ANNUAL REPORT
1994-95

PROJECT DIRECTORATE OF BIOLOGICAL CONTROL
HEBBAL, BANGALORE - 560 024.

ANNUAL REPORT
1994-95

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

PROJECT DIRECTORATE OF BIOLOGICAL CONTROL
HEBBAL, BANGALORE - 560 024.

Published by :

Dr. S. P. Singh
Project Director
Project Directorate of Biological Control (ICAR)
Hebbal, Bangalore 560 024, India

Cover page photograph : Anthocorid bug feeding on *Helicoverpa armigera* larva (Part of Ph. D work of Mrs. C. R. Ballal, Scientist SS, PDBC, Bangalore)

Printed at : Shruthi Print Products, Bangalore 560 010, Phone : 3357748

CONTENTS

1. PROJECT DIRECTOR'S REPORT

All India Co-ordinated Research Project on Biological Control of Crop Pests and Weeds was initiated in 1977 under the Indian Council of Agricultural Research, New Delhi with funds from Department of Science and Technology, Government of India, New Delhi and within two years (1979) ICAR started providing full financial support. The Project Co-ordinator's cell during the VIII plan was upgraded to a Project Directorate (PDBC). The PDBC started functioning on 18th October,1993 with 16 centres.

1.1 Mandate

* To evolve effective biological control strategy for important pests and weeds
* To coordinate research on biological control aspects at the national level
* To serve as a nodal agency for introduction, exchange and conservation of biological control agents at the national level
* To disseminate information and impart training in biological control

1.1.1 Organization

With a view to fulfilling its mandates effectively and efficiently the PDBC at its headquarters in Bangalore is functioning with the following five laboratories and a cell.

* Biosystematics, Cataloguing, Introduction and Quarantine Laboratory
* Mass Production Laboratory
* Pathology Laboratory
* Entomophagous Insect Behaviour Laboratory
* Genetic Improvement and Production on Artificial Diets Laboratory
* Co-ordination, Documentation and Training Cell
* The Co-ordinating or Co-operating centres are:

  - CPCRI : Central Plantation Crops Research Institute, Kayangulam
  - CTRI : Central Tobacco Research Institute, Rajahmundry
  - IARI : Indian Agricultural Research Institute, New Delhi
  - IIHR : Indian Institute of Horticultural Research, Bangalore
  - IISR : Indian Institute of Sugarcane Research, Lucknow
  - SBI : Sugarcane Breeding Institute, Coimbatore
  - AAU : Assam Agricultural University, Jorhat
  - APAU : Andhra Pradesh Agricultural University, Hyderabad
  - GAU : Gujarat Agricultural University, Anand
  - KAU : Kerala Agricultural University, Trichur
  - MPKV : Mahatma Phule Krishi Vidyapeeth, College of Agriculture, Pune
  - PAU : Punjab Agricultural University, Ludhiana
  - SKUAS&T : Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar

- TNAU : Tamil Nadu Agricultural University, Coimbatore
- YSPUH&F : Dr. Y. S. Parmar University of Horticulture & Forestry, Nauni, Solan
- GBPUAS&T : Govind Vallabh Pant University of Agricultural Sciences & Technology, Pantnagar

1.1.3 Facilities at PDBC

Equipments

Since its inception all efforts are being made to create facilities to bring the PDBC to international level. Presently the laboratories are equipped with modern scientific equipments like Environmental chambers programmable for temperature, humidity and photoperiod ; Image analysis system complete with software, videocamera, video playing unit and computer for requisite analysis ; Ultra refrigerated centrifuge; Auto Elisa reader ; Fermenter ; Electrophoresis and electrofocussing unit ; Inverted phase contrast microscope with fluorescence; Deep freeze (-85°C); Leaf area analysis system; HPLC; and all other requisite facilities for biological control research work.

Library

The library has a collection of 1,285 books, 858 volumes of journals, 22 bulletins and several miscellaneous publications including several reprints on various aspects of biological control. For quick and efficient literature search CD-ROM (Compact Disc Read Only Memory) is provided along with CABPESTCD abstracts.

Technical Documentation

Photostat copiers, electronic typewriters, computers, laser printer, laminating machine, binding machine, FAX and telex are ready at hand for efficient and quick compilation and documentation work as well as quick communication. The computer facility includes software for scientific data analysis and graphics.

National Insect Reference Collection

The PDBC has 3,597 authentically identified species belonging to 1,063 genera under 205 families. The collection includes representatives of the orders Hymenoptera, Coleoptera, Hemiptera, Orthoptera, Strepsiptera, Neuroptera, Diptera, Lepidoptera, etc.encompassing crop pests, parasitoids and predators.

The PDBC is in a position to collaborate on all aspects of biological control for mutual benefit, particularly on exchange of beneficial organisms, preparation of projects and advance training.

1.1.4. Major achievements during 1994-95

1.1.4.1. Introduction, Quarantine handling and Basic research

Successful egg laying and partial larval development of *Trichogramma chilonis* and *T. pretiosum* was obtained with artificial diets containing *Helicoverpa armigera* haemolymph and other constituents including an egg laying stimulant, which is a step forward in the attempts at 'in vitro' production of these parasitoids.

Chrysoperla carnea could successfully complete five generations in diets containing *Spodoptera litura* and *H. armigera* abdomen powder.

Though the larval and pupal durations were prolonged as compared to natural diet when reared on some synthesized artificial diets of *Plutella xylostella* there was better percentage of pupation and adult emergence in one diet which seems promising.

Cheilomenes sexmaculata and an unidentified syrphid were found to be the chief predators which kept the population of *Aphis craccivora* under check in areas around Bangalore.

Campoletis chlorideae, an effective endoparasitoid of *H. armigera* could also be reared on *S. litura* in the laboratory and it completed its development in 15-17 days and the adult longevity was 25 days.

In an attempt to develop endosulfan resistant strain of *Trichogramma chilonis* the parasitoid has been reared upto 170 generations under pesticide pressure of upto 0.0525% concentration.

There was an increase in percentage parasitization, adult emergence and proportion of females emerged when average size egg clusters (20 - 30 eggs) of *Chilo partellus* were exposed to increasing number of females (1 - 5 females).

Seven day old females of *Allorhogas pyralophagus* parasitized more larvae and produced more adults per larvae of *C. partellus* with parasitization extending upto 36 days of the female life.

There was a strong positive relationship between *C. partellus* larval weight and emergence of *A. pyralophagus* adults with larvae of 43.6g producing one adult and that of 163.4g producing 24 adults.

The females of *Cotesia flavipes* could parasitize *Plutella xylostella* larvae upto 9 days of their life and females of 7-8 days age parasitized maximum larvae and adult emergence was also high.

Chrysoperla carnea larvae spent more time (1.66 minutes) as compared to control (0.68 minutes) and also probed more number of times (3.8 times) as compared to control (0.6 times) the wax droplets coated with kairomones extracted from the scales of *Corcyra cephalonica*.

Hunger level determined the movement pattern of *C. carnea* larvae with those in hunger moving at a slow speed in a zig zag pattern while the satiated ones moved in a straight line with more speed.

The introduced American serpentine leaf-miner, *Liriomyza trifolii* was found on more than three dozen hosts and some indigenous natural enemies which have adopted to this pest have been recorded. Attempts are underway to import some natural enemies of the pest from USA.

The polyhedral inclusion bodies of both *S. litura* and *H. armigera* have been successfully encapsulated into beads using calcium alginate and polysaccharide sodium alginate solution with gustatory stimulants, UV protectants and screeners incorporated in it.

The virus infected larvae of *H. armigera* and *S. litura* consumed more oxygen (4490 µl/g/h and 3625 µl/g/h) as compared to healthy larvae (916 µl/g/h and 873 µl/g/h).

A new rickettsia like organism has been recorded on *H. armigera* in Bangalore.

Studies using Sl NPV revealed that $1x16^7$ PIB/ml concentration gave 90% mortality of the larvae and is being used for further studies for use with UV protectants obtained from mango and guava leaves.

SPO-*B. t* @ 300g/ha has proved superior to Dipel 8L and NSKE @ 4% for controlling *Plutella xylostella* in two field trials in Bangalore recording lesser population of the pest and higher yield.

1.1.4.2 Biological suppression of insect pests of commercial crops

The sugarcane borers *Chilo auricilius* and *Chilo infuscatellus* could be kept under check in Ludhiana, Punjab through 16 releases of *Trichogramma chilonis* @ 50,000/ha.

Trials to compare the effect of release of Indonesian and indigenous strains of *Cotesia flavipes* to control the sugarcane borers, *C. auricilius*, *C. infuscatellus* and *Acigona steniellus* in Ludhiana and Lucknow, though revealed reduced incidence of the borers, strain difference was not seen . The release rate of more than 2000/ha at weekly interval gave best results.

Laboratory studies in Lucknow to compare the Indonesian and indigenous strains of *Cotesia flavipes* revealed that they preferred 3rd - 5th instar larvae of *C. auricilius*. Studies in Coimbatore revealed maximum mating activity within 15 minutes of exposure to males and also that mating was not affected by a lower proportion of males.

In Ludhiana and Lucknow release of *Epiricania melanoleuca* @ 5000/ha kept a check on the population of sugarcane leafhopper *Pyrilla perpusilla*. 32.5% of the adults and nymphs of *P. perpusilla* were affected by *Metarrhizium anisopliae* in Pravaranagar.

The integrated pest management strategy consisting of *Trichogramma* releases, *Chrysoperla* releases, *B.t* treatment and NPV application for cotton pests was compared with the regular spray schedule and control in Punjab, Gujarat and Andhra Pradesh. The results revealed that IPM practice resulted in low incidence of boll worms in all the trials with the yields also comparable to the spray schedule.

In Andhra Pradesh 13.2 q/ha of seed cotton yield was obtained in IPM plot which was comparable and on par with 14.4 q/ha obtained from regular spray schedule plot, resulting in higher returns in IPM (Rs. 26,280) than spray schedule (Rs. 17,840), which was even less than untreated check (Rs 18,620).

The addition of adjuvants like Boric acid 0.025% to *B.t.* preparations (Delfin, Dipel) could reduce the dosage by half to 0.5 kg/ha thus resulting in cost effective strategy to control *Spodoptera litura* in the tobacco nursery in Rajahmundry. The results were similar for *B. t.* formulation and Ha NPV combination for controlling *H. armigera* in the tobacco field crop, in Rajahmundry and Anand.

The IPM practice for *Spodoptera litura* control consisting of trap crop of castor, NPV spray, *B. t.* application, NSKS spray, use of *Chrysoperla*, *Telenomus remus* and *Apanteles africanus* has proved cost effective with cost : benefit ratio of 1:2.74 as compared to 1: 1.52 for chemical control.

1.1.4.3. Biological suppression of insect pests of pulses and oil seed crops

Coccinellids and syrphids were the major predators found during a survey of natural enemies of the mustard aphid, *Lipaphis erysimi* during February- March in Punjab followed by the parasitoid, *Diaretiella rapae* during the end of March..

The use of HaNPV in combination with endosulfan (0.035%) at half the dosage of 125 LE/ha as one spray following HaNPV @ 250 LE/ha proved effective in reducing pod damage by *H. armigera* in chickpea, both at Hyderabad and Ludhiana.

Establishment of *Trichogramma chilonis* was not seen even where pigeonpea was intercropped with sorghum in Hyderabad. However, three rounds of HaNPV @ 250 LE/ha at 10 days interval effectively reduced the larval population and pod damage in Hyderabad and Ludhiana.

Amongst several *B. t.* formulations tested for the control of *H. armigera* in pigeonpea BTK-II was found superior during trials at Hyderabad.

1.1.4.4. Biological suppression of cereal crop pests

Trichogramma japonicum released @ 50,000/ha at weekly interval for 6 weeks could effectively reduce the percentage dead hearts due to the rice stem borer, *Scirpophaga incertulas* in Jorhat (Assam),Ludhiana (Punjab) and Pune (Maharashtra). The treatment of parasitoid releases was found to be on par with insecticidal sprays.

The rice leaf folder, *Cnaphalocrosis medinalis* could be effectively checked by six releases of *T. chilonis* @ 50,000/ha which resulted in 9.2% leaf damage as compared to 7.7% in monocrotophos sprayed plot and 19.4% in control. *B.t.* formulations could also effectively check the damage by leaf-roller in Punjab.

1.1.4.5. Biological suppression of tree crop pests

Release of *Goniozus nephantidis*, *Elasmus nephantidis* and *Brachymeria nosatoi* @ 20.5, 49.4 and 31.9% in relation to the percentage of larvae, prepupae and pupae of *Opisina arenosella* brought about significant reduction in pest population in Kayangulam, Kerala.

The predators *Stethoconus praefectus* and *Ankylopteryx octopunctata* were efficient predators of the lace wing bug *Stephanitis typicus* in Kayangulam while the predators could not effectively check *S. typicus* population in other parts of Kerala.

Coccinellid predators *Chilocorus nigrita* and *C.circumdatus* effectively controlled the green scale, *Coccus viridis* on acid lime while *C. nigrita* releases @ 15 adults per tree kept under check the red scale, *Aonidiella aurantii* in Bangalore.

Cryptolaemus montrouzieri effectively predated and suppressed the population of the mango green shield scale, *Chloropulvinaria polygonata* and also the citrus spherical mealybug, *Nipaecoccus viridis*.

The pomegranate white fly in Bangalore was parasitized upto an extent of 90% by the aphelinid parasitoid, *Encarsia inaron*. *Leptomastix dactylopii* effectively controlled mealybug (*Planococcus citri*) on pomegranate.

A lycaenid predator, *Spalgis epius* was found feeding on the ber mealybug *Planococcus lilacinus* in Bangalore and could effectively clear the infestation.

Cypermethrin was found to be toxic to the ber scale parasitoid, *Anicetus ceylonensis* even upto 50 days while dichlorvos, endosulfan and methyl demeton were found to be non- toxic a week after application.

1.1.4.6. Biological suppression of vegetable and potato pests

Trichogramma pretiosum alone @ 5,00,000/ha and in combination with Ha NPV at 250 LE/ha effectively reduced the fruit damage by *H. armigera* in Bangalore, Anand and Pune.

Early second instar larvae of *Chrysoperla carnea* released in a ratio of 1:5, 1:10 and 1:15 to reduce the population of *Myzus persicae* on capsicum resulted in a reduction to an extent of 80.34, 61.59 and 55.93 %, respectively in Bangalore.

Trichogrammatoidea bactrae was collected from the eggs of *Bactra venosona* on *Cyperus rotundus* and successfully reared on *Corcyra* for trials against the diamond back moth, *Plutella xylostella*.

Potato tuber moth, *Phthorimaea operculella* could be effectively controlled in the field in Pune by the release of the parasitoids *Chelonus blackburni* and *Copidosoma koehleri* as also the use of granulosis virus, alone and in combinations with parasitoids. However, only the parasitoids were effective in the store while the granulosis virus and *B. t.* proved less effective.

Trichogramma chilonis parasitized egg cards could be stored at 10°C for up to 35 days while the pupae of *Chelonus blackburni* remained unaffected in terms of emergence upto 17 days.

1.1.4.7. Biological suppression of aquatic and terrestrial weeds

The weevils, *Neochetina eichhorniae* and *N. bruchi* have established well in Jorhat area of Assam and have been noticed 200 km away from the original release site.

The studies on the factors and physiological changes associated with diapause in *Zygogramma bicolorata* revealed that the diapause was facultative and nearly 70% of the beetles went into diapause during December. Diapuase was induced by depletion of food, reproduction was affected as revealed by atrophied ovary and testes, fat body reserves showed an increase and the flight muscles were degenerated making the adults incapable of flight.

1.1.5. Acknowledgements

I am extremely grateful to Dr.R.S.Paroda, Secretary DARE & Director General, ICAR, New Delhi for the encouragement and guidance given in running the project. The support extended by Dr.E.A.Siddiq, Deputy Director General (Crop Sciences), Dr.A.K.Raheja, Assistant Director General (Entomology & Biocontrol), ICAR, New Delhi in carring out the reserch projects and to uplift the Project Directorate is greatfully acknowledged. My sincere thanks to all project workers for their sincere efforts to complete their programme given for the year 1994-95. Thanks are due to the Vice Chancellors, Directors of Research of SAUs and Directors of ICAR Institutes for providing constant support for this project. Help rendered by the Technical cell for their assistance in compiling and editing of Annual Report is greatfully acknowledged.

S. P. Singh

1.2. Proposed programme for the year 1995-96

1. Basic Research (PDBC, Bangalore)

a. Identification of chemical cues (Kairomones / synomones) which evokes behavioural response of parasitoids and predators; Standardization of methods for extractions of the kairomones and synomones and their evaluation; To maintain cultures of host insects, predators and parasitoids; To develop resistant strains of parasitoids and predators; To develop suitable synthetic and semi-synthetic diets for certain host insects and predators; Standardising mass production technology for natural enemies; Software development for identifying and suggesting biocontrol measures for different crop-pests using a P.C.

b. Basic research on entomopathogens (PDBC, IARI)

Basic studies and mass multiplication of NPV of *Helicoverpa armigera, Spodoptera litura* in vivo and in vitro (PDBC); Maintenance of varieties of *Bacillus thuringiensis* (IARI); Basic studies on baculoviruses of *Achaea janata, Agrotis ypsilion* and *Chilo partellus* (IARI)

2. Biological suppression of sugarcane pests

Survey for natural enemies of insect pests; evaluation of egg parasitoids against borer pests; multiplication of parasitoids; studies on predatory coccinellids; Survey/Monitoring of pathogens of internode borer; Evaluation of *B. thuringiensis* formulations against internode borer, evaluation of parasitoids of *Pyrilla* (IISR, SBI, PAU)

3. Biological suppression of cotton pests

Development of biocontrol based IPM for cotton pests
(TNAU, APAU, PAU & GAU)

4. Biological suppression of tobacco pests

Development of biocontrol based IPM for tobacco pests in nurseries as well as in main crop area in field crop; evaluation of *Bt* formulations against *Helicoverpa armigera* and *Spodoptera litura* (CTRI)

5. Biological suppression of pulse crop pests

Evaluation of *Bacillus thuringiensis* formulations against *Helicoverpa armigera* on pigeonpea; Effectiveness of HaNPV against *Helicoverpa armigera* on chickpea; Effectiveness of *Trichogramma chilonis* and HaNPV against *Helicoverpa armigera* on pigeonpea (TNAU, APAU, PAU & GAU)

6. Biological suppression of oil seed crop pests

Testing of *Metarrhizium anisopliae* and *Bacillus popilliae* against white grub on groundnut; Testing of *Metarrhizium anisopliae* and *Bacillus popilliae* against white grub on groundnut (PAU, GAU, MPAU & APAU)

7. Biological suppression of paddy pests

Studies on *T. japonicum* and *T. chilonis* ; Evaluation of the efficiency of miridbug, *Cyrtorhinus lividipennis* against brown planthopper, *Nilaparvata lugens*; Survey of different rice growing tracts for obtaining

seasonal calender of natural enemy complex of rice pests; Management of leaf folders with different *Bacillus thuringiensis* formulations; Evaluation of *Allorhogas pyralophagus* against yellow stem borer of rice (TNAU, AAU, PAU, KAU & AAU)

8. Biological suppression of coconut pests

Screeing, evaluation and re-release of baculovirus of *Oryctes rhinoceros*; Studies on biological suppression of the lace bug *Stephanitis typica*; Mass multiplication of *Apanteles taragamae*; Field evaluation of the performance of lab-reared larval, pre-pupal and pupal parasitoids of *Opisina arenosella*; Studies on natural enemies of eggs of *Opisina arenosella* (CPCRI, KAU)

9. Biological suppression of tropical fruit crop pests

Biological control of *R. invadens* on mango; Seasonal studies of pomegranate white fly parasitoid *Encarsia incaron*; Studies on the egg parasitoids of pomegranate fruit borer; Safety studies of botanical pesticides to the natural enemies of various pests of citrus; Collection and identification of natural enemies of fruit crop pests (IIHR)

10. Biological suppression of temperate fruit crop pests

Studies on the natural enemies of San Jose scale, Seasonal incidence of San Jose scale and woolly aphid in relation to their natural enemies; Performance of *Aphelinus mali* and chrysopids against woolly aphid Studies on the entomophilic nematodes, Relative effectiveness of parasitoids & predators against San Jose scale (YSPUH & F and SKUAS & T)

11. Biological suppression of vegetable crop pests

Laboratory studies on *Trichogramma bactrae*; Field releases and evaluation of *T. bactrae* against *Plutella xylostella* on cabbage; Continuation of field evaluation of integration of both *Trichogramma pretiosum* and NPV; Field evaluation of *T. achaeae* against other fruit borer *Earias* spp; Large scale field trial to prove the efficacy of sporeless mutant of Bt @ 300 g/ha against *Plutella xylostella* on cabbage; Continuation of UV- protectant studies with guava and mango flavinoids; Modification in the composition of artificial rearing diet with a view to economising the production cost; Collection and identification of natural enemies of vegetable crop pests (IIHR, YSPUH & F, SKUAS & T); Collection and identification of natural enemies of vegetable crop pests; Evaluation of *Trichogramma pretiosum* against tomato fruit borer (IIHR, GAU, YSPUH & F and SKUAS & T)

12. Biological suppression of potato pests

Survey of natural enemies and to evaluate the efficacy of parasitoids and pathogens against potato tuber moth (MPAU)

13. Biological suppression of weeds

Effect of feeding on sunflower on reproduction, fat body and wing muscle development of *Zygogramma bicolorata* adults; Feeding response, growth and development of *Z. bicolorata* larvae smeared with parthenium leaf extract; Surveys in farmers' fields in and around Bangalore for feeding by *Z. bicolorata*, Effect of defoliation and studies on diapause in *Z. bicolorata* (IIHR), Evaluation of biological control of *Chromolaena odorata* (IIHR & AAU); Biological control of water hyacinth using *Neochetina* spp. and *Orthogalumna terebrantis* (PAU, AAU, GAU & MPAU)

1.3.EXPERIMENTALRESULTS

1.3.1. Beneficial insects introduction, quarantine handling and basic research

1.3.1.1. Shipments received

During 1994-95, no exotic natural enemy was obtained.

