Academic Qualification

Sr. No.	Name of degree awarded	Year in which obtained	Division / Class	Name of awarding university	Subjects
1	B.Sc. (Agri.)	2008	First	Dr.PDKV,Akola	Agriculture and Allied Science

6. Research paper published : Nil

7. Field of Interest : Agricultural Entomology

Place: Akola

Date: 31 / 05 /2010

Sonawane
Signature of student