The following promising natural enemies for *Liriomyza trifolii* have been identified for their importation.

Parasitoid	Family	To be imported from
Diglyphus begini	Eulophidae	California
D. intermedius	Eulophidae	California
Chrysocharis oscinidis	Eulophidae	Hawaii
Chrysonotomyia punctiventris	Eulophidae	Hawaii
Ganaspidium utilis	Eulophidae	Hawaii
Halticoptera circulus	Pteromalidae	Hawaii

A request has been made for obtaining import permits from the concerned authorities for the import of the above six parasitoids. The permits are awaited.

1.3.1.2. Shipments sent

Fifty eight shipments of natural enemies and seven shipments of host insects were sent from the Project Directorate of Biological Control, Bangalore to various co-ordinating and other centres (Table 1).

1.3.1.3. Maintenance of host insects and natural enemies

At the head quarters of the Project Directorate, the following host cultures were maintained.

1.3.1.3.1. *Plutella xylostella*

It is being continuously reared in the laboratory for 15 generations at the level of 2,000 eggs/day. About 20,000 larvae and 10,000 pupae were obtained during the above mentioned period.

1.3.1.3.2. *Helicoverpa armigera*

It is being continuously reared in the laboratory for 9 generations at the level of 1,200 eggs/day. About 9,000 larvae and 1,033 pupae were obtained during the period.

1.3.1.3.3. *Planococcus citri*

The mealybug was infested on 60 pumpkins and used as host to rear *C. montrouzieri* and *Nephus* sp.

1.3.1.3.4. *Corcyra cephalonica*

Reared on broken sorghum, yeast tablets and streptomycin sulphate. Eggs thus produced were utilized to produce egg parasitoids and were also supplied to various centres in India.

1.3.1.3.5. *Liriomyza trifolii*

This culture is being maintained on the seedlings of greengram and cotton. The seedlings are raised in pots and enclosed in acrylic sheet cages. Ten day old seedlings are infested with freshly emerged adults from field infested leaves. New seedlings are raised once in 15 days to maintain the culture.

1.3.1.3.6. *Heteropsylla cubana*

Culture of *H. cubana* is maintained on small bushes of subabul. The branches are pruned to regulate the availability of new and tender shoots/leaves which are required for the breeding of the psylla.

Apart from these, *Aonidiella aurantii, Aspidiotus destructor, Hemiberlesia lataniae, Maconellicoccus hirsutus, Spodoptera litura, Chilo partellus* and *Phthorimaea operculella* were also maintained.

Table 1. Shipments sent to various centres

Host insect/ natural enemy	Place	No.of ship-ments	Stage	Numbers
Helicoverpa armigera	Bangalore	2	Egg	200
			Pupa	20
Spodoptera litura	Trivandrum	1	Egg	5000
Corcyra cephalonica	Jorhat	2	Egg	10 cc
	Madurai	1	Egg	5 cc
	Devanhalli	1	Egg	2 cc
Telenomus remus	Aurangabad	2	Parasitized eggs	3000
Cotesia flavipes	Kolhapur	2	Parasitoid cocoons	500
Chelonus blackburni	Pune	1	Parasitized eggs	200
Bracon kirkpatricki	Bhubaneswar	1	Parasitoid cocoons	30
Trichogramma achaeae	Nagpur	1	Parasitized eggs	5,000
	Hyderabad	1	Parasitized eggs	2,000
T. brasiliensis	Nagpur	1	Parasitized eggs	5,000
T. chilonis	Pune	1	Parasitized eggs	90,000
	Raichur	1	Parasitized eggs	75,000
	Rajhamundry	2	Parasitized eggs	79,000
	Madras	1	Parasitized eggs	5,000
	Faridabad	1	Parasitized eggs	5,000
	Eriur	1	Parasitized eggs	10,000
	Port Blair	1	Parasitized eggs	8,000
	Nagpur	1	Parasitized eggs	5,000
	Khandwa	1	Parasitized eggs	40,000
	Lucknow	2	Parasitized eggs	2,00,000
	Mandya	2	Parasitized eggs	1,20,000

T. japonicum	Ambajipet	1	Parasitized eggs	5,000
	Mandya	1	Parasitized eggs	30,000
	Pennadam	1	Parasitized eggs	10,000
	Nagpur	1	Parasitized eggs	5,000
	Madras	1	Parasitized eggs	5,000
	Pune	1	Parasitized eggs	4,000
	Ludhiana	1	Parasitized eggs	30,000
	Hissar	1	Parasitized eggs	20,000
	Annamalai-nagar	1	Parasitized eggs	5,000
T. pretiosum	Nauni, Solan	2	Parasitized eggs	27,000
	Anand	1	Parasitized eggs	7,500
	Faridabad	1	Parasitized eggs	5,000
	Madras	1	Parasitized eggs	5,000
Trichogrammatoidea armigera	New Delhi	1	Parasitized eggs	5,000
	New Delhi	1	Parasitized eggs	5,000
T. embryophagum	Kayangulam	1	Parasitized eggs	2,000
Cheilomenes sexmaculata	Solan	1	Adult	15
Curinus coeruleus			Adult	30
Chilocorus nigrita	Bhubaneswar	2	Adult	65
	Madras	1	Adult	15
Pharoscymnus horni	Bhubaneswar	2	Adult	40
Cryptolaemus montrouzieri	Madras	1	Adult	15
Chrysoperla carnea	Ahmadnagar	2	Egg	15,000
	Faridabad	1	Egg	20,000
	Aurangabad	1	Egg	1,00,000
	Dharmapuri	1	Cocoon	1,000
	Solan	1	Cocoon	8,000
			Adult	5,000
	Madras	1	Egg	2,000
	Dharwad	1	Egg	10,000
	Raichur	1	Egg	40,000
	Coimbatore	1	Egg	2,000
Chrysoperla sp.	Anand	1	Egg	5,000
Mallada boninensis	Nagpur	1	Egg	150

1.3.1.3.7. Natural enemies

Cultures of the following natural enemies were maintained at the Project Directorate.

Eleven species of *Trichogramma* were maintained on eggs of *C. cephalonica* (Table 2).

Also, *Trichogramma* species collected from different locations were reared on *C. cephalonica* eggs (Table 3).

Cultures of other natural enemies like *Campoletis chlorideae, Cheilomenes sexmaculata, Cryptolaemus montrouzieri, Chilocorus nigrita, Chrysopa* spp. were maintained during the period.

Mass production of NPVs of *H. armigera* and *S. litura* using their respective hosts is being done.

Table 2. Trichogrammatid cultures

Species exposed	No. of generations	No. of eggs
Trichogrammatoidea armigera	25	12,500
Trichogramma sp. (Italian)	33	16,500
T. achaeae	28	14,000
T. brasiliensis	39	19,500
T. chilonis	27	13,500
T. dendrolimi	29	14,500
T. embryophagum	31	15,500
T. evanescens	24	12,000
T. japonicum	30	15,000
T. pretiosum	32	16,000

Table 3. Strains / species of *Trichogramma* from different locations

Species	Location	No. of generations
Trichogramma sp.	Anand	48
Trichogramma sp.	Lucknow	73
T. chilonis	Nilgiris	36

1.3.1.4. Survey for natural enemies

Helicoverpa armigera

Field surveys conducted during December 1994, revealed that twenty per cent of late instar *H. armigera* larvae were parasitized by *Goniophthalmus halli* (13 %) and *Palexorista* sp. (7%) on pigeonpea in Bangalore.

Liriomyza trifolii

Host plants and indigenous parasitoids of *L. trifolii* on cultivated crops in and around Bangalore were surveyed. Samples of infested leaves were brought to the laboratory for collecting emerging adults/natural enemies. The survey revealed that this leaf-miner is infesting tomato, beans, castor, cotton and gourds. Few native natural enemies which had adapted to the leafminer were collected and preserved for further identification.

1.3.1.4.1 Studies on *Cheilomenes sexmaculata* feeding on *Aphis craccivora*

Survey was carried out in and around Bangalore for collection of *Aphis craccivora* and its predators from various crops like lablab, cowpea and pigeon pea. During December to January the intensity of aphid population was more on pigeonpea (Table 4). On lablab and cowpea more infestation was recorded from January to March. Population of *A. craccivora* increased rapidly with crop growth and the peak coincided with pod formation. Amongst predatory coccinellids only *C. sexmaculata* was noted in pigeonpea and lablab fields.

1.3.1.5. Biology and developmental studies

1.3.1.5.1. Studies on the longevity and effect of age of the parasitoid, *Allorhogas pyralophagus* on parasitism of *Chilo partellus*

Allorhogas pyralophagus, a Mexican larval braconid parasitoid, imported into our country

Table 4. Survey of predators of *Aphis craccivora*

Place	Date of survey	Host plant	Stage of predator					
			Coccinellids			Syrphids		
			E	L	A	E	L	A
GKVK fields	01-12-94	Pigeonpea	-	-	2	-	-	-
	08-12-94	Pigeonpea	-	1	-	-	-	-
	19-12-94	Pigeonpea	-	2	-	-	-	-
	20-01-95	Pigeonpea	-	-	-	-	-	-
Devanahalli	26-12-94	Lablab	-	1	3	-	-	-
Jakkur	03-01-95	Pigeonpea	-	-	-	-	-	-
Amruthalli	12-01-95	Lablab	-	3	4	-	3	-
Devanhalli	23-02-95	Lablab	8	-	-	2	5	-
	01-03-95	Lablab	-	-	-	-	9	-
	09-03-95	Lablab	-	-	5	5	-	-
	20-03-95	Lablab	-	1	-	-	16	-
	31-03-95	Lablab	-	-	-	5	11	-

E = Egg; L = Larva and A = Adult

earlier for the control of graminaceous stem borers was taken up for certain investigations. Fifteen mated females of the parasitoid were enclosed separately in glass tube (15 cm x 2cm) and provided with 50% honey solution and water. The females were thus maintained and examined daily for mortality. The females were provided on alternate days with *C. partellus* larvae individually placed inside a paper drinking straw. The parasitized larvae were then kept individually from each of those females till adult emergence. The number of larvae parasitized by each female and the number of adults emerged were observed. The influence of age of female on parasitization and adult emergence was also noted.

Table 5 presents the results of the longevity study for the 15 females as also the per cent larvae of *C. partellus* parasitized and adult parasitoids emerged. The results showed that *A. pyralophagus* adult females lived on an average for 40.87 days (range 18 - 47 days) and each female parasitized 48.49 per cent of the larvae presented to them during their life time. There was a high proportion of females in the adults emerged from these parasitized larvae with an average of 8.19 proportion of females and an average production capacity of 52.3 adults per female parasitoid.

The influence of female age (15 adult females) was similarly observed and the results are presented in Table 6 and Figs. 1 and 2. It can be seen that maximum larvae were parasitized (100, 93.3%) by 7-9 days old females and this slowly reduced as the age advanced to 10% by females 36 days old. The mean larvae parasitized was 56.49%. Similarly the number of adults emerging per larva parasitized was also high for 7-9 days females, being 12.40 and 6.87 adults /larva with an average of 4.41 adults/ larva for the entire life of the female. The trend for proportion of females was also similar with 7 - 9 day old females showing maximum proportion of females (22.25 and 13.71). The trend is clearly seen in Figs. 1 and 2.

1.3.1.5.2. Biological studies on *Cotesia plutellae*, a larval parasitoid of *Plutella xylostella*

Cotesia plutellae was field collected and maintained in the laboratory on *Plutella xylostella* larvae reared on mustard seedlings. Ten females were utilized to study the biology of the parasitoid. *P. xylostella* larvae were presented to these females till their death and the per cent larvae parasitized and adults emerged from the cocoons were recorded. The results are presented in Table 7.

Table 5. Longevity of *A. pyralophagus* females, their parasitizationand adults emerged from parasitized *C. partellus*

Female No.	Longevity (in days)	Percent larvae parasitized	Total adults emerged per female	Proportion of females
1	47	35.39	29	100.00
2	47	35.29	35	100.00
3	47	35.29	62	3.77
4	32	63.64	46	6.67
5	47	35.29	78	7.67
6	35	46.15	56	17.67
7	34	50.00	71	9.14
8	40	50.00	65	4.91
9	18	86.15	11	4.50
10	45	35.29	59	6.38
11	46	52.94	47	3.70
12	47	41.18	40	12.33
13	47	47.06	79	8.88
14	47	47.06	61	4.25
15	34	66.67	46	6.67
Mean	40.87	48.49	52.33	8.19

The results showed that an average of 21.12 per cent of the larvae were only parasitized (range 4.00 to 50%) while 84 per cent of the cocoons formed emerged as adults. However, overall only 17.88 per cent of the larvae presented were parasitized and parasitoid adult emergence was successful showing that the per cent parasitism by *C. plutellae* was low.

The parasitized larvae were observed for cocoon formation individually and the emerging adults sexed to find out the larval and pupal periods of male and female parasitoids. The males had a larval period of 7.52 days and a pupal period of 3.76 days while the female parasitoids took 7.72 days to complete larval development and 4.05 days to emerge as adults after cocoon formation.

Fig. 3 shows the influence of parasitoid female age on per cent larvae parasitized and adult emergence from them. It shows that the parasitization was bimodal with 2 day old female parasitizing about 35 per cent larvae which reduced to almost 3% in 4 day old females. This subsequently increased to nearly 50% in 7 days old females and then gradually tapered down as the female age increased to 11 days.

The results in Table 8 show that female parasitoids lived for an average of 10.2 days and parasitized 22.87% larvae presented and from them 19.78% adults emerged.

1.3.1.5.3. Alteration of sex ratio in *Chrysoperla carnea*

Attempts were made to alter the sex ratio in favour of females in *C. carnea*. This could prove useful in mass multiplying them in laboratory.

Althrocin at the rate of 100 mg + 10 ml honey + 10 ml of water was provided as swabs to the adults. The sex ratio obtained in the next generation was observed (Table 9). The feeding of Althrocin was continued for three generations and the sex ratio monitored in comparison with control which were fed on *C. cephalonica* eggs.

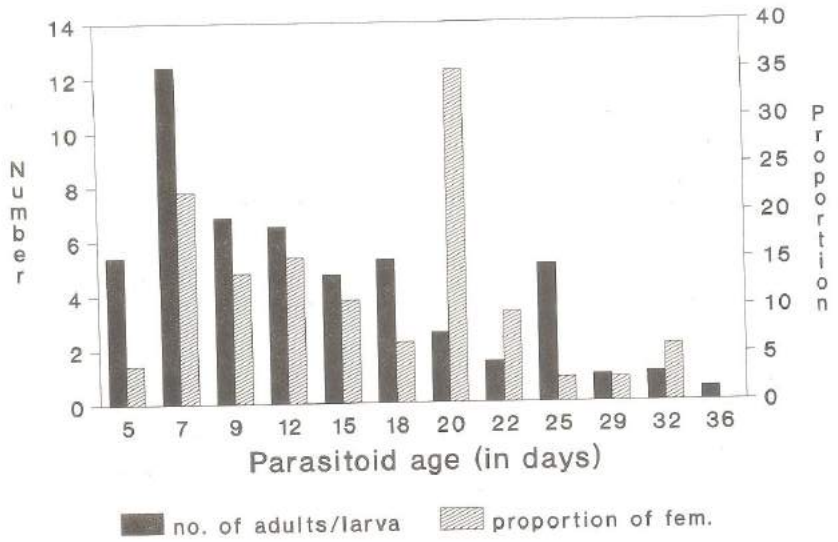

Fig. 1 Influence of *A. pyralophagus* age on the proportion of females and adult emergence from parasitised *C. partellus* host larvae

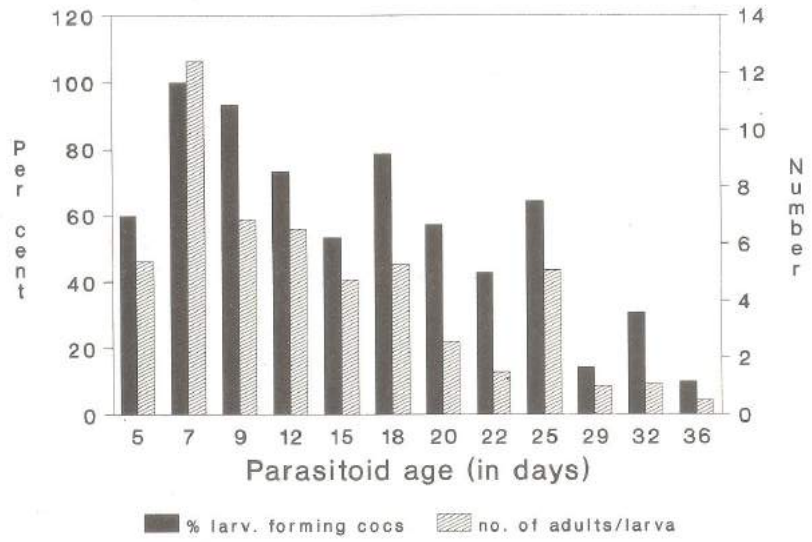

Fig. 2 Influence of *A. pyralophagus* age on parasitisation and adult emergence from *C. partellus* host larvae

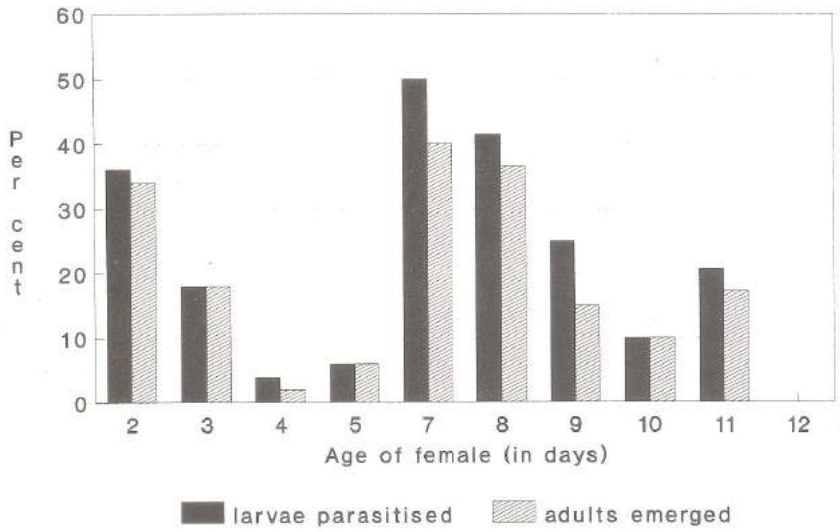

Fig. 3 Influence of *C. plutellae* female age on parasitism and adult emergence from *P. xylostella* larvae

Table 6. Influence of *A. pyralophagus* female age on parasitization and adult emergence from parasitized *C. partellus* larvae

Age of the female	Per cent larvae parasitized	No of adults per larva	Proportion of females
5	60.00	5.40	4.06
7	100.00	12.40	22.25
9	93.33	6.87	13.71
12	73.33	6.53	15.33
15	53.33	4.73	10.83
18	78.57	5.29	6.40
20	57.14	2.57	35.00
22	42.86	1.50	9.50
25	64.28	5.07	2.55
29	14.29	1.00	2.50
32	30.77	1.07	6.00
36	10.00	0.50	0.00
Mean	56.49	4.41	7.90

Table 7. Per cent parasitization and adult emergence from *P. xylostella* larvae parasitized by *C. plutellae* of different ages

Female age	Percent larvae forming cocoons	Percent cocoons from which adults emerged	Percent adults emerged for larvae exposed
2	36.00	94.44	34.00
3	18.00	100.00	18.00
4	4.00	50.00	2.00
5	6.00	10.00	6.00
7	50.00	80.00	40.00
8	41.46	88.24	36.59
9	25.00	60.00	15.00
10	10.00	100.00	10.00
11	20.69	83.33	17.24
12	0	-	-
Mean	21.12	84.00	17.88

Table 8. *C. plutellae* female longevity and parasitization of *P. xylostella*

Female number	Female longevity	Per cent larvae parasitized	Per cent adults emerged
1	7	25.00	25.00
2	11	25.84	24.72
3	13	24.75	19.81
4	11	14.44	12.22
5	9	24.29	17.14
Mean	10.2	22.7	19.78

Table 9. Effect of antibiotic in sex ratio alteration

Generation	Althrocin		Control	
	Female	Male	Female	Male
I	1	0.87	1	0.67
II	1	1.00	1	0.78
III	1	1.43	1	1.14

In the first generation the sex ratio was biased towards the female with a similar trend in control. The ratio was 1:1 in the second generation when provided with althrocin while the ratio was biased towards females in control. In the third generation both in treated and in control the ratio was biased towards male.

1.3.1.5.4. Biological studies on *Campoletis chlorideae*

Females of *C. chlorideae* were collected from lablab fields at flowering stage and reared in the laboratory. Parasitoids were released in a cage (1x1x1 ft.) in the ratio of 1:1 for mating. Females of *C. chlorideae* readily mated and mating lasted for 2.5 to 4.5 min. Young females preferred old males for copulation. The culture of *C. chlorideae* has been continuously maintained in the laboratory for more than six generations with the diet consisting of honey, protinex, vitamin E, streptomycin sulphate and water.

First instar larvae (three days old) of *H. armigera* and *S. litura* on okra and castor, respectively, were exposed to *C. chlorideae* for parasitization for a period of 24 hrs. The efficiency of *C. chlorideae* was almost equal on *S. litura* (57%) and *H. armigera* (60%). The per cent females emerged from parasitized *S. litura* was higher (22%) as compared to that from *H. armigera* (8%). Attempts are being made to mass rear *C. chlorideae* on the larvae of *C. cephalonica* and *Plutella xylostella*.

1.3.1.5.5. Studies on an unidentified syrphid feeding on *Aphis craccivora*

The fields were visited from December - May. Plants were thoroughly searched for aphid colonies as well as immature stages of syrphids. Two different species of syrphids were recorded in second week of January. These larvae were prevalent throughout March and declined thereafter. Increase in the larval population of syrphid coincided with increase in the number of aphid colonies. Only one generation could be completed in 20-23 days in the laboratory condition and egg, larval and pupal period lasted for 3-4, 8-9 and 9-10 days, respectively. Oviposition could not be observed under confinement. However, oviposition by the adult syrphid in potted plants kept outside the net house was seen.

1.3.1.6. Behavioural studies

1.3.1.6.1. Performance of *Trichogramma chilonis* on average size egg clusters of *Chilo partellus*

Chilo partellus eggs laid on butter paper folded like a fan and placed in an oviposition cage with *Chilo partellus* adults were used for the study. Average size egg clusters having 20-30 eggs were made use of, to study the performance of 1,3 and 5 females of *Trichogramma chilonis* when allowed to parasitize these egg clusters. Freshly mated females of *T. chilonis* were allowed to oviposit in the egg clusters and the trial was replicated ten times. The number of eggs parasitized, number of adults emerged and sex ratio was observed. The results are presented in Table 10.

Table 10. Performance of *Trichogramma chilonis* on egg clusters (20-30 eggs/cluster) of *Chilo partellus*

No.of *T. chilonis* females	Per cent eggs parasitized	Mean no. of adults emerged per cluster	Sex ratio (F:M)
1	37.83	4.8	1:0.56
3	82.53	6.3	1:0.52
5	82.82	11.50	1:0.54

The results showed that as the number of parasitoid females increased from 1 to 5 there was a steady increase in per cent eggs parasitized with 1 female recording 37.83%, 3 females 82.53% and 5 females 82.82% . Similarly there was also an increase in the number of adults emerged with 1 female recording 4.8 adults/cluster, 3 females 6.3 adults/cluster and 5 females 11.50 adults/cluster. However, there was no great variation in the sex ratios of the emerged adult parasitoids with the treatments recording about 1 : 0.5 (female:male).

1.3.1.6.2. Influence of *C. partellus* larval weight on parasitization by *A. pyralophagus*

Chilo partellus larvae were individually weighed and presented to mated females of *A. pyralophagus* in a paper drinking straw. Ninety seven such larvae were presented with an average weight of 86.45 mg of (range 43.6 mg to 163.4 mg). After exposing for 24 h the straw bits were removed and placed individually in tubes to note adult emergence and proportion of females in them. The results are presented in Table 11.

The results showed that an average of 7.94 adults (range 1 to 24) emerged from each larva irrespective of the weight. There was a greater proportion of females amongst the emerged adults (7.56). A correlation was worked out to know the influence of larval weight on adults emerged and proportion of females in them and the results are presented

Table 11. Influence of *C. partellus* host larval weight on *A. pyralophagus* adult emergence

	Larval weight (mg)	Adults emerged per larva	Days to adult emergence	Proportion of females
Mean	86.45	7.94	22.84	7.55
Min.	43.60	1.00	19.00	-
Max.	163.40	24.00	24.00	-

in Figs. 4 and 5. The results showed that there was a strong positive relationship between the weight of larvae and emergence of parasitoid adults per larva (r = 0.296**). The relationship was also positive between the larval weight and proportion of females emerged from each larva (r = 0.285**). The regression equations are presented in Figs. 4 and 5.

1.3.1.6.3. Basic behaviour of *Chrysoperlacarnea* larvae

The basic feeding behaviour of *Chrysoperla carnea* larvae was studied as it is an essential component for the behavioural studies with the kairomones. The first and second instars did not consume many eggs. However, the third instar larvae consumed many eggs of *C. cephalonica*. Hence, third instar larvae were selected for the behavioural studies. The early third instar larvae were starved for 4 hours and then released in filter papers. The host searching behaviour of the larvae was observed.

The larvae showed two different types of behaviour depending on their hunger level. The larvae which were more hungry immediately searched the arena making zigzag wandering movements while those satiated moved straight at high speed and entered below the filter paper. These larvae did not wander for their food. The larvae showing searching behaviour were alone selected for experiments. In all the experiments given below the released larvae were allowed for sometime to overcome the forced displacement and once the movement began the observations were begun.

1.3.1.6.4. Behaviour response of *Chrysoperla carnea* larvae to the kairomones

The adult wing scales of *Corcyra cephalonica* and *Helicoverpa armigera* were cleaned and extracted in hexane or water. The hexane / aqueous extracts were placed in different places in a circular Whatman filter paper disc in a petriplate. Previously starved (for 4 hours) early III instar larvae of *C. carnea* were placed individually on the filter paper. The filter paper was then covered with the lid of the petriplate and the movements of the larvae recorded for 3 minutes by tracing the path taken by the larvae with the help of a glass marking pen. After the experimental period the lid of the petriplate was removed and the movements recorded photocopied. The total distance travelled by the larva, number of stop overs and number of turnings were recorded. The wandering movements (if any) in the marked areas (where kairomones were placed) were also recorded. The experiment was conducted for 5 larvae per set and 4 sets were conducted for each treatment.

The speed of the larvae and the movement patterns of the larvae did not vary in the kairomone treated as well as in the control filter papers treated with the solvents only. The larvae also were not noticed to wander in the patches treated with the kairomones.

1.3.1.6.5. Importance of three dimensional structure in the host finding behavior of *Chrysoperla carnea* larvae

Wax droplets (0.4 to 0.8 mm in size) coated with kairomones were prepared and placed in two patches on a Whatman filter paper and the previously starved (for 4 hours) early III instar larvae *C. carnea* released individually in each filter paper. The experiment was conducted as described earlier. In addition to the above parameters walking speed, the number of times the wax droplets were probed and the time spent was also recorded. A control was maintained

using wax droplets sprayed with hexane alone.

The larvae of *C. camea* could immediately reach the wax droplets coated with the kairomones in most of the cases and the number of probes attempted by the larvae was more (average 3.8) compared to control (average 0.6). The time spent on the wax coated with kairomones was also more (average 1.66 minutes) compared to control (0.68).

1.3.1.6.6. Behaviour response of *Chrysoperla carnea* adults to kairomonal substances

Adults of *Chrysoperla carnea* were starved for 24 hours and placed individually in a petriplate. Fifty per cent honey solution was placed in the petriplate on a filter paper. The petriplate was covered with the lid. The walking speed of the adults, turning speeds, turning angles, etc. were recorded for a period of 5 minutes. For each replication 5 adults were used and each treatment was replicated 5 times.

The adults which were exposed to honey showed reduced walking speed (20.1 cm/m), increased turning points (19.88) and increased turning angles (less than 20°) compared to control (water) (12.54 cm/m, 14.65 and above 50°, respectively).

1.3.1.6.7. Wind tunnel studies for studying the attraction of *Chrysoperla carnea* adults to kairomonal substances

Adults of *Chrysoperla carnea* were starved for 24 hours. Fifteen such adults were placed in a rectangular acrylic sheet container (test chamber) and the container connected to the another rectangular container (bait chamber) through a polypropelene sheet. Fifty per cent honey solution (kairomonal source) was placed in the bait chamber and a constant wind was allowed to pass through these chambers for 30 minutes. The number of adults flying against the wind direction and reaching the tip of the bait chamber was recorded. No adult could be recorded in the first set of experiments.

1.3.1.6.8. Use of kairomonal substances as a phagostimulant for *Chrysoperla carnea* synthetic diets.

Synthetic diets which were developed earlier using *Spodoptera litura* abdomen powder were encapsulated with wax and the scales of *Corcyra cephalonica* were dusted or hexane extracts of the *Corcyra cephalonica* were applied to the artificial diets and the 2nd instar larvae of *C. camea* were fed on this diet. Total larval duration, the number of cocoons formed and number of adults emerged were recorded.

The results indicated larval duration, number of cocoons formed and adults emerged were 14.8, 34.5 and 8.5%, respectively and were on par with control where no treatments were imposed.

1.3.1.7. Artificial diets for host insects and their natural enemies

1.3.1.7.1. Synthesis of diets for *Plutella xylostella*

Attempts were made to synthesize artificial diets for *P. xylostella*. The diets were prepared using the ingredients mentioned below (Table 12). The diet was poured into glass tubes (7.5 x 2.5 cm) and 2 day old larvae were released after cooling.

Table 12. Ingredients for *P. xylostella* artificial diets

Ingredients	Quantity	
	Diet I	Diet-II
Soybean flour	20.00 g	-
Kabuligram flour	-	20.00 g
Cabbage/cauliflower leaf powder	30.00 g	30.00 g
Ascorbic acid	0.80 g	0.80 g
Sorbic acid	0.25 g	0.25 g
MPHB	0.50 g	0.50 g
Yeast tablets	2.50 g	2.50 g
Multivitaplex	1 cap.	1 cap.
Vitamin E	1 cap.	1 cap.
Streptomycin sulphate	0.07 g	0.07 g

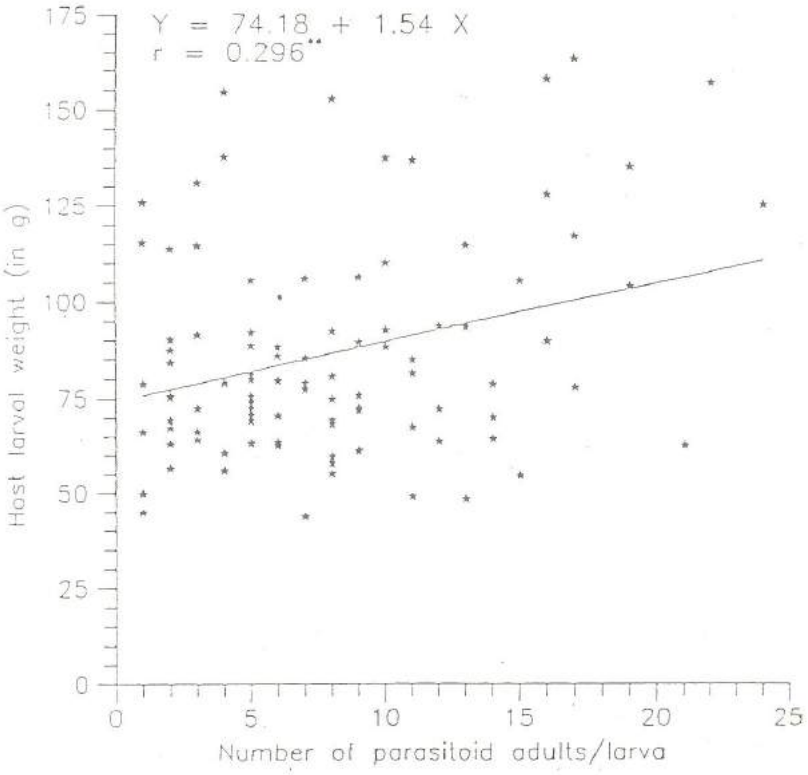

Fig. 4 Relationship between *C. partellus* host larval weight and emergence of *A. pyralophagus* adults

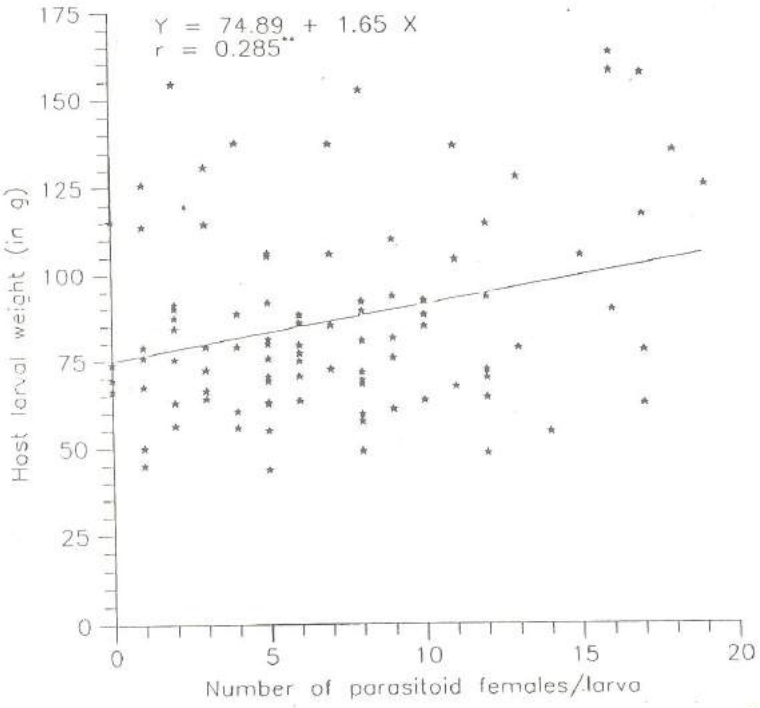

Fig. 5 Relationship between *C. partellus* host laval weight and emergence of *A. pyralophagus* parasitoid females

Sucrose	2.00 g	2.00 g
Filter paper (powdered)	5.00 g	5.00 g
Wesson's salt mixture	2.00 g	2.00 g
Water	100.00 ml	100.00 ml
Agar agar	3.20 g	3.20 g
Water	100.00 ml	100.00 ml
Formalin 1.0%	0.25 ml	0.25 ml

MPHB = Methyl para-hydroxy benzoate

The larval duration in Diet I (14.83 days) and Diet II (13.47 days) were prolonged when compared to natural diet (9.8 days). Similar trend was observed for the pupal period in Diet I (5.28 days) and Diet II (6.37 days) as compared to natural diet (4.5 days). Low per cent pupation in Diet I (40%) and Diet II (56.66%) was noticed when compared to natural diet (95%). Similarly per cent adult emergence was also reduced in Diet I (23.33%) and Diet II (30%) in comparison with natural diet (90.40%). Among the two diets, Diet II proved to be better with a higher per cent pupation and adult emergence (Fig. 6).

1.3.1.7.2. Evaluation of diet for *P. xylostella*

The diet formulated by Jayanth and Sudha Nagarkatti (1981) for *Crocidolomia binotalis* and *Hellula undalis* was tried for *P. xylostella*.

Water	140 ml
KOH 22.5%	1.8 ml
Casein (vitamin-free)	12.6 g
Wesson's salt mixture	12.6 g
Formaldehyde 10%	1.3 ml
15% methyl p-hydroxy benzoate in 95% ethyl alchol	3.6 ml
Choline chloride	3.6 ml
Wheat germ	10.8 g
Cellulose powder	1.8 g
Vitamins (Multivitaplex forte)	0.5 g
Agar dissolved in 220 ml of boiling water	9.0 g
Ascorbic acid	1.4 g
Tetracycline	100 mg
Sorbic acid	0.5 g
Linseed oil	2.0 ml
Dried cabbage leaf powder (in 50 ml water at 50°C)	5.0 g

The larval period (10.2 days) and pupal period (6.4 days) was prolonged when compared with the natural diet (9.8 and 4.5 days, respectively (Fig.6). Per cent pupation (27.78) and adult emergence (13.89) was also greatly reduced as compared to natural diet (95 and 90.4%).

Among the three diets, Diet II was superior to the other diets with better per cent pupation and adult emergence (Fig.7).

1.3.1.7.3. 'In vitro' rearing of *Trichogramma* spp.

Preliminary attempts were made for 'in vitro' production of trichogrammatid egg parasitoids. *T. chilonis* and *T. pretiosum* were used for the study in the laboratory. The below mentioned diets were tried (Table 13).

Table 13. Diet ingredients for *'in vitro'* rearing of *T. chilonis* and *T. pretiosum*

Ingredient	Quantity
Diet I	
Helicoverpa armigera haemolymph*	50.00 %
Egg yolk	25.00 %
Milk suspension (15g dried milk in 100 ml water)	25.00 %
Gentamycin/streptomycin	00.15 %
Wax + Petroleum jelly (3:1)	
Diet II	
H. armigera haemolymph*	43.30 %
H. armigera egg liquid	20.00 %
Egg yolk	18.30 %
Milk suspension	18.30 %
Gentamycin sulphate/ streptomycin sulphate	00.15 %
Wax +Petroleum jelly (3:1)	

* *H. armigera* haemolymph (50%) was obtained by immersing IV and early V instar larvae in hot water at 60° C for 10 minutes. This prevented melanization of haemolymph.

Egg preparation, exposure and rearing were done under aseptic conditions to avoid contamination. Egg oviposition stimulant (0.62% KCL + 0.60% $MgSO_4.7H_2O$) was mixed along with wax and petroleum jelly and placed as droplets on petri plates. Mated adults were released and they were observed to readily parasitize a few eggs. After 4 hrs the wax and petroleum jelly coating was removed and artificial diet added. In some cases larval development was seen. The number of larvae developing was more on Diet II. However, no pupation or adult emergence could be obtained even after repeated trials several times.

1.3.1.7.4. Synthesis of new diet for *Chrysoperla carnea* larvae

Attempts were made to synthesise semi-synthetic diet for *C. carnea* larvae using the available laboratory wastes like the spent or dead adults of *C. cephalonica*, *S. litura*, *H. armigera*, mealy bugs and bees. They were further enriched by adding yeast extract, egg yolk and honey. The senescent insects were killed by deep freezing, dried in an oven at 100° C for 90 to 120 minutes and powdered. The diet ingredients were mixed in a beaker, and placed in a water bath. A small quantity of wax (52° C MP) and vaseline were added to the diets to enable placing them as droplets on polyethylene sheet. Fresh droplets were provided every day to the larvae. The composition of the diets developed after trying various combinations are presented in Table 14.

Table 14. Constituents for different semi-synthetic diets for *Chrysoperla carnea* larvae.

Constituents	Quantity
A. Mealy bug diet (MD)	
Mealy bug powder	0.2 g
Egg yolk	5.0 g
Honey	2.5 g
Yeast extract	0.2 g
Distilled water	6.0 ml
B. *Corcyra cephalonica* abdomen diet (CAD)	
C. cephalonica abdomen powder	0.2 g
Egg yolk	5.0 g
Honey	2.5 g
Yeast extract	0.2 g
Distilled water	6.0 ml
C. Protinex diet (PD)	
Protinex	0.2g
Egg yolk	5.0 g
Honey	2.5 g
Yeast extract	0.2 g
Distilled water	6.0 ml
D. Bee diet (BD)	
Bee powder	0.2 g
Egg yolk	5.0 g
Honey	2.5 g
Yeast extract	0.2 g
Distilled water	6.0 ml
E. *Spodoptera litura* abdomen diet (SAD)	
S. litura abdomen powder	0.2 g
Egg yolk	5.0 g
Honey	2.5 g
Yeast extract	0.2 g
Distilled water	6.0 ml
F. *Helicoverpa armigera* abdomen diet (HAD)	
H. armigera abdomen powder	0.2 g
Egg yolk	5.0 g
Honey	2.5 g
Yeast extract	0.2 g
Distilled water	6.0 ml
G. Control (*C. cephalonica* eggs)	-

In all the diets larval feeding was noticed on the diets while pupation was observed to vary (Table 15).

Adult emergence was nil in mealy bug powder diet (MD) and Protinex diet (PD) and per cent adult emergence was very low (0.38) in *Corcyra* abdomen powder diet (CAD). Hence, the data collected on the above three diets were not subjected to statistical analysis. The larval periods reared on the diets ranged from 11.7 to 27.3 days. The per cent pupation in all the semi synthetic

diets was significantly lower than in control. However, among the three semi synthetic diets, SAD proved to be superior followed by BD, while minimum per cent pupation was observed in the case of HAD. Larvae fed on SAD and HAD spinned heavier cocoons in comparison with BD, but still they were lesser in weight than those from control. Pupal periods in all the three treatments were similar. While BD and SAD were on par with control, the pupal period in HAD was significantly longer. Adult emergence in varying degrees were observed in the BD (16.22%), SAD (29.63%) and HAD (23.53%).

Since SAD and HAD performed better compared to the remaining diets, *C. carnea* was reared on these diets for 5 generations and the results are presented in Table 16 & Table 17.

Larval duration was reduced and per cent pupation was more in SAD when compared to HAD. Pupal weight was almost same in both SAD and HAD. Larvae fed on HAD took longer to pupate when compared with those fed on SAD. Adult emergence was comparatively more in SAD than in HAD. Egg laying was observed in the 5th generation in both the treatments.

1.3.1.7.6. Synthesis of diet for coccinellids.

Attempts were made to develop artificial diets for rearing *Cryptolaemus montrouzieri, Cheilomenes sexmaculata, Chilocorus nigrita,* and *Nephus* sp.

The following diet combinations were utilised

i) Bee powder + yeast extract + sucrose

ii) *Spodoptera* abdomen powder + yeast extract + sucrose

iii) Silkworm pupal powder + yeast extract + sucrose

iv) *H. armigera* abdomen powder + yeast extract + sucrose

Both adults and grubs of *Nephus* sp. did not survive for long when fed on these diets. Early instar grubs of *C. montrouzieri, C. sexmaculata and C. nigrita* did not survive when fed on the diets, whereas the late instar grubs pupated when fed on these diets. Adult beetles of the latter three species reared on these diets survived long (4 to 5 months) but did not lay eggs.

1.3.1.8. Evoluation of endosulfan resistant strain of *Trichogramma chilonis*

This study started in 1989-90 and is being continued. Bio C_1 strain of *Trichogramma* selected for field trial was exposed to 0.12 ml/litre solution of endosulfan. Endosulfan at the rate of 1.25 ml/litre solution was sprayed in F 164 generation and this was continued till the test species reached F 170 generation when the concentration was increased to 1.5 ml/litre. Glass tube (20 x 30.5 cm) with both ends open was sprayed with endosulfan solution and dried under shade. Adult parasitoids were released inside after covering both ends of the tube with cloth. After 15-30 minutes of adult release the egg card was introduced when susceptible ones were dead. Observation on per cent mortality of adult was recorded after 6 and 24 hours of exposure and later for per cent parasitism of eggs.

The experiment was started with 0,12 ml/litre and is at present at 1.5 ml/l stage in generation 196.

At F 165 generation the test insects were shifted to 1.25 ml/l. A mortality of 95 and 100 per cent occurred after exposure of 6 and 24 hrs, respectively, and parasitism was 65%. By F 180 generation mortality reduced to 70% and 90% after 6 and 24 hrs, respectively, and parasitism improved to 100 per cent. After obtaining 100% parasitism in the next generation also, the parasitoids were shifted to a higher concentration {1.5 ml/liter (0.525%)} in F 196 generation. Per cent mortality increased to 95% and 100% after 6 and 24hrs exposure, respectively, and parasitism was reduced to 42%. (Table 18) The experiment will continue till resistant/tolerant strain is obtained at field recommended dosage of endosulfan (0.07%).

Table 15. Development of *Chrysoperla carnea* larvae on semisynthetic diets

Diet	Average larval period (days)	Pupation (%)	Average pupal weight (mg)	Average pupal period (days)	Per cent adult emergence
MD*	26.50	17.50	3.6	0.0	0.0
CAD*	27.30	34.60	3.5	12.0	0.38
PD*	22.00	0.76	3.3	0.0	0.0
BD	14.64	75.50	3.6	6.9	16.22
SAD	11.70	77.14	4.2	8.2	29.63
HAD	23.41	48.57	4.0	8.	23.53
CONTROL	8.18	96.00	9.2	6.4	90.00
SEm	1.32	0.24	0.003	0.71	0.28
CD 5%	3.76	0.69	0.009	2.03	0.81
CV %	37.61	20.26	169.42	43.01	44.25

* Not subjected to statistical analysis due to poor performance

Table 16. Development of *C. carnea* larvae on *S. litura* diet for five generations

Parameters	Generations				
	I	II	III	IV	V
Larval period (days)	11.70	15.85	23.73	18.05	28.55
Pupation (%)	77.14	80.00	55.88	79.60	77.78
Pupal weight (mg)	4.20	4.70	4.50	3.80	3.95
Pupal period (days)	8.20	8.73	9.84	10.3	010.70
Adult emergence (%)	29.63	30.00	23.53	69.38	38.89
Fecundity	418.00	335.00	357.50	648.70	257.80
Sex ratio (Male:Female)	1:0.6	1:0.3	1:3	1:1.4	1:0.6

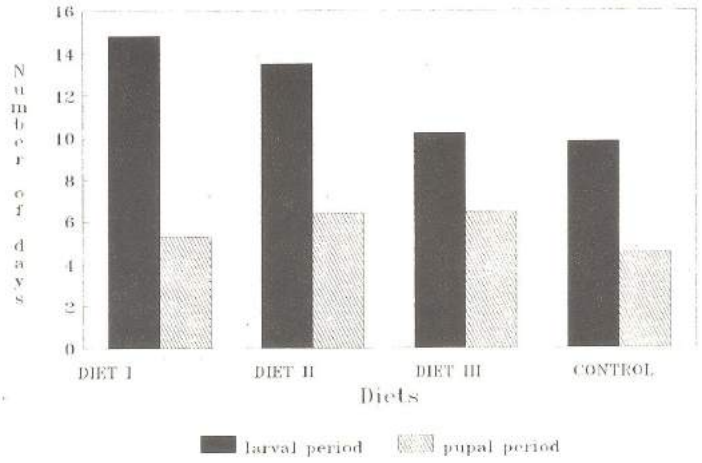

Fig. 6 Larval and pupal duration of *Plutella xylostella*

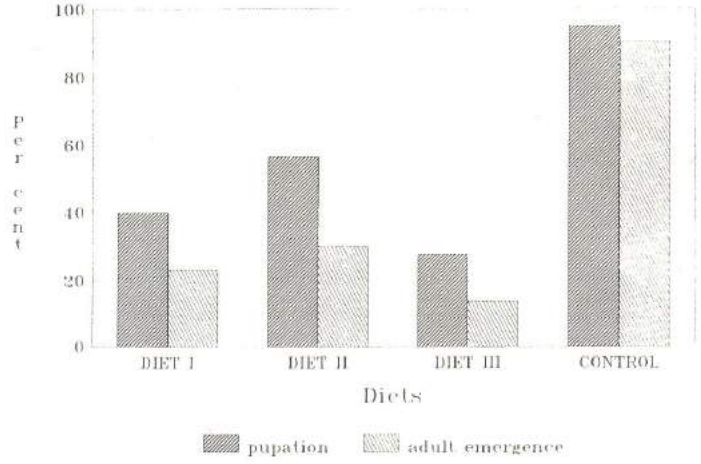

Fig. 7 Pupation and adult emergence in *Plutella xylostella*

Table 17. Development of *C. cumea* larvae on *H. armigera* diet for five generations

Parameters	Generations				
	I	II	III	IV	V
Larval period (days)	23.41	16.53	24.36	27.13	32.26
Pupation (%)	48.57	93.33	73.33	51.00	60.42
Pupal weight (mg)	4.10	4.50	3.60	3.70	3.82
Pupal period (days)	8.50	9.21	9.71	11.70	11.41
Adult emergence (%)	23.53	36.67	30.00	22.22	25.00
Fecundity	461.50	183.50	202.00	289.00	233.00
Sex ratio (Male:Female)	1:1	1:1.7	1:1.2	1:1.5	1:0.5

1.3.1.9. Insect Pathology

1.3.1.9.1. Oxygen consumption study to establish host - pathogen relationship

For a better understanding of the mechanism and development of the nuclear polyhedrosis virus infection in *H. armigera* and *S. litura*, oxygen consumption was investigated in NPV infected larvae of *H. armigera* and *S. litura* using an infra red analyzer by way of studying respiratory carbon dioxide gas exchange. The above study revealed that the virus infection in the insect body causes an increase in the oxygen consumption of both insects, and it was 3625 µl/g/hr and 4490 µ l/g/hr in the case of virus infected *S. litura* and *H. armigera* when compared to 873 µl/g/hr and 916 µl/g/hr in the case of healthy *S. litura* and *H. armigera*, respectively. Measuring oxygen consumption in virus infected insects will be useful and convenient for the determination of the incubation period and host - pathogen relationship including better understanding of the specific behaviour of virus infected insects in future.

1.3.1.9.2. Studies on the encapsulation of NPV

Preliminary attempts in encapsulating the polyhedral inclusion bodies of nuclear polyhedrosis viruses of both *H. armigera* and *S. litura* in calcium alginate into beads by way of adding an ionic sodium alginate solution (which is incorporated with encapsulation viz., either alone like gustatory stimulant, uv protectants and screeners) as a means to increase their use as biopesticides has been successful. This technique will greatly increase the potential of insect viruses alone or in combination with various spray adjuvants as biological control agent in future because it will not only lead to prolonged residual activity, but also overcome one of the limitations to the use of the microbial insecticides, utilization by incorporating into bait and other spray adjuvants has distinct feasibility in future.

1.3.1.9.3. Survey for insect pathogens of important pests

During the course of our field survey natural incidence of nuclear polyhedrosis virus of *H. armigera*, protozoans like *Nosema* and *Vairimorpa* including rickettsia like organism has been recorded more in the case of *H. armigera* when compared to *S. litura*.

Table 18. Exposure of *Trichogramma chilonis* adults to endosulfan

Concentration	Continuous generation	Adult mortality after hours (%)		Parasitism (%)
		6	24	
0.044% (1.25 ml/ litre)	F 165	95	100	65
	F 170	95	100	65
	F 175	80	95	95
	F 180	70	90	100
	F 185	50	80	100
0.052% (1.50 ml/ litre)	F 196	95	100	42
	F 197	95	100	50
	F 198	90	100	55
	F 199	85	100	55
	F 200	80	100	58
	F 201	80	100	60

1.3.2. BIOLOGICAL SUPPRESSION OF SUGARCANE PESTS

1.3.2.1 Field evaluation of *Trichogramma chilonis* against *Chilo infuscatellus* (PAU, Ludhiana).

Field experiments to evaluate the effectiveness of *Trichogramma chilonis* against *Chilo infuscatellus* was conducted at Bahar Muzara (Jalandhar, Punjab). Two fields of sugarcane (var.CoJ 64), each measuring 2 ha were selected at a distance of 0.5 km from each other. In one of the fields *T. chilonis* was released @ 50,000/ha from April to June, 1994 on different dates as indicated in Table 19 while the 2nd field was left without parasitoid release as check. Pre and post release incidence of *C. infuscatellus* were recorded twice a month from April to June 1994 from both the plots. Recovery tests were carried out by collecting and rearing the host egg masses from both the plots. The emerged parasitoids were identified.

The data in Table 19 reveal that the pre-release incidence recorded in April in parasitoid release plot and the check plot was 0.8 and 0.7 per cent, respectively. The post-release incidence of *C. infuscatellus* during May was 3.9 and 7.6 per cent and in June 8.6 and 16.1 per cent in the release and check plots, respectively. The data also showed that parasitism by egg parasitoid was 43.8 and 9.5 per cent in release and check plots, respectively.

It could be concluded that 7 releases of *T. chilonis* @ 50,000 per ha during April - June reduced the incidence of *C. infuscatellus* by 46.6 per cent.

1.3.2.2. Field evaluation of *Trichogramma chilonis* against *Chilo auricilius* (PAU, Ludhiana)

A field experiment to evaluate the effectiveness of *Trichogramma chilonis* against *Chilo auricilius* was laid out in Lassara and Chakdana (Jalandhar, Punjab)). Three fields were selected, each measuring one hectare, (var. CoJ 64) separated by 0.5 km. In two plots 7 day old eggs of *Corcyra cephalonica* parasitized by *T. chilonis* were released @ 50,000/ha from second week of July to middle of October 1994 (Table 20). A 3rd field without release of parasitoid was kept as check. Observations on the incidence of *C. auricilius* were recorded before and after starting the parasitoid releases in all the three plots on different dates. For recovery tests, four egg clusters of *C. auricilius* (laboratory laid) were exposed in each field for 48 hr during July and September and reared in laboratory in individual test tubes till emergence of host larvae or parasitoids. The emerged parasitoid were identified and the data are presented in Table 21.

The data (Table 20) reveal that the pre-release incidence of *C. auricilius* was 1.0, 0.9 and 0.9 % in the three plots. The post-release mean incidence of borer in I and II plots and in the control varied from 4.9 - 19.9%, 5.0 - 21.0% and 8.7 - 53.0%, respectively from July to October, 1994.

The data on recovery tests is presented in Table 21. The data showed that in I, II and control plots 3,2 and 0 eggs/cluster, respectively, were found parasitized. The results indicate that the parasitoid multiplied in the field and checked borer incidence in the released plots.

1.3.2.3. Field evaluation of *Trichogramma chilonis* against *Chilo auricilius* and *Chilo sacchariphagus indicus* (IISR, Lucknow)

The experiment was conducted in a ratoon cane field (Var.CoLK 8102) at the Institute farm in one hectare. The field was divided into two equal halves with a buffer area of 55x 50M in between the two halves. One half was used for release of the parasitoid while the other was left as a check (No release). Tricho cards of *T. chilonis* were supplied by PDBC, Bangalore. The releases were made @ 50,000/ha at 10 days interval from 25th July to 28th September, 1994. Observations were made on the incidence of stalk and internode borers in the last week of September from a unit of 4 clumps selected at random at 15 spots both in the release and check blocks. At harvest, 15

samples each of 25 canes in a row were taken at random both in the release and check blocks and split open for recording the incidence and infestation of the joints.

The data on the incidence and intensity of the two borers during September and at harvest are presented in Table 22. The data indicate that incidence of stalk borer tended to increase from September to February both in release and check plots whereas in case of internode borer it remained static. The difference in the incidence and intensity in the release and check plots were not significant, except for the incidence of stalk borer at harvest which too is higher in release block than check block. This year the pest build up remained low, hence the differences were not marked.

1.3.2.4. Comparative efficacy of indigenous and Indonesian strains of *Cotesia flavips* against three species of sugarcane borers

Chilo infuscatellus

The experiment to study the efficacy of indigenous and Indonesian strains of *Cotesia flavipes* to control *C. infuscatellus* was laid near Bahar Muzara village (Jalandhar) in three sugarcane fields of 0.5 ha each of CoJ 64 variety. The fields were 1/2 km apart from one another. In one field indigenous strain and in the 2nd Indonesian strain of *C. flavipes* @ 800/ha were released from last week of April to 3rd week of June, 1994 on different dates (Table 23). Larvae of the borer were collected by dissecting the shoots from all the three plots during May to July and reared in the laboratory till formation of host pupae or parasitoid. From indigenous and Indonesian strain plots and the check plot 78,82 and 92 larvae, respectively, were collected during May to July and reared. It is seen from the data (Table 23) that the pre release incidence of *C. infuscatellus* in April 1994 varied from 1.0 to 1.4 % in all the three plots. In May, the mean incidence was 4.3, 7.1 and 7.6 percent in the plots where indigenous and Indonesian strains of *C. flavipes* were released and the check plots, respectively.

The corresponding figures for June increased to 8.3 , 15.6 and 16.1 per cent. This showed that the incidence was low in the plots where indigenous strain was released while the incidence in the other two plots were on par with each other. Similarly , the per cent parasitism by the larval parasitoid was 10.7% in the indigenous strain release plot while it was almost equal in the rest of the two plots. From all the three plots only indigenous strains of *C. flavipes* was recovered. This showed that the Indonesian strain failed to establish and exercise a check on the pest incidence while the indigenous strain played its role.

Chilo auricilius and *Acigona steniellus*

The experiments to study the efficacy of two strains of *C. flavipes* to control these two pests were laid out in the villages Lassara and Chakdana (Jalandhar). Three fields of var. CoJ 64 each measuring 0.5 ha were selected at a distance of about one kilometer from each another. In one field the indigenous strain and in the 2nd Indonesian strain of *C. flavipes* were released @ 800/ha on different dates from last week of July to 8th October (Table 24). The field without release was kept as check.

The pre-release incidence of *A. steniellus* was 1.2, 1.6, 1.4 per cent in the indigenous, Indonesian strain plots and the check plot, respectively, while in the case of *C. auricilius*, the corresponding figures were 0.8, 1.2 and 1.0%, respectively (Table 24).

The post release incidence of *A. steniellus* was 9.4, 16.4 and 17.6% in indigenous, Indonesian and the check plot, respectively. The corresponding figures for *C. auricilius* were 32.6, 53.8 and 57.4%, respectively. This showed that indigenous strain was better in controlling both the pests. Only indigenous strain was recovered from all the treatments during recovery tests.. The parasitism of *A. steniellus* and *C. auricilius* larvae was 9 and 10%, respectively, where indigenous strain was released as the parasitism varied from 2-4% in all other treatments.

Table 19. Field evaluation of *Trichogramma chilonis* against *Chilo infuscatellus*

Treatment/ Dosage/ha	Date of release	* Mean incidence (%) Pre-release April 1994	Post-release May 1994	Post-release June 1994	Reduction (%)	Recovery of parasitoid Egg clusters collected	Parasitism** recorded
T. chilonis @ 50,000 (7 day old parasitized host eggs)	19-04-1994 26-04-1994 12-05-1994 20-05-1994 31-05-1994 07-06-1994 17-06-1994	0.8	3.9	8.6	46.6	16	43.8
Control (No release)	-	0.7	7.6	16.1	-	21	9.5
Observation dates		6th & 19th April	12th& 31st May	7th & 26th June			

* based on units of 100 shoots
** includes the parasitism by *T. chilotraeae*

Table 20. Evaluation of *Trichogramma chilonis* against *Chilo auricilius*

Month	Date of release	* Mean incidence of *C. auricilius* (%) Field - 1	Field -2	Control
June	- Pre-release	1.0	0.9	0.9
July	15,26	4.9	5.0	8.7
August	5,16,25	14.1	14.2	22.9
September	1,12,28	18.5	18.8	44.2
October	8,12	19.9	21.0	53.0

* Average of 3 observations each based on 5 units each of 5 clumps
T. chilonis released @ 50,000 parasitized host eggs

Table 21. Recovery of *Trichogramma chilonis* by host exposure method

Treatment	Month of exposure of host eggs	No.of egg clusters parasitized	Parasitoid recovered
T. chilonis release			
Field-I	July	1	*T. chilonis*
	September	2	*T. chilonis*
Field-II	July	1	*T. chilonis*
	September	1	*T. chilonis*
Control	July	0	-
	September	0	-

4 egg clusters were exposed each month for 48hrs in each treatment

Table 22. Efficacy of *Trichogramma chilonis* against the sugarcane tissue borers *Chilo auricilius* and *Chilo sacchariphagus indicus*

Period of observation	Mean percent incidence			
	Chilo auricilius		*Chilo sacchariphagus indicus*	
	Release plot	Control plot	Release plot	Control plot
September, 1994	8.13[1]	4.86[2]	13.17[1]	11.22[2]
February, 1995	22.13[3] (1.55)[1]	11.20[4] (0.73)[2]	14.40[1] (1.46)[1]	9.86[2] (0.55)[2]

Figures in parentheses denote the intensity of infestation.
Differences between 1 and 2 are not significant and that between 3 and 4 are significant at 5% level.

Table 23. Field efficacy of two strains of *Cotesia flavipes* against *Chilo infuscatellus*

Treatment	No. released /ha	Date of release	** Mean incidence of *C. infuscatellus* (%)			Recovery of parasitoid	
			Pre-release	Post-release		No. of larvae collected & reared (May-July)	Parasitism (%)
			April	May	June		
C.flavipes (Indigenous strain)	800	April 26 May3,12,29,31 June 7,17	1.4	4.3	8.3	78	10.3
C.flavipes (Indonesian strain)	800	As above	1.0	7.1	15.6	82	3.7
Control	No release	-	1.3	7.6	16.1	92	3.3
Dates of observation			8 & 19 April	12 & 31 May	7 & 26 June		

Note: The plot size was 0.5 ha for each treatment
** Average of 2 observations, each based on 5 units of 100 shoots

Table 24. Field efficacy of two strains of *Cotesia flavipes* against *Acigona steniellus* and *Chilo auricilius*

*Treatment	Date of release	** Mean incidence of *C. infuscatellus* (%)				Recovery (%)	
		Pre-release		Post-release			
		A.s	*C.a*	*A.s*	*C.a*	*A.s*	*C.a*
C.flavipes (Indigenous strain)	July 28 August 5,16,18 September1,12,20 October 8	1.2	0.8	9.4	32.6	9.0	10.0
C.flavipes (Indonesian strain)	-do-	1.6	1.2	16.4	53.8	2.0	6.0
Control		1.4	1.0	17.6	57.4	2.0	4.0
Dates of observation		23 June	15 July	20 Sept-ember	28 Octo-ber		

* Releases were made @ 800 adults/ha and plot size was 0.5 ha/treatment
** Average of 5 units of 100 canes each
+ Recovery tests based on 50 larvae of each species per treatment
A.s = *Acigona steniellus* and *C.a* = *Chilo auricilius*

1.3.2.5 Field evaluation of exotic strain of *Cotesia flavipes* (IISR, Lucknow)

1.3.2.5.1. Efficacy of exotic larval parasitoid, *Cotesia flavipes* (Indonesian strain) against stem borers

A field experiment was laid out in RBD with four treatments replicating five times each treatment on the releases of *C. flavipes* with variety CoLk 8102 planted in November in D-32. The treatments included the releases of *C. flavipes* @ 800, 1200 and 2000 mated females/ha and from July to November at 15 days interval and an untreated check. The observations on progressive field infestation of stalk and internode borer were recorded,in July, September and final harvest in January. The results revealed that in July the infestation of stalk and internode borer remained very low (0 to 4.19 per cent). In September, the infestation of stalk borer was 10.39, 11.52 and 12.31 per cent in parasitoid released area @ 800, 1200 and 2000 adults/ha, respectively, as against 15.10 per cent in check (Table 25). Similarly, the infestation of internode borer was 13.42, 11.15 and 13.98 per cent in parasitoid released area @ 800, 1200 and 2000 adults/ha, respectively, as against 18.99 per cent in check. The infestation of both the borers remained low in all the released treatments as compared to check. However, at harvest no definite trend was observed in the infestation of stalk and internode borer in released and control blocks. At harvest the parasitization of stalk borer was 10.0, 10.59 and 9.07 per cent in wasps released @ 800, 1200 and 2000 adults/ha, respectively, as against 6.66 per cent in check. In general, the larval population of stalk borer remained low (3.65 larvae/100 canes), therefore, the larval parasitization also remained low.

1.3.2.5.2 Releases of *C. flavipes* @ 250 mated females/ha at weekly interval

A block trial was conducted in one hectare ratoon field of the variety CoLk 8102. Weekly releases were made of *C. flavipes* @ 250 mated females/ha. The field was marked into two blocks of 75 x 54 m each separated by a buffer area of 30 m. In one block, the releases of the wasps were carried out from 29th June to 11th November as per the treatment and the other block was treated as check (unreleased). The progressive field infestation of stalk and internode borer was recorded in both the released and unreleased blocks in July, September - October and November. The infestation of internode borer was 27.65 per cent in July and reached its peak of 32.36 per cent in September - October and remained at 31.36 per cent in September-October and was at 31.36 per cent in November, whereas in released block the infestation in July, after one month of releases of the wasp, was only 6.25 per cent which increased to 16.5 per cent in September -October and remained at 15.04 per cent in November. In the case of stalk borer the infestation was in traces in July, 11.53 per cent in Sept-Oct. and 22.21 per cent in November in unreleased block in July, September - October and November, respectively (Table 26). The differences in infestation of stalk borer in released and control blocks during November alone were statistically significant.

1.3.2.6. Comparative studies of exotic and indigenous strain of *Cotesia flavipes* (IISR, Lucknow)

1.3.2.6.1. Laboratory studies on exotic strain of *Cotesia flavipes*

Host stage preference test

Host stage preference tests were performed in plastic jars of 1.5 lit. capacity fitted with wire mesh. In each jar four 1-day old mated females were released alongwith 2 larvae each of 2nd, 3rd, 4th and 5th instar of *Chilo auricilius* and 5 gm. diet. The results revealed that the 2nd instar larvae were significantly less preferred for oviposition by *C. flavipes* than the 3rd, 4th and 5th instar larvae. However, the differences among 3rd, 4th and 5th instar larvae were not significant (Table 27).

Host-stage suitability test

Host stage suitability tests were performed in glass tubes of 3.5 x 10 cm size. In each tube single 1-day old mated female was released alongwith 2 larvae of 3 instar (other than first instar) and 5 gm diet with 10 replications. The larvae were exposed to the parasitoid for 24 hr and then transferred to artificial diet for development. The results indicated that the differences in per-host larvae production of parasitoid cocoons, adults and sex ratio (M:F) of progeny were non-significant among 2nd, 3rd, 4th and 5th instar larvae of *C. auricilius* (Table 28).

Storage of cocoons

The 3 day old cocoons of *C. flavipes* were found to be more suitable for storage at 10 C than the fresh and 5-day old cocoons. The 3 day old cocoons gave 71.6 percent emergence of wasps when stored for 15 days (Table 29).

1.3.2.7. Natural parasitism by *Cotesia flavipes* (SBI, Coimbatore)

Natural parasitism of sugarcane shoot borer and internode borer and sorghum borer by *C. flavipes* was monitored from April 1994 to Mach 1995 (Table 30). The mean monthly parasitism was generally low in all the borers. The highest parasitism amongst all the borers and months was noticed in March in internode borer (2.6%). The parasitoid was least active on shoot borer. The remaining two borers did not differ much in the levels of parasitism.

1.3.2.8 Mating behaviour of *C. flavipes* (SBI, Coimbatore)

The mating rate of females in batches of varying sex ratios was assessed to determine the role of proportion of males in mating success (Table 31). The proportion of males in the test samples varied from 0.14 to 0.50 and the mating success was recorded in terms of number mating over the

number of females, assuming monogamy in females. In the ratios tested, the mating rate varied from 75-100% of the females released within 15 minutes of exposure, indicating high mating success even at low proportion of males.

Table 25. Per cent infestation of internode borer and stalk borer

Treatment Adults/ha	July		September		January	
	IB	SB	IB	SB	IB	SB
800	3.78	0.00	13.42 (1.19)	10.39 (1.15)	21.52 (1.63)	21.40 (2.17)
1200	2.22	0.00	4.15 (1.03)	11.52 (1.23)	21.91 (1.76)	26.21 (2.55)
2,000	4.19	0.00	13.98 (1.25)	12.31 (1.12)	28.36 (2.46)	26.67 (2.79)
Check	2.52	0.23	18.99 (1.76)	15.10 (1.56)	23.99 (3.27)	22.73 (4.23)

Figures in parenthesis are the infestation on internode basis
IB: Internode borer; SB: Stalk borer

Table 26. Progressive field infestation of internode and stalk borer in released and control block in July, September - October and November

Field	Per cent internode borer incidence			Per cent stalk borer incidence		
	July	September - October	November	July	September -October	November
Released	6.25	16.9 (1.4)	15.0 (1.0)	0.8	3.6 (0.2)	8.7 (0.5)
Control	27.6	32.5 (2.8)	31.3 (2.3)	0.0	11.5 (0.9)	22.2 (2.0)
't' test significance at 5%	NS	NS	NS	NS	NS	*

Figures in parentheses are per cent infestation on internode basis; NS = Non significant

Table 27. Host stage preference test involving exposure of 2 larvae each of 2nd, 3rd, 4th and 5th instar to *C. flavipes*

Host instar	Per cent parasitization of *C. auricilius* larvae							
	1	2	3	4	5	6	7	Mean
2nd	5.0	5.0	7.5	2.5	2.5	0.0	5.0	3.92
3rd	15.0	12.5	10.0	12.5	20.0	10.0	7.5	12.50
4th	12.5	5.0	10.0	15.0	10.0	10.0	5.0	9.64
5th	15.0	12.5	15.0	10.0	10.0	7.5	12.5	11.78

Table 28. Host stage suitability of *C. auricilius* to *C. flavipes*

Host instar	No of hosts that produced parasitoid cocoons (when 2 host larvae were exposed to an individual female wasp)	Parasitoids produced from each parasitized larva			
		No. of cocoons produced	Per cent emergence of adults from cocoons	No. of parasitoid progeny	Sex ratio of progeny M:F
2nd	0.72 (0.69)	18.73 (8.62)	89.56 (17.05)	16.52 (8.52)	1:2 (2.36)
3rd	0.93 (0.62)	25.66 (13.38)	89.85 (11.93)	23.55 (13.42)	1:4.4 (4.35)
4th	0.93 (0.58)	25.62 (9.83)	83.40 (23.84)	22.33 (11.94)	1:4.73 (6.02)
5th	0.96 (0.62)	21.57 (8.57)	87.94 (14.04)	18.73 (7.72)	1:2.94 (3.01)
CD	NS	NS	NS	NS	NS

Table 29. Effect of storage of fresh, 3-day and 5-day old cocoons at 10°C on adult emergence of *C. flavipes*

Age of cocoon	Per cent of adult emergence at different intervals(days)				
	5	10	15	20	25
Fresh	59.4[a] (50.83)	54.2[a] (47.57)	4.66[a] (5.77)	0.5[a] (2.03)	Nil
3-day old	94.8[b] (78.64)	77.8[a] (63.17)	71.60[b] (59.31)	17.2[b] (21.75)	Nil
5-day old	86.9[b] (73.11)	65.05[a] (55.13)	16.70[a] (20.18)	6.3[ab]	Nil

In vertical columns means followed by the same letters are not different statistically at 5%
Figures in parenthesis are arcsin transformed values

Table 30. Natural parasitism of sugarcane borers by *Cotesia flavipes*

Year Month		No. of larvae collected			Per cent parasitism		
		CP	INB	SB	CP	INB	SB
April	1994	231	418	346	0.0	0.0	0.0
May		268	983	601	0.0	0.0	0.0
June		727	1084	392	0.0	0.1	0.0
July		584	828	872	0.0	0.1	0.0
August		539	1095	252	1.5	0.0	0.0
September		572	592	773	0.4	0.0	0.0
October		1158	375	633	0.0	0.8	0.0
November		941	328	499	0.1	0.0	0.0
December		307	918	768	2.0	1.3	0.1
January	1995	0	206	612	0.0	1.5	1.1
February		521	327	840	0.2	0.6	0.0
March		657	645	752	0.0	2.6	0.0

CP : *Chilo partellus* INB: Internode borer SB: Shoot borer

Table 31. Mating behaviour of *C. flavipes*

No.of adults exposed (M : F)	Sex ratio (M : F)	Proportion of males	% mated females at different intervals (min.)			
			5	15	30	45
5:5	1:1	0.50	40.00	100.00	100.00	100.00
6:6	1:1	0.50	0.00	66.70	83.30	83.30
6:12	1:1	0.50	33.30	75.00	75.00	75.00
3:9	1:1	0.50	0.00	100.00	100.00	100.00
2:12	1:1	0.50	0.00	75.00	83.30	83.30

1.3.2.9 Oviposition success rate of *C. flavipes* (SBI, Coimbatore)

The oviposition success rate of the parasite was assessed in the laboratory to understand the factors responsible for low levels of parasitization. Females from batches of varying sex ratio were allowed to oviposit individually on a single sorghum borer larva and the oviposition rate was recorded. The oviposition rate by the parasite varied from 7.7 to 76.2% amongst different batches (Table 32). The correlation between the percentage of males in the different batches and the corresponding oviposition rates was non-significant (r= 0.560; p 0.05). Less males did not seem to affect mating chances and oviposition rate, thus suggesting polygamy amongst males.

1.3.2.10 Studies on kairomonal principals *C. partellus* frass (SBI, Coimbatore)

Studies were initiated to identify active kairomonal principles in the frass. Dichloromethane extract of the frass was obtained by steam distillation in Soxhlet apparatus. After reducing the volume, the extract was fractionated in a silica gel column using different com-

binations and later was vacuum evaporated to reduce their volume. The fractions need further purification.

1.3.2.11. Studies on the indigenous parasitoids of sugarcane borers, their seasonal availability and parasitism in nature (PAU, Ludhiana)

The egg clusters, larvae and pupae of four species of sugarcane borers (*C. infuscatellus*, *C. auricilius S. excerptalis* & *A. steniellus)* were collected from fields during different months of the year and reared in the laboratory till emergence of host or parasitoids. On emergence , the parasitoids were identified and the extent of parasitism was recorded. The data on life stages collected, parasitoids emerged and per cent parasitism are presented in Tables 33 - 36.

Chilo infuscatellus

Two species of trichogrammatids, viz., *Trichogramma chilotraeae* and *T. chilonis* were recorded during April to July and the parasitism by former varied from 6.3 to 10.0% and by the latter 2.3%. Three larval parasitoids, viz., *Cotesia flavipes*, *Bracon* sp. and *Stenobracon nicevillei* were recorded and these exercised parasitism from 2.3 -3.9 %, 1.6-1.8% and 1.6-6.0%, respectively (Table 33).

Chilo auricilius

Four species of larval parasitoids were recorded from July 1994 to February, 1995. During this period, 471 larvae and 145 pupae were collected and reared. The parasitism by *C. flavipes* ranged from 3.2 to 7.0%. The corresponding figures for *G. nicevillei*, *Sturmiopsis inferens* and an unidentified species were 2.4 - 3.2%, 1.7 - 7.1% and 3.2 - 4.3 %, respectively (Table 34).

Scirpophagaexcerptalis

The data (Table 35) indicated that out of 113 egg clusters, 437 larvae and 53 pupae collected and reared two species of egg parasitoids and three larval parasitoids emerged. The egg parasitoids, viz., *Telenomus dignoidis* and *Trichogramma japonicum* were recorded during April to September. The parasitism of the former species ranged from 8.3 - 37.5% and that of latter from 3.1 - 4.8%. The parasitism by larval parasitoids *Rhaconotus scirpophagae* ranged from 5.7 - 8.9 %, *Isotima javensis* from 4.3 - 5.70% and *G. nicevillei* from 2.0 - 8.6%.

Acigona steniellus

350 larvae and 85 pupae were collected and reared in the laboratory. Four species of larval parasitoids namely *C. flavipes*, *G. nicevillei*, *Rhaconotus signipennis* and *I. javensis* were recorded with the parasitism ranging from 2.4-5.4%, 1.8-7.3%, 1.4-2.4% and 2.1%, respectively. The two pupal parasitoids *Xanthopimpla stemmator* and *Tetrastichus israeli* with a parasitism level of 2.9% were recorded (Table 36).

1.3.2.12 Studies on indigenous parasitoids and entomo- pathogens of sugarcane pests with particular reference to their seasonal availability and parasitism / predatism (IISR, Lucknow)

Shoot borer, *Chilo infuscatellus*

At Sardar Nagar, the infestation of shoot borer during premonsoon remained low being 5.2 to 6.01 per cent on dead heart basis. The shoot borer complex of the area comprised *C.infuscatellus*, the green borer, *Raphimetopus ablutellus* and the root borer, *Emmalocera depressella* and the pink borer, *Sesamia inferens*. Of this assemblage, *C. infuscatellus* remained the most abundant borer comprising 56 to 92% of the population. In March, however, pink borer dominated.

At Nellore, the shoot borer infested the crop both at shoot and cane stages. At the shoot stage its infestation was higher in May planted crop (3.4 - 5.9 per cent) than in January planted crop (2.1 - 2.9 per cent). At cane stage, the infestation of internode borer was higher in January planted crop (0.39-6.72 per cent incidence and 0.06-0.99 per cent intensity) than May planted crop (1.30-2.00 per cent incidence and 0.15-0.43 per cent

intensity). Eggs of *C. infuscatellus* were parasitized by *Trichogramma* spp. (50%). At Pravaranagar, the shoot borer infestation ranged from 2.7 in October and December to 10.40 per cent in May, 1994. Low level of parasitization was recorded by *Cotesia flavipes* from June to February and by *Sturmiopsis* spp. in April, August, September, February to March (Table 37).

Table 32. Oviposition success rate of *C. flavipes*

No. of adults allowed to mate (Male : Female)	Males (%)	Oviposition rate (%)
5:25	16.7	20.0
18:36	33.3	36.1
13.48	21.3	12.5
13:26	33.3	76.2
7:101	6.5	12.0
54:24	69.2	70.0
6:58	9.4	27.3
2:8	20.0	50.0
10:13	43.5	7.7
6:46	11.5	12.5

Table 33. Field incidence of parasitoid of *Chilo infuscatellus* on sugarcane in Punjab

Month	No. of life stages of pest collected and reared			Parasitoids recovered and % parasitism in nature				
				Egg parasitoids		Larval parasitoids		
	Egg cluster	Larva	*Pupa	*T.chilonis*	*T.chilonis*	*C.flavipes*	*Bracon* sp.	*G.nicevillei*
April	10	88	-	10.0	0.0	2.3	0.0	0.0
May	15	109	10	6.7	0.0	3.7	1.8	0.0
June	44	128	40	6.8	2.3	3.9	1.6	1.6
July	16	33	-	6.3	0.0	3.0	0.0	6.0
Total	85	358	50					

* Pupal parasitoids not recovered.

Table 34. Field incidence of parasitoids of *Chilo auricilius* on sugarcane in Punjab

Month	No.of life stages of pest collected and reared		Parasitoids recovered and % parasitism in nature			
	Larva	Pupa*	*C. flavipes*	*G. nicevillei*	*S. inferens*	Unidentified
July	31	0	3.2	-	-	-
August	20	0	-	-	-	4.3
September	46	28	7.0	-	-	-
October	70	0	4.3	-	-	-
November	55	0	5.5	-	1.8	-
December	17	6	0	3.4	1.7	-
January	42	35	4.8	2.4	7.1	-
February	31	82	3.2	3.2	6.5	3.2
Total	471	145				

* No pupal parasitoids were recovered

Table 35. Field incidence of parasitoid of *Scirpophaga excerptalis* in Punjab

Month	No.of life stages of pest collected and reared			Parasitoids recovered and % parasitism in field				
				Egg parasitoids		Larval parasitoids		
	Egg	Larva	Pupa*	*T.dignoides*	*T.japonicum*	*E.scirpophagae*	*I. javensis*	*G. nicevillei*
April	12	35	0	8.3	-	0.0	0.0	0.0
May	21	50	0	23.8	4.8	0.0	0.0	0.0
June	10	34	0	20.0	0.0	0.0	0.0	0.0
July	4	35	35	0.0	0.0	5.7	5.7	8.6
August	32	45	28	37.5	3.1	8.9	4.4	6.7
September	28	70	0	21.4	0.0	7.1	4.3	5.7
October	6	70	0	-	-	-	5.7	7.1
November	0	50	0	-	-	-	4.0	2.0
December	0	48	0	-	-	-	4.8	4.2
January	0	-	0	-	-	-	-	-
February	0	-	0	-	-	-	-	-
March	0	-	0	-	-	-	-	-
Total	113	437	53					

* No pupal parasitoids were recovered

Table 36. Incidence of the parasitoids of *Acigona steniellus* on sugarcane in Punjab.

Month	Life stages collected & reared		* Parasitoids recovered and parasitism (%)					
	Larva	Pupa	*C. flavipes*	*G. nicevillei*	*R. signipennis*	*T. javensis*	*X. stammator*	*T. israeli*
July	104	20	4.8	-	-	-	-	-
August	141	35	5.0	1.8	1.4	2.1	2.9	2.9
September	131	30	4.6	-	-	-	-	-
October	130	0	5.3	3.0	-	-	-	-
November	82	0	2.4	7.3	2.4	-	-	-
December	92	0	5.4	-	-	-	-	-
January	80	0	5.0	2.5	-	-	-	-
February	90	0	3.3	2.2	-	-	-	-
Total	850	85						

* Last two species are pupal and others are larval parasitoids

Table 37. Infestation and natural parasitization of shoot borer at Pravaranagar

Month	Incidence of shoot borer (%)	Prevalence of larval parasitoids	
		Sturmiopsis sp.	*Cotesia flavipes*
April	8.95	+	-
May	9.15	-	-
June	7.90	-	+
July	4.80	-	+
August	5.10	+	+
September	4.70	+	+
October	2.95	-	+
November	3.30	-	+
December	3.00	-	+
January	4.15	-	+
February	5.30	+	+
March	8.55	+	-

+ = indicates presence, - = indicates absence

Field evaluation of *T. eldanae*

Two plots were earmarked for the release of the parasitoid and the other for the control. The releases were made at weekly intervals from 09-02-95 to 16-03-95 @ 50,000/ha. The released plots recorded lower level of incidence of shoot borer (3.19%) than the unreleased plot (9.80%). Egg masses were also collected from released and unreleased plot for record of parasitization. While egg parasitism was 78.05% in the released plot it was only 11.62% in the unreleased plot.

Field evaluation of *T. chilonis*

This was carried out against early shoot borer in two blocks earmarked for this purpose, including one for release of parasitoid and the other for control. The released block recorded an incidence below 9.00 per cent whereas in unreleased block it was 13.36 per cent.

Top borer, *Scirpophaga excerptalis*

At Sardarnagar, the top borer incidence ranged from 2.3 to 7.0 per cent in 1st to 5th brood. Maximum natural parasitization (23.3%) was recorded in 4th brood and minimum in 5th (2.0%). *Rhaconotus* sp. predominated in 4th brood (16.3%) followed by *Isotima javensis* in the 3rd (8.2%). Other parasitoids were at a low level (Table 38). Maximum parasitization of egg masses was recorded in 4th brood (60.92%) as against minimum in 2nd brood (31.5%). *Telenomus* sp. was the only parasitoid of the egg masses of top borer.

Infestation of top borer was negligible at Nellore and Pravaranagar. At Nellore egg parasitization by *Telenomus* sp. was recorded upto 29.62 per cent.

Stalk borer, *Chilo auricilius*

At Sardarnagar, activity of this borer was noticed from August to December although its incidence ranged from 0.2 to 5.5 per cent. It was parasitized by *Cotesia flavipes* (2.5%) and *Campyloneurus mutator* (3.5%).

Internode borer, *Chilo sacchariphagus indicus*

In Nellore area its incidence was higher in January planted crop (incidence 0.66 to 7.26% and intensity 0.05 to 1.38 per cent) as compared to May planted crop (incidence 1.06 - 2.00% and intensity 0.11 to 0.18 per cent).

The extent of parasitization by *Cotesia flavipes* was 1.61% whereas that of its eggs by *Telenomus* sp. was 75.00%.

Sugarcane leaf hopper, *Pyrilla perpusilla*

At Sardarnagar, its activity was noted from April to September with peak at the end having 6-7 nymphs and adults/leaf. At Nellore, its infestation was noted from May to November with peak in August having a population of 16-47 nymphs/adult/leaf.

At Pravaranagar, *Pyrilla* incidence was noted from June with a peak in August at the level of 9-10 adults and 15-28 nymphs on 100 clumps. Natural parasitization of eggs of *Pyrilla* was recorded by *Tetrastichus pyrillae* (65.525) and that of its nymphs by *Recharsdrypus pyrillae* (5.50%). *Metarhizium anisopliae* also was found to infect nymphs and adults (32.50%).

The population of the parasitoid, *Epiricania melanoleuca* was monitored at Dadh Farm in Pravaranagar. The activity of *E. melanoleuca* was noted from 2nd fortnight of July with peak in August and September, 1994.

The scale insect, *Melanaspis glomerata*

Infestation of scale insect was not there at Sardarnagar. At Nellore, its maximum incidence recorded was 11.04 per cent and intensity of 4.6 per cent. Parasitization of its crawlers was recorded by *Adelencyrtus mayuri* to the extent of 10.23%.

At Pravaranagar, observations were recorded during May, 1994 to March, 1995 from adsali and ratoon crop at monthly intervals (Table 39). Peak infestation was recorded in November in adsali crop and February - March in ratoon. The major

parasitoids recorded on scale insect were again *Adelencyrtus mayurai, A. moderatus* and *Botryoideclavata bharatiya*. Maximum parasitization was noticed to the extent of 22.59% during September. Predatory beetle *Pharoscymnus horni* was also noticed during August and September.

1.3.2.13. Seasonal occurrence of parasitoids on internode borer (SBI, Coimbatore)

Seasonal occurrence of internode borer parasitoids were monitored from April, 1994 to March, 1995 by sampling the borer larvae at fortnightly intervals (Table 40). *C. flavipes* was the only parasitoid recovered from the borer. The parasitoid was generally more active during January - March, 1995 than in the remaining months.

1.3.2.14. Survey for natural enemies of internode borer in factory areas (SBI, Coimbatore)

Natural enemies of internode borer were surveyed in four sugar factory areas of Tamil Nadu at harvest time (Table 41). Amongst sugar factory areas, only Salem Co-op. Sugar Mills, Mohanpur, showed the presence of *C. flavipes* at a very low level.

1.3.2.15 Seasonal and regional variation of shoot borer parasitoids (SBI, Coimbatore).

The activity of shoot borer parasitoids was monitored from January to March, 1995 in four different areas of Coimbatore (Table 42). *C. flavipes* and *Sturmiopsis inferens* were noticed in the borer in all the areas surveyed. *C. flavipes* was more active in Perur area while *S. inferens* was more abundant in Perur and Telungupalayam areas. *S. inferens* was generally more active in February followed by during March and January. *S. inferens* was more active than *C. flavipes* on shoot borer.

1.3.2.16 Studies on the internode borer egg parasitoid, *Telenomus* spp. (SBI, Coimbatore)

As a part of the studies to exploit this potential egg parasitoid of internode borer, egg masses of the borer were collected from the field and examined for parasitism. The per cent parasitism of a small batch of egg masses was as high as 87.5% on egg mass basis and 97.1% on individual basis. When *C. partellus* egg masses were exposed to the parasitoids, the adults attempted oviposition repeatedly, but no parasitoid emergences from the eggs was noticed.

Table 38. Parasitization of top borer larvae and pupae by natural enemies

Brood	Total parasitization	Parasitization by different parasitoids				
		Temelucha sp.	*Isotima javensis*	*Stenobracon* sp.	*Elasmus* sp.	*Rhaconotus* sp.
Ist	2.6	1.5	1.1	-	-	-
2nd	2.2	1.2	1.0	-	-	-
3rd	17.3	-	8.2	2.2	2.4	4.5
4th	23.3	-	4.5	-	2.5	16.3
5th	2.0	-	0.5	-	-	1.5

Table 39. Infestation and parasitism of scale insect at Pravaranagar

Month		Adsali			Ratoon		
		% scale inci-dence	% scale inten-sity	% scale para-sitism	% scale inci-dence	% scale inten-sity	% scale para-sitism
May	1994		Traces			Traces	
June		34.57	11.67	7.37	38.46	18.77	8.59
July		44.89	13.54	10.20	60.69	21.74	10.32
August		75.76	20.01	19.13	81.89	25.93	18.44
September		76.10	24.78	22.59	83.86	30.64	21.95
October		88.29	29.46	19.77	86.88	38.94	16.54
November		95.69	44.35	16.70	92.45	42.98	15.41
December		92.06	43.73	15.86	95.37	52.28	14.64
January	1995	-	-	-	96.47	51.54	14.69
February		-	-	-	91.94	53.47	13.96
March		-	-	-	98.66	47.09	12.50

Table 40. Seasonal occurrence of *C. flavipes* on Internode borer

Month/ Fortnight			No. of larvae collected	Recovery of *C. flavipes* (%)
April	1994	I	100	2.0
		II	-do-	0.0
May		I	-do-	0.0
		II	-do-	0.0
June		I	-do-	0.0
		II	-do-	0.0
July		I	-do-	0.0
		II	-do-	0.0
August		I	-do-	0.0
		II	-do-	0.0
September		I	-do-	0.0
		II	-do-	0.0
October		I	-do-	0.0
		II	-do-	3.0
November		I	-do-	0.0
		II	-do-	0.0
December		I	-do-	1.0
		II	-do-	3.0
January	1995	I	-do-	2.0
		II	-do-	3.0
February		I	-do-	0.0
		II	-do-	2.0
March		I	-do-	0.0
		II	-do-	0.0

Table 41. Incidence of natural enemies of Internode borer in sugar mill areas of Tamil Nadu

Sugar Mill	No.of larvae collected	% parasitism	
		C. flavipes	Others
Ambur Co-op. Sugar Mills Vadapudupet	33	0.0	0.0
E.I.D. Parry (P) Ltd Pugalur	858	0.0	0.0
Salem Co-op . Sugar Mills Mohanpur	108	0.9	0.0
Vellore Co-op. Sugar Mills Amundi	18	0.0	0.0

Table 42. Seasonal and regional variation of shoot borer parasitoids

Area	January, 95			February, 95			March, 95		
	No.of larvae collected	Parasitization (%)		No.of larvae collected	Parasitization (%)		No.of larvae collected	Parasitization (%)	
		S.i	*C.f*		*S.i*	*C.f*		*S.i*	*C.f*
Perur	141	2.1	2.8	96	3.1	2.1	90	4.6	1.1
Telungupalayam	95	0.0	1.1	77	15.6	0.0	88	1.1	0.0
Kovaipudur	-	-	-	95	1.1	0.0	116	0.9	0.0
Kuniamuthur	39	0.0	0.0	100	1.0	1.0	145	0.7	0.0
Total	275	1.1	1.8	368	4.6	0.8	439	1.6	0.2

S.i = *Sturmiopsis inferens*; *C.f* = *Cotesia flavipes*

1.3.2.17 Effectiveness of *Epiricania melanoleuca* cocoons against *Pyrilla perpusilla* (PAU, Ludhiana)

The effect of releases of *Epiricania melanoleuca* cocoons to control *Pyrilla perpusilla* was studied by collecting cocoons from different fields and releasing these in a 0.5 ha field. The releases were made @ 5000/ha in the last week of August by stapling the leaf pieces bearing cocoons at different spots. The pre and post release observations on the number of *P. perpusilla* and *E. melanoleuca* was recorded in the last week of August and September, 1994, respectively. The observations were recorded from 5 units of 10 leaves each and the data are presented in Table 43. The population of egg clusters, nymphs and adults of *P. perpusilla* were low in the cocoon released plots as compared with the check plot. However, there was increase in the population of parasitoid life-stages in the cocoon released plots. It is concluded that by supplementing the population of *E. melanoleuca* by releasing its cocoons a check was kept on the population of *Pyrilla*.

1.3.2.18 Studies on the predatory carabid beetles (SBI, Coimbatore)

The activity of carabid beetles was monitored during the crop season of '94 by trapping the beetles in 24 pit fall traps placed in an acre of cropped area. Maximum number of beetles was collected in the traps in October (Table 44).

1.3.2.19 Survey for predatory coccinellids (SBI, Coimbatore)

Surveys were conducted in Thiru Arooran Sugars and Sakthi Sugar Mill areas for predators of white fly. Low levels of activity of the predators like *Brumus* and *Cheilomenes* were noticed in the fields surveyed.

1.3.2.20 Seasonal incidence of insect pathogens of internode borer (SBI, Coimbatore)

Fortnightly collections of larvae were made at Coimbatore from April, 1994 to March, 1995. The granulosis virus was found to infect the host throughout the year and the maximum infection level noticed was 23 per cent (Table 45). The only fungal pathogen observed to infect internode borer larvae was *Hirsutella nodulosa*. The fungus was absent from April to June 94. It started infecting the larvae from July and reached a peak level of 22 per cent in September second fortnight. Thereafter the fungal infection declined and no infection was noticed during February, 1995.

1.3.2.21 Incidence of pathogens of internode borer in sugar factory areas (SBI, Coimbatore)

In a survey conducted for pathogens infecting internode borer larvae in four sugar factory areas in Tamil Nadu, the granulosis virus infection ranged from 0.9 to 22.2 per cent (Table 46) . No fungal pathogen was observed.

1.3.2.22 Seasonal incidence of pathogens of shoot borer (SBI, Coimbatore)

Monthly collections of shoot borer larvae made at Coimbatore from September, 1994 to March, 1995 revealed 3.8 to 35.6 per cent virus infection (Table 47). The study revealed the absence of fungal pathogens on shoot borer larvae.

1.3.2.23 Seasonal incidence of pathogens of shoot borer in selected villages (SBI, Coimbatore)

In a study conducted during January to March, 1995, it was observed that the mean virus infection was high at Telengupalya and low at Kovaipudur (Table 48).

1.3.2.24. Pathogenity of *Hirsutella nodulosa* to internode borer (SBI, Coimbatore)

The fungal pathogen isolated on Sabourd's dextrose + yeast extract medium and medium enriched with 1.5% host extract could not infect the internode borer larvae under the laboratory conditions. The fungus was sprayed on host larvae at 10^7 - 10^8 spores/ml.

1.3.2.25 Evaluation of Delfin against internode borer (SBI, Coimbatore)

Delfin, a commercial formulation of *Bacillus thuringiensis* var. *kurstaki* was evaluated in the laboratory against third instar larvae of internode borer by allowing the larvae to feed on treated shoot bits. At a concentration range of 0.03 to 0.1% the highest mortality was caused at 0.075% concentration (Table 49). The mortality was considerable (70.0%) at concentrations above 0.025%.

1.3.2.26 Field evaluation of *Beauveria bassiana* for control of sugarcane borers *Chilo auricilius* and *Chilo sacchariphagus indicus*

The experimental plot was planted with variety

COLK 8102 in autumn season (13-10-1993) with four treatments, T_1 - *B. bassiana* broadcast application @ 2.0 kg/ha, T_2 - *B. bassiana* broadcast application @ 4.0 kg/ha, T_3 - foliar spray of 10^7 spores/ml and T_4 - untreated check. All the treatments were replicated five times in RBD. Three applications of the fungus were given starting from last week of July to August at 15 days interval. Observations on the borer incidence were recorded at harvest time by harvesting two middle rows and recording stalk borer infestation as well as internode borer.

Internode borer incidence and intensity ranged from 15.5 to 24.6 per cent and 1.2 to 1.6 per cent, respectively, in the different treatments.

Table 43. Effectiveness of *Epiricania melanoleuca* against *Pyrilla perpusilla*

*Treatment	No.released/ ha (date)	Date of observation	** Mean population/leaf						
			P. perpusilla			*E. melanoleuca*			
			E	N	A	E	C	A	PN
E. melanoleuca (Cocoon)	5000 (31-08-94)	August, 25	0.5	2.2	0.3	0.4	0.5	0.1	0.1
		September, 28	0.5	5.0	0.6	1.6	3.2	0.5	0.3
Control	-	August, 25	0.3	2.2	0.3	0.3	0.4	0.2	0.1
		September, 28	0.1	15.0	2.4	0.6	0.8	0.1	0.1

* 0.5 ha area was under each treatment
** Based on 5 units of 10 leaves each
E = Egg cluster; N = Nymph; A = Adult; C = Cocoon; PN = Parasitized nymph

Table 44. Pitfall trap catches of ground beetles in sugarcane crop

Month (1994)	No. of beetles trapped
June	7
July	2
August	4
September	3
October	24
November	4
December	Nil

Table 45. Seasonal occurrence of microorganisms in internode borer larvae

Month and Fortnight		No. of larvae examined	% infection	
			Virus	Fungi
April 1994	I	100	6.0	0.0
	II	100	4.0	0.0
May	I	100	5.0	0.0
	II	100	23.0	0.0
June	I	100	9.0	0.0
	II	100	0.0	0.0
July	I	100	4.0	1.0
	II	100	10.0	1.0
August	I	100	7.0	0.0
	II	100	10.0	2.0

contd.

September	I	100	13.0	6.0
	II	100	0.0	22.0
October	I	100	23.0	6.0
	II	100	9.0	2.0
November	I	100	10.0	5.0
	II	100	12.0	4.0
December	I	100	6.0	2.0
	II	100	8.0	3.0
January 1995	I	100	10.0	1.0
	II	90	1.1	1.0
February	I	103	1.9	0.0
	II	104	1.0	0.0
March	I	100	2.0	1.0
	II	100	4.0	0.0

Table 46. Survey for microorganisms of internode borer larvae in different sugar factory areas

Name of the sugar factory	No.of larvae examined	% infection	
		Virus	Fungi
Vellore Co-op. Sugar Mill	18	22.2	0.0
Ambur Co-op. Sugar Mill	33	3.0	0.0
Salem Co-op. Sugar Mill	108	0.9	0.0
E.I.D. Parry (I) Ltd.,	857	1.1	0.0

Table 47. Natural occurrence of microorganisms in shoot borer

Months	No.of larvae examined	% infection	
		Virus	Fungi
1994			
September	105	3.8	0.0
October	125	12.8	0.0
November	81	33.3	0.0
December	351	35.6	0.0
1995			
January	275	15.6	0.0
February	368	9.7	0.0
March	439	13.2	0.0

Table 48. Infection or GV in shoot borer in different villages

Village	% infection during			Mean infection (%)
	January	February	March	
Perur	16.31	10.42	11.11	12.61
Telungupalayam	9.47	22.08	22.00	18.85
Kovaipudur	-	5.26	12.07	8.67
Kuniamuthur	28.21	4.00	8.23	13.50

Table 49. Evaluation of Delfin granules (WG) against internode borer

Treatments	Dose (%)	Mortality (%)
T_1	0.003	43.3
T_2	0.006	50.0
T_3	0.013	66.7
T_4	0.025	73.3
T_5	0.05	83.3
T_6	0.075	100.0
T_7	0.01	100.0
T_8	Control	0.0

1.3.3. BIOLOGICAL SUPPRESSION OF COTTON PESTS

1.3.3.1. Research - cum - demonstration trials on IPM of insect pests of old world cotton bollworm (PAU, Ludhiana)

Research - cum - demonstration trials on IPM in cotton were carried out at farmer's fields jointly by PAU and State Department of Agriculture, Punjab at villages Sandhwan (Faridkot), Nangal Kalan (Mansa), Deralang (Bathinda) and Alamgarh (Ferozepur) during 1994 cropping season.

A. Sandhwan (Faridkot)

The experiment was laid out at farmer's field on American cotton variety F 846 sown on May 10, 1994. The plot size was 2 acres for IPM, half acre each for *Bacillus thuringiensis* (*B.t.*) alone and *B. t.* alternated with *Trichogramma chilonis* while it was one acre each for PAU spray schedule (PAU SS) , Farmers' spray schedule (Farmer's SS), *Trichogramma chilonis* alone and Control (Tables 50 and 51). *T. chilonis* releases were made in IPM plot @ 1,50,000/ha in all the four locations. All the harvestable open bolls at maturity from 30 plants taken at random from each treatment were plucked along with burst ones (separately for each plant) to record the bollworm incidence. The bollworm incidence was recorded both on boll and loculi basis. The carry-over of pink bollworm larvae was also studied by taking 30 plants from each treatment.

B. Nangal Kalan (Mansa)

The experimental details were the same as in the experiment at village Sandhwan and the crop was sown on May 14, 1994. The details of sprays and releases are given in Tables 52 and 53.

C. Deralang (Bathinda)

The experiment at Deralang was laid out at farmer's field during second fortnight of May, 1994 on American cotton variety F 414. The plot size and methodology of the experiment was same as described above. The spray schedule and releases are given in Tables 54 and 55

D. Alamgarh (Ferozepur):

The experiment was carried out on an undescript cotton material , Jhurar, sown on May 15, 1994. The plot size and methodology adopted for the experiment was the same as before (Tables 56 &57).

The results of all experiments conducted at different locations are discussed.

i) Bollworm incidence:

The data presented in Table 58 indicated that bollworm incidence, both on boll and loculi basis was lowest in PAU spray schedule at all locations. It was followed by Farmer's spray schedule.

Bollworm incidence among freshly shed fruiting bodies was recorded at Nangal Kalan (Mansa) and Sandhwan (Faridkot). It was lowest in PAU spray schedule (16.91%) closely followed by IPM (17.3%) at Sandhwan (Table 59) The lowest incidence of bollworms among the freshly shed fruiting bodies was recorded in Farmer's spray schedule and PAU spray schedule at Nangal Kalan (Mansa).

ii) Carry-over of pink bollworm (PBW) larva:

The carry-over of PBW was lowest in insecticidal spray by schedule (Table 60). The number of PBW larvae in left over bolls and buds was much higher in fields treated with *T. chilonis* releases alternated with *B.t.* spray.

iii) Seed cotton yield:

The seed cotton yield was higher in PAU spray schedule and farmer's spray schedule treatments in comparison with other treatments at Sandhwan (Faridkot) and Nangal Kalan (Mansa). The seed cotton yield in IPM, *Trichogramma* and *B. t.* treatments were at par with control (Table 61).

Table 50. Details of releases and /or sprays in village Sandhwan (Faridkot)

Sprays/IPM Releases	PAU spray schedule	Farmer's spray schedule	Bio control		
			B.t	*Trichogramma*	*B.t.* + *Trichogramma*
Oxydemeton methyl 0.75 l / ha (28-7-94)	Oxydemeton methyl 0.75 l / ha (28-7-94)	Oxydemeton methyl 0.75 l / ha (28-7-94)	*B.t.* 1.0 kg / ha (05-08-94)	*Trichogramma* @ 2,00,000/ha (05-08-94)	B.t. @ 1.0 kg *Trichogramma* (05-08-94)
Trichogramma 2,00,000/ha (09-08-94)	Endosulfan 2.5 l/ha (11-08-94)	Monocrotophos 1.25l/ha (11-08-94)	-do- (25-08-94)	-do- (01-09-94)	-do- (22-09-94)
-do- 18-08-94	Fenvalerate 0.25 l/ha (20-08-94)	Endosulfan 2.5 l/ha (21-08-94)	-do- (22-09-94)	-do- (12-10-94)	
-do- 24-08-94	Quinalphos 20 l/ha (02-09-94)	Fenvalerate 0.5 l/ha (01-09-94)			
-do- 31-08-94	Cypermethrin 0.2 l/ha (12-09-94)	Ethion 1.75 l+ Cypermethrin 0.5 l/ha (13-09-94)			
-do- 07-09-94	Ethion 2.0 l/ha (22-09-94)	Carbaryl 2.5 kg/ha (22-09-94)			
-do- 19-09-94	Carbaryl 2.5 kg/ha (03-10-94)				
-do- 27-09-94					
-do- 06-10-94					

Date of spray and/or release given within parentheses

Table 51. Number of sprays and *Trichogramma* releases at Sandhwan

Treatment	*Number of sprays I	II	Number of releases
PAU spray schedule	1	6	0
Farmer's spray schedule	1	5	0
IPM	1	0	8
B. t	0	0	3
Trichogramma	0	0	3
B.t + *Trichogramma*	0	0	4
Control	0	0	0

* I - Against sucking pests
II - Against bollworms
Cotton Variety used : F 846

Table 52. Details of various sprays and /or releases at Nangal Kalan (Mansa)

Farmer's spray schedule (per ha)	PAU spray schedule (per ha)	IPM (Dose/ha)	*B.t.* alone (Dose/ha)	*Trichogramma* (Dose/ha)	B.t. + *Trichogramma* (Dose/ha)
1	2	3	4	5	6
Oxydemeton methyl 0.75 l (01-08-94)	Oxydemeton methyl 0.75 l (01-08-94)	Oxydemeton methyl 0.75 l (01-08-94)	Oxydemeton methyl 0.75 l (01-08-94)	Oxydemeton methyl 0.75 l (01-08-94)	Oxydemeton methyl 0.75 l (01-08-94)
Deltamethrin 0.5 l + Endosulfan 1.0 l (19-08-94)	Endosulfan 2.5 l (6-08-94)	Endosulfan 2.0 l (07-08-94)	B.t. @ 0.4 kg / ha 02-08-94	*Trichogramma* @ 2,00,000 02-08-94	*Trichogramma* @ 2,00,000 02-08-94
Quinalphos 2.0 l (28-08-94)	Fenvalerate 0.25 l (17-08-94)	*Trichogramma* @ 1,50,000 (09-08-94)	-do- 27-08-94	-do- 26-08-94	*B.t.* 1.0 kg (12-08-94)
Quinalphos 2.0 lit.+ Monocrotophos 0.5 l 07-09-94	Fenitrothion 2.175 l (21-08-94)	*Trichogramma* @ 1,50,000 (17-08-94)	-do- 14-08-94	-do- 06-09-94 (31-08-94)	*Trichogramma* @ 2,00,000

1	2	3	4	5	6
Ethion 0.5l + Fenvalerate 0.5l (14-09-94)	Acephate 2.0 kg (31-08-94)	-do- 26-09-94	24-09-94	-do- (14-09-94)	*B.t.*
Ethion 0.5l +Monocrot-ophos 2.0 l (26-09-94)	Cypermethrin 0.2 l 09-09-94	-do- 04-10-94			
Ethion 0.5 l+ Cypermethrin 0.25l (03-10-94)	Oxydemeton methyl 0.75 l (09-09-94)	*Chrysoperla* + *Trichogramma* (07-10-94)			
	Quinalphos 2.0 l (20-09-94) Carbaryl 2.5 kg (28-09-94)				
	Quinalphos 2.5 l (7.10.94)				

Date of spray/release given in parenthesis

Table 53. Number of sprays and *Trichogramma* releases at Nangal Kalan

Treatment	* Number of sprays I	II	Number of releases
PAU spray schedule	2	8	0
Farmer's spray schedule	1	11	0
IPM	1	1	6
B. t	1	0	3
Trichogramma	1	0	4
B.t + *Trichogramma*	1	0	4
Control	0	0	0

* I - Against sucking pests
II - Against bollworms
Cotton Variety used : F 846

Table 54. Details of various releases and / or sprays among different treatments at Deralang (Bathinda)

PAU spray schedule (Dose/ha)	Farmer's spray schedule (Dose/ha)	IPM (Dose/ha)	*Trichogramma*	*B.t.*	*B.t.*+ *Tricho-gramma*
Oxydemeton methyl 0.8251 (13-08-94)	Oxydemeton methyl 0.751 (13-08-94)	Oxydemeton methyl 0.8251 (13-08-94)	(23-08-94)	(13-08-94)	(13-08-94)
Endosulfan 2.51 (23-08-94)	Fenvalerate 3.125 l+ phospamidon 0.3751 (18-08-94)	Endosulfan 2.51 (13-09-94)	(01-09-94)	(23-08-94)	(26-08-94)
			(20-09-94)	(21-09-94)	(01-09-94)
Endosulfan 2.51 repeated (28-08-94)	Endosulfan 2.5 + Cyper-methrin 0.251 (28-08-94)	Quinalphos 2.01 (07-10-94) Deltamethrin 0.41 (14-10-94)	(11-10-94)		(21-09-94)
Fenvalerate 0.251 (08-09-94)	Cypermethrin 0.3751 Quinalphos 2.01 (13-09-94)	Release of *Trichogramma*			
Fenvalerate 0.251 (repeated) (13-09-94)	Cypermethrin 0.375 l + monocrotophos 1.251 (22-09-94)	(09-08-94) (18-08-94) (24-08-94)			
Quinalphos 2.01 (02-09-94)		(31-08-94) (07-09-94) (19-09-94)			
Deltamethrin 0.41 (03-10-94)	Quinalphos 2.01 (03-10-94)	(27-09-94) (06-10-94)			
Carbaryl 2.5 kg (13-10-94)					

Date of spray and /or release given within parentheses.

Table 55. Number of sprays and *Trichogramma* releases at Deralang

Treatment	* Number of sprays I	II	Number of releases
PAU spray schedule	1	7	0
Farmer's spray schedule	2	5	0
IPM	1	3	8
B. t	3	-	0
Trichogramma	-	-	4
B.t + *Trichogramma*	2	-	2
Control	-	-	0

* I - Against sucking pests
II - Against bollworms

Table 56. Details of releases and / or sprays in different treatments at village Alamgarh (Abohar)

PAU spray schedule (Dose/ha) 1	Farmer's spray schedule (Dose/ha) 2	IPM (Dose/ha) 3	Bio control (Dose/ha) 4
Endosulfan @ 2.5 l (20-08-94)	Malathion @ 1250 ml (06-08-94)	*Trichogramma* @ 1,50,000 (09-08-94)	*Trichogramma* *B.t.* @ 1.2 kg / ha 04-08-94
Alphamethrin 0.25 l	Endosulfan @ 2.0 l (20-08-94)	Endosulfan 35 @ 2.5 l (20-08-94)	-do- 10-08-94
Phospamidon 1.875 l (31-08-94)			
Oxydemeton methyl @ 0.75 l 12-09-94	Alphamethrin 450 ml+phos-phamidon 0.25 l 31-08-94	*Trichogramma* (25-08-94)	-do- (24-08-94)
Quinalphos @2.0 l (15-09-94)	Quinalphos @2.0 l (12-09-94)	Alphamethrin @ 250 ml + phospamidon @ 1.875 l (31-08-94)	*B.t.* (31-08-94)

1	2	3	4
Acephate @ 2.0 kg (22-09-94)	Oxydemeton methyl 0.75 l (15-09-94)	*Trichogramma* @ 1,50,000 (06-09-94)	*Trichogramma* (02-09-94)
Chlorpyriphos 5.0 l (30-09-94)	Deltamethrin @ 0.4 l + phospamidon 0.25 l (22-09-94)	-do- (19-09-94)	-do- (06-09-94)
Cypermethrin @ 0.2 l (10-10-94)	Cypermethrin @ 0.3 l (02-10-1994)	*Trichogramma* (01-10-94)	*Trichogramma* (21-09-94) Trichogramma + *B.t* (14-10-94)

Date of spray and /or release given within parentheses.

Table 57. Number of sprays and *Trichogramma* releases at Alamgarh (Abohar)

Treatment	* Number of sprays I	II	Number of releases
PAU spray schedule	2	6	0
Farmer's spray schedule	3	6	0
IPM	1	2	5
Biocontrol	0	0	10
Control	0	0	0

* I - Against sucking pests
II - Against bollworms

Table 58. Incidence of bollworms in pickable seed cotton at different locations

Treatment	Per cent incidence of bollworms									
	Boll basis				Mean	Loculi basis				Mean
	Nangal Kalan	Sandhwan	Alam-garh	Deralang*		Nangal Kalan	Sandhwan	Alamgarh	Deralang*	
PAU spray schedule	17.30 (25.52)	8.90 (17.24)	14.83 (22.57)	49.00 (44.40)	13.67	8.13 (16.52)	5.10 (12.92)	7.77 (16.12)	25.10 (29.98)	7.00
IPM	79.00 (63.13)	42.37 (40.58)	43.67 (41.59)	81.50 (69.55)	55.01	50.30 (45.15)	18.20 (25.23)	22.70 (28.35)	60.97 (56.66)	30.40
B.t.	54.93 (47.84)	58.50 (49.91)	38.73 (38.45)	79.47 (64.18)	50.72	35.53 (36.40)	29.33 (32.75)	19.60 (26.21)	54.13 (47.36)	28.15
Tricho-gramma	78.70 (63.10)	35.33 (36.45)	45.43 (42.33)	80.77 (68.53)	53.15	52.93 (46.67)	15.50 (23.17)	22.80 (28.34)	52.37 (46.34)	30.41
B.t + Tricho gramma alternate	86.23 (68.47)	44.50 (41.82)	55.13 (47.93)	66.80 (54.93)	61.95	53.43 (46.96)	21.97 (27.86)	27.90 (31.84)	50.83 (45.39)	34.43
Farmer's spray schedule	25.80 (30.28)	14.50 (22.25)	52.97 (46.69)	91.47 (79.83)	31.09	13.43 (21.29)	7.88 (16.14)	29.50 (32.83)	62.40 (52.26)	16.92
Control	77.26 (61.67)	48.57 (44.14)	58.40 (49.89)	84.96 (67.46)	61.41	44.97 (42.09)	23.20 (28.71)	32.80 (34.82)	52.06 (46.22)	33.6
CD at 5%	(10.47)	(6.01)	(NS)			(6.86)	(4.06)	(5.85)	(NS)	

Figures in parentheses are arcsin transformation

* Not included in working out mean value

Table 59. Bollworms incidence among the freshly shed fruiting bodies at Sandhwan(Faridkot) and Nangal Kalan (Mansa)

Treatment	Bollworm incidence (%)	
	Sandhwan*	Nangal Kalan **
PAU spray schedule	16.9	37.7
I.P.M.	17.3	49.9
Farmer's spray schedule	21.3	31.9
B.t.	24.7	62.5
Trichogramma	24.1	64.4
B.t. + *Trichogramma*	23.3	60.5
Control	27.6	59.0

* Mean of 20 observations from August 4th to October 10th, 1994
** Mean of 14 observations from August 6th to October 29th, 1994

Table 60. Extent of carryover of pink bollworm(PBW) larvae in pickable seed cotton at different locations

Treatment	No. of PBW larva hibernating (per 30 plants)			In leftover bolls and burs (per 30 sticks) at Mansa
	Nangal Kalan	Sandhwan	Alamgarh	
PAU spray schedule	1.67 (1.63)	1.33 (1.41)	2.67 (1.90)	0.00
IPM	80.00 (8.99)	24.00 (4.93)	22.00 (4.53)	6.00
B.t.	13.67 (3.00)	35.67 (6.05)	13.00 (3.71)	0.00
Trichogramma	44.33 (6.73)	20.33 (4.60)	28.33 (5.79)	11.00
B.t + *Trichogramma*	130.33 (11.44)	31.00 (5.55)	29.67 (5.48)	9.00
Farmer's spray schedule	11.0 (3.22)	1.66 (1.58)	6.33 (2.66)	1.00
Control	109.33 (10.50)	25.00 (5.09)	1.33 (1.47)	0.00
CD at 5%	(1.530)	(1.31)	(1.720)	

Figures in parentheses are transformed value
PBW = Pink bollworm

Table 61. Yield of seed cotton in Research-cum-IPM demonstration trials at different locations

Treatment	*Yield kg/acre	
	Sandhwan	Nangal Kalan
PAU spray schedule	550	554
IPM	359	490
B.t.	312	444
Trichogramma	316	454
B. t. + *Trichogramma*	338	403
Farmer's spray schedule	505	731
Control	350	492

* Yield data at Deralang and Alamgarh could not be recorded

1.3.3.2. Development of biocontrol based IPM for cotton pests (APAU, Hyderabad)

A field trial was laid out at Regional Agricultural Research Station, Lam (Guntur, APAU) in an area of 4000 m^2. There were four treatments viz., sustainable cotton production treatment, conventional method of control (farmer's practice), judicious usage of insecticides and untreated control. In sustainable cotton production treatment cotton crop was intercropped with groundnut in 1:2 ratio, while sole cotton crop was sown for farmer's practice, judicious usage of insecticides and untreated control treatments.

The sustainable cotton production treatment plot received seed treatment with carbofuran, application of granular insecticide (furadan) @ 33 kg/ha 15 days after sowing, inundative releases of *Trichogramma chilonis* @ 1,50,000 and *Chrysoperla carnea* @ 50,000/ha 60 days after sowing and spray application of BTK-II @ 2.0 kg/ha 120 days after sowing.

The conventional method of control treatment (farmer's practice) plot received the following insecticidal treatments at weekly intervals for 16 times. The spray treatments included: dimethoate, monocrotophos, methyl-o-demeton, phosphamidon, endosulfan, chlorpyriphos, acephate, quinalphos, trizophos, fenvalerate and cypermethrin.

The judicious use of insecticide treatment plot received spray application of monocrotophos, endosulfan, chlorpyriphos, quinalphos and trizophos 8 times on need basis. The control plot received no sprays.

The observations on the population of sucking pests viz., jassids, aphids, thrips and white flies were recorded on 15 sampled leaves selected at random from lower, middle and upper region of the plant. The data on the incidence of *H.armigera* in terms of number of eggs and larvae and also damaged squares and bolls were recorded from five plants from each treatment. The population of natural enemies was also recorded on five plants in each treatment.

The results presented in Table 62 revealed that among the sucking pests, the population level of aphids and white flies was very low in sustainable cotton production treatment and was on par with judicious use of insecticides treatment when compared to farmer's practice. The population level of jassids and thrips in sustainable cotton production treatment, judicious use of insecticides and untreated control plot were on par. Low population was recorded in farmer's practice treatment plot.

The build up of larval population of *H.armigera* was very slow in sustainable cotton production treatment. However, the level of larval population in untreated control plot, judicious usage of insecticides treatment plot was on par with that of sustainable cotton production treatment and it was found to be superior over other treatments.

The presence of predatory fauna (coccinellids, spiders and chrysopids) was significantly felt in sustainable cotton production treatment when it was negligible or low in other treatments.

The cotton yield obtained through sustainable strategies (13.2 q/ha) was statistically on par with that of conventional method of control (farmer's practice) (14.4 q/ha). The economical benefits derived from sustainable cotton production treat-

Table 62. Evaluation of effectiveness and economics of sustainable cotton production treatment

Particulars	Sustainable cotton production	Farmer's method	Judicious use of insecticides	Untreated check
I.Sucking Pests (for 15 sampled leaves)				
Jassids	55.8^{b}	13.6^{a}	71.8^{b}	69.6^{b}
Aphids	14.0^{a}	65.6^{b}	41.4^{ab}	121.8^{c}
Thrips	83.2^{c}	38.2^{a}	70.2^{bc}	59.4^{b}
White flies	0.8^{a}	2.0^{b}	0.6^{a}	0.4a
II. Boll worms (per 5 plants)(*H. armigera*)				
Eggs	4.8^{a}	6.4^{a}	6.2^{a}	5.8^{a}
Larvae	0.6^{a}	2.6^{b}	1.2^{ab}	0.8^{a}
III.Damage (%)				
Squares	0.4^{a}	8.2^{c}	7.5^{c}	2.8^{b}
Bolls	3.1^{a}	6.9^{b}	6.4^{b}	7.7^{b}
IV.Natural enemies				
Coccinellids	6.0^{b}	0.0^{a}	5.4^{b}	1.2^{a}
Spiders	2.4^{b}	0.2^{a}	0.6^{a}	1.2^{a}
Chrysopids	1.6^{b}	0.0^{a}	0.4^{a}	0.8^{ab}
V. Yield (kg/ha)				
Cotton	13.2^{a}	14.4^{a}	10.4^{b}	9.3^{b}
Groundnut	4.2	-	-	-
VI. Economics (Rs)				
Cost of inputs	4320	11000	8000	-
Net returns	26280	17840	12360	18620

Mean values denoted with same letters are not significantly different

ment (Rs 26,280) were far superior to farmer's practice (Rs. 17,840) where excessive chemical insecticides were used. The net benefits derived out of farmer's practice was even lesser than that of untreated control (Rs. 18,620). The sustainable cotton production treatment thus excelled due to the significant role played by the beneficial insects which could be increased through intercropping (cotton-groundnut) and avoiding of insecticidal treatment.

1.3.3.3 Development of biocontrol based IPM for cotton pests (GAU, Anand)

To evaluate the efficacy of IPM module against pest complex in Hybrid cotton-6 an experiment was laid out at Agronomy Farm, B.A. College of Agriculture, GAU, Anand in the year 1993-94.

The following three treatments were replicated ten times in a CRD design.

1. Integrated Pest Management (IPM)

a. Blanket application of methyl demeton @ 0.05% during early part of the season i.e . 30 DAG.

b. Three releases of *Chrysoperla* @ 50,000 larvae (2-3 days old) per hectare per week starting from 19-8-94.

c. Eight releases of *Trichogramma chilonis* each @ 1,50,000 per hectare per week starting from 9-9-94.

d. Need based application of endosulfan 0.07% and monocrotophos 0.04% alternatively after 8th release of *T. chilonis*. The ETL for spray application was 20 and 15 larvae of *E. vittella* and *H. armigera* per 20 plants.

2. Need Based application of insecticides recommended by GAU

Insecticides used		Date of spraying
Methyl demeton	(0.03%)	03-09-94
Monocrotophos	(0.036%)	04-10-94
Endosulfan	(0.07%)	19-10-94
Monocrotophos	(0.036%)	16-11-94
Endosulfan	(0.07%)	05-12-94
Monocrotophos	(0.036%)	19-12-94
Endosulfan		05-01-95

3. Control (Untreated)

The entire plot (0.2) was divided into 10 divisions. From each division 5 plants were selected and tagged. The observations on population of aphids, jassids, whiteflies and thrips was recorded from such tagged plants at fortnightly intervals from lower, middle and upper regions. Healthy and damaged buds/boll were counted from each tagged plant and the extent of damage (%) was worked out for each replication each fortnight. Eggs of bollworms were collected fortnightly from different treatments and kept individually in glass vials to record extent of parasitism. The larvae of bollworms were collected fortnightly from different treatments and were reared in the laboratory to record the extent of parasitism. The mummified larvae (due to parasitism of *Rogas*) observed in the field were collected from the field and added to the number of larvae collected while working out per cent parasitism. Number of other predators viz. *Chrysoperla carnea* (egg + larvae), *Cheilomenes sexmaculata* (eggs + larvae + pupae + adults), *Geocoris bicolor* (adults), spiders and staphylinids were recorded on each tagged plant at fortnightly intervals.

Sucking pests :

Results presented in Tables 63, 64 and 65 reveal that the population of sucking pests was significantly low in IPM and need based insecticidal treatment over control. The combined application of *Chrysoperla* and insecticides gave significantly better protection against the aphids (23.40), jassids (5.05) and whitefly (3.97), when compared with control plots which recorded 35.60, 13.44 and 9.63, respectively. The population of aphid, jassid and whitefly in need based insecticidal treatment was 26.88, 9.95 and 5.81, respectively.

Table 63. Number *A. gossypii* in different treatments.

Treat-ment	August		September		October		November		December		January		Pooled
	I	II	I	II	I	II	I	II	I	II	I	II	
IPM	4.686* (20.958)	5.185 (25.884)	6.114 (36.380)	3.971 (14.768)	3.136 (08.834)	2.421 (04.861)	4.772 (21.771)	5.092 (25.998)	5.776 (32.362)	5.865 (33.398)	3.978 (14.824)	8.327 (68.338)	4.94 (23.40)
Insect-icide	4.325 (17.705)	3.305 (09.923)	7.173 (50.451)	5.712 (31.626)	7.297 (52.246)	4.997 (23.970)	3.142 (08.872)	3.989 (14.912)	3.948 (14.586)	7.147 (50.079)	6.515 (41.445)	5.790 (32.524)	5.28 (26.878)
Control	3.666 (12.439)	4.791 (21.953)	6.999 (47.986)	5.773 (32.327)	6.772 (44.859)	5.209 (26.133)	4.459 (18.882)	6.739 (44.414)	6.446 (40.809)	7.607 (56.866)	7.949 (62.186)	6.190 (37.316)	6.05 (35.602)
Mean	4.23 (16.892)	4.43 (18.624)	6.76 (44.697)	5.15 (25.522)	5.74 (31.947)	4.21 (16.724)	4.12 (15.974)	5.28 (26.878)	5.40 (28.160)	6.87 (46.196)	6.15 (36.822)	6.77 (44.832)	5.42 (32.376)
SEm T	0.475	0.455	0.433	0.315	0.532	0.659	0.458	0.596	0.844	0.663	0.729	0.939	0.198
P													0.355
TxP													0.615
CD at T	NS	1.315	NS	0.913	1.545	1.913	1.329	1.729	NS	NS	2.115	NS	0.589
P													0.985
TxP													1.706
CV%	35.56	32.36	20.26	19.31	29.35	49.54	35.10	35.71	49.47	30.49	37.49	43.87	40.03

* Figures in parentheses are retransformed values, those outside are √x+1 values.

Table 64. Number of jassids, *A. biguttula biguttula* in different treatments

Treat-ment	August		September		October		November		December		January		Pooled
	II	I	II	I	II	I	II	I	II	I	II		
IPM	2.215 (03.906)	2.432 (04.914)	1.855 (02.441)	2.797 (06.823)	2.613 (05.827)	3.019 (08.114)	3.168 (09.036)	3.200 (09.240)	2.201 (03.844)	2.010 (03.040)	1.525 (01.325)		2.46 (05.051)
Insect-icide	2.652 (06.033)	4.565 (19.839)	2.998 (07.988)	4.038 (15.305)	4.022 (15.176)	3.368 (10.343)	4.489 (19.151)	2.587 (05.587)	3.128 (08.784)	2.957 (07.745)	1.64 (01.702)		43.31 (09.956)
Control	2.683 (06.198)	4.305 (17.533)	4.174 (16.422)	4.804 (22.078)	4.371 (18.105)	4.688 (20.977)	4.663 (20.743)	3.708 (12.749)	3.590 (11.888)	2.748 (06.551)	2.070 (03.284)		3.80 (13.440)
Mean	2.517 (05.335)	3.767 (13.190)	3.009 (08.054)	3.880 (14.054)	3.669 (12.461)	3.692 (12.630)	4.107 (15.867)	3.165 (09.017)	2.973 (07.838)	2.572 (05.615)	1.746 (02.048)		3 .19 (09.176)
SEmT	0.270	0.266	0.197	0.181	0.210	0.255	0.189	0.236	0.297	0.144	0.284		0.077
P													0.130
TxP													0.255
CD at T	NS	0.773	0.570	0.526	0.608	0.740	0.549	0.686	0.862	0.418	NS		0.228
P										0.360			
TxP										0.624			
CV%	33.88	22.35	20.66	14.77	18.06	21.85	14.56	23.62	31.60	17.71	39.52		25.18

* Figures in parentheses are retransformed values, those outside are √x+1 values.

Table 65. Number *B. tabaci* in different treatments.

Treatment	September		October		November		December		January		Pooled
	I	II	I	II	I	II	I	II	I	II	
IPM	1.290 (00.664)	1.248 (00.557)	1.207 (00.456)	3.901 (14.217)	3.367 (10.336)	2.943 (07.661)	2.506 (05.280)	1.629 (01.653)	2.082 (03.334)	2.089 (03.363)	2.23 (03.97)
Insect-icide	2.914 (07.491)	1.280 (00.638)	3.428 (10.750)	3.016 (08.096)	2.942 (03.655)	3.487 (11.159)	2.558 (05.543)	2.814 (06.918)	2.164 (03.682)	1.429 (01.042)	2.61 (05.81)
Control	3.058 (08.351)	2.428 (04.895)	2.960 (07.761)	3.310 (09.956)	4.417 (18.509)	4.289 (17.395)	3.810 (13.516)	3.249 (09.556)	2.509 (05.295)	2.528 (05.390)	3.26 (09.03)
Mean	2.447 (4.987)	1.652 (1.729)	2.532 (5.411)	3.410 (10.628)	3.576 (11.787)	3.573 (11.766)	2.958 (7.749)	2.564 (5.574)	2.252 (4.071)	2.015 (3.060)	2.70 (6.29)
SEm T	0.125	0.162	0.126	0.221	0.251	0.169	0.178	0.270	0.191	0.087	0.067
P											0.105
TxP											0.182
CD at T	0.361	0.470	0.364	0.641	0.727	0.491	0.518	0.783	NS	0.251	0.200
P											0.292
TxP											0.505
CV%	16.09	30.97	15.68	20.50	22.16	14.99	19.07	33.2	26.78	13.59	24.97

* Figures in parentheses are retransformed values those outside are x+1 values.

Bollworm (*Earias vittella*)

The results presented in Table 66 and 67 show that both the treatments IPM, as well as need based application of insecticides were significantly superior over control.

The bud and boll damage was significantly low in IPM and need based insecticidal treatment than in control. Both *Trichogramma* and *Chrysoperla* exerted effective check on the bollworms which resulted in 8.56 and 13.53 per cent bud and boll damage, respectively, as compared to 24.52 and 45.52 per cent bud and boll damage in control. The per cent bud and boll damage in need based insecticidal treatment was 18.20 and 30.59, respectively.

Since IPM received only two sprays, many of the bio- agents were conserved (Table 68 and 69). Noteworthy among them were *Aleiodes aligharensi (= Rogas aligarhensis), C. sexmaculata* and *Geocoris* sp. which played their role in natural control of pests. On the other hand 7 sprays of insecticides, though need based, had deleterious effect on the activity of the above natural enemies as could be seen in Tables 68 and 69. The per cent parasitism by *Aleiodes* averaged 18.54% as against 37.29% parasitism in IPM. Similarly egg count of chrysopids (0.18), coccinellids (0.51) , *Geocoris* (0.10), spider (1.21) and staphylinids (0.09) was much lesser than in IPM. The population counts of chrysopids, coccinellids, *Geocoris*, spider and staphylinids, averaged 0.87, 1.36, 0.24, 0.37 and 0.16, respectively.

Table 66. Extent of bud damage by *E. vittella* in different treatments

Treatment	October		November		December		January		Pooled
	I	II	I	II	I	II	I	II	
IPM	16.54 (08.11)	15.96 (07.56)	18.60 (10.24)	19.53 (11.18)	16.15 (07.73)	4.06 (05.90)	18.99 (10.59)	16.21 (07.79)	13.01 (08.56)
Insecticide	27.61 (21.48)	20.49 (12.25)	22.51 (14.66)	27.43 (21.22)	26.99 (20.60)	26.41 (19.78)	23.90 (16.41)	26.63 (20.09)	25.25 (18.20)
Control	30.15 (25.23)	25.30 (18.26)	25.98 (19.19)	41.25 (43.47)	25.85 (19.01)	33.92 (31.14)	23.48 (15.87)	31.53 (27.35)	29.68 (24.52)
Mean	24.77 (17.95)	20.58 (12.36)	12.38 (04.60)	29.40 (24.10)	23.00 (15.27)	24.80 (17.59)	22.13 (14.19)	24.79 (17.58)	23.96 (16.52)
SEm T	1.894	1.947	1.201	1.257	0.956	1.603	1.804	1.507	0.559
P									0.899
TxP									1.556
CD T	5.496	5.651	3.484	3.649	2.773	4.653	NS	4.272	1.662
P									2.491
TxP									4.314
CV%	24.18	29.92	16.96	13.52	13.14	20.45	25.79	19.22	20.86

* Figures in parentheses are retransformed value, those outside are $\sqrt{x+1}$ values.

Table 67. Extent of boll damage by *E. vittella* in different treatments

Treatment	October		November		December		January		Pooled
	I	II	I	II	I	II	I	II	
IPM	24.22 (16.83)	22.20 (14.28)	20.59 (12.37)	20.46 (12.22)	28.32 (22.51)	23.30 (15.65)	13.55 (09.09)	15.93 (07.53)	21.58 (13.53)
Insecticide	40.97 (42.99)	25.64 (18.72)	22.75 (14.95)	38.68 (39.06)	35.21 (33.24)	24.22 (31.63)	33.15 (29.90)	37.99 (37.89)	33.58 (30.59)
Control	48.70 (56.44)	44.35 (48.87)	41.71 (44.27)	50.66 (59.81)	37.13 (36.44)	40.54 (42.25)	36.39 (35.20)	39.93 (41.20)	42.43 (45.52)
Mean	37.97 (37.88)	30.73 (26.11)	28.35 (22.56)	36.60 (35.55)	3.55 (30.54)	32.70 (29.19)	39.03 (39.66)	31.28 (26.96)	32.53 (28.92)
SEm T	2.130	1.848	1.569	1.331	1.553	2.114	1.624	1.876	0.586
P									1.048
TxP									1.816
CD T	6.181	5.364	4.533	3.862	4.506	6.133	4.714	5.444	1.742
P									2.906
TxP									5.033
CV%	17.74	19.02	17.50	11.50	14.63	20.44	17.69	18.96	16.12

* Figures in parentheses are retransformed values, those outside are arcsin transformed values

Table 68. Mean % parasitism by *T. chilonis* in eggs and of *Aleiodes aligharensi* in larvae of *Earias vittella* in different treatments

Parasitism	T1	T2	T3
Egg parasitism by *T. chilonis*	17.50	6.96	8.64
Larval parasitism by *A. aligharensi*	37.29	18.54	23.80

T1 = IPM; T2 = Insecticides; T3 = Control

Table 69. Population of biocontrol agents per 50 plants in various treatments

Period		Chrysopids			Coccinellids			*Geocoris*			Spiders			Staphylinids		
		T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
August	II	3	2	1	11	10	10	-	-	-	12	5	6	-	-	-
September	I	29	2	1	28	16	16	10	2	6	36	16	32	-	-	-
September	II	35	4	10	28	10	12	8	5	7	9	7	9	-	-	-
October	I	42	5	9	40	29	31	7	5	10	20	10	22	13	4	11
October	II	81	7	27	116	22	49	20	2	18	23	14	17	3	-	2
November	I	114	28	47	137	18	40	20	4	10	35	23	31	10	10	11
November	II	97	18	43	88	34	39	26	7	14	27	8	14	24	6	13
December	I	33	10	17	27	7	23	3	1	2	11	4	7	8	5	6
December	II	21	8	13	27	13	14	11	5	6	8	8	9	10	2	7
January	I	14	9	10	131	91	119	16	11	16	13	10	13	14	12	26
January	II	12	8	10	116	32	73	13	14	9	10	10	8	4	9	9
Total		481	101	188	749	282	426	134	56	95	204	115	168	86	48	85
Average		0.8	0.2	0.3	1.4	0.5	0.6	0.2	0.1	0.2	0.4	0.2	0.3	0.2	0.1	0.2

T1 = IPM ; T2 = Insecticides; T3 = Control

The effectiveness of the IPM module was further substantiated from the yield. The IPM module recorded higher cotton yield (1177 kg/ha) over control (633 kg/ha).

Thus, the studies showed that biocontrol based IPM module was better than insecticides and control. It was also clear that reducing insecticidal sprays helps in conserving natural enemies.

1.3.3.4 Development of biocontrol based IPM for cotton crop (TNAU, Coimbatore).

In cotton three management practices viz., AICRP, TNAU and farmer's method were compared. AICRP method is a combination of need based application of oxy-demeton methyl, release of *Chrysoperla carnea* @ 50,000 /ha on 45 and 60 DAS and a third release @ 1,00,000/ha on 130 DAS, *Trichogramma chilonis* @ 1.5 lakh, 8-10 weekly releases starting from 70 DAS as need arises, based on 5 moths trapped / pheromone baited trap and need based application of HaNPV @ 450 LE/ha (7 second instar larvae / 20 plants). TNAU method involves the use of need based application of insecticides / HaNPV and the farmer's method consisted of insecticidal application only (6-8 rounds)

The results of the trial showed that both AICRP and TNAU methods of protection were superior to farmer's method in suppressing leafhopper and bollworms while the data on aphids was not significant. AICRP method recorded highest yield (651 kg) of kapas which was on par with TNAU treatment (636 kg). Both these treatments were superior to farmer's method of protection which yielded 577 kg kapas. (Tables 70 & 71; Fig.8.)

Table 70. Data on per cent bollworm damage on cotton (var.MCU 1)

Treament	Per cent boll damage (DAS)							
	80	90	100	110	120	130	140	150
I	5.17[a]	5.02[a]	4.11[a]	4.96[a]	5.23[a]	4.93[a]	7.17[a]	7.18[a]
II	6.08[a]	5.11[a]	5.51[b]	4.15[a]	3.99[a]	5.13[a]	7.79[a]	7.21[a]
III	9.33[b]	6.99[b]	6.55[b]	5.16	8.16[b]	9.51[b]	13.95[b]	11.63[b]
CD at 5%	1.72	0.75	0.75	NS	1.62	1.51	1.08	2.21

Table 71. Data on the incidence of leafhopper and aphids in cotton (var. MCU 5)

Treatment	Leaf hopper/ plant (DAS)		Aphids/plant (DAS)		Yield (Kapas) kg/ha
	30	50	60	50	
I	0.95[a] (8.95)	0.65 (4.50)	0.39[a] (2.50)	[b] 1.40 (25.10)	651[a]
II	1.41[ab] (13.80)	0.63 (4.30)	1.12[a] (13.20)	1.36 (22.90)	636[a]
III	1.26[b] (18.20)	0.64 (4.40)	0.76[b] (5.80)	1.32 (20.90)	577[b]
CD at 5%	0.21	NS	0.42		36

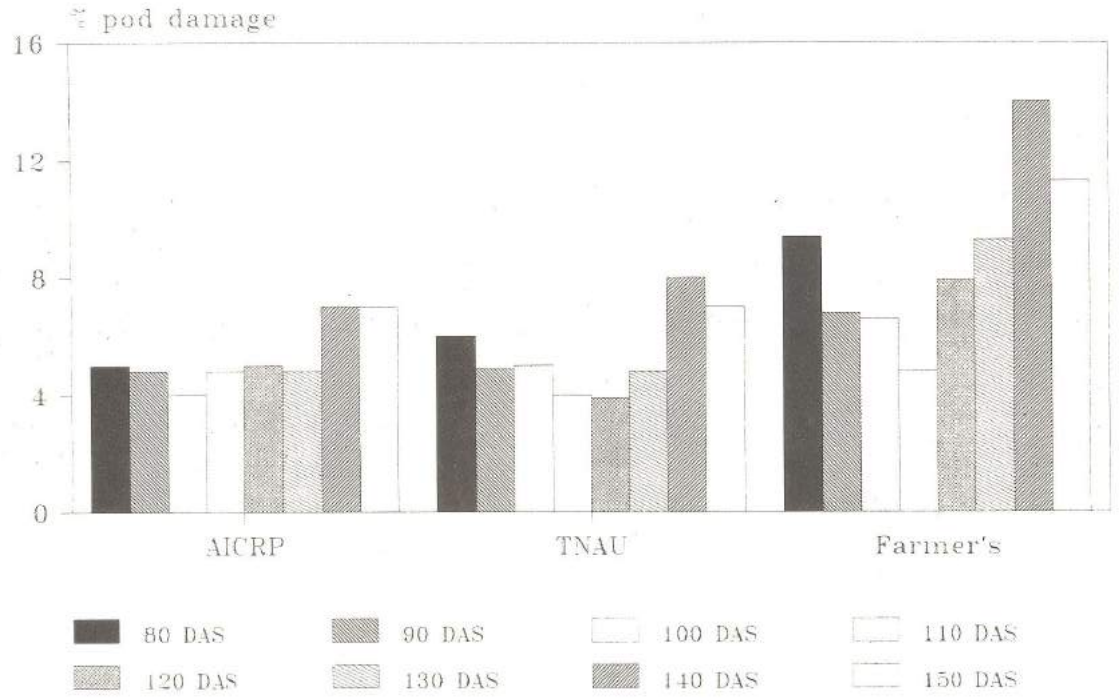

Fig. 8 Effect of method of protection on cotton bollworms

1.3.4. BIOLOGICAL SUPPRESSION OF TOBACCO PESTS

1.3.4.1 Evaluation of *B.t* formulation at reduced doses and their effect on *Helicoverpa armigera* in tobacco crop (CTRI, Rajahmundry)

Three early 3rd instar larvae reared in laboratory were released per plant on five labelled plants per plot as soon as tobacco plants flowered and capsule formation took place, and the different treatments applied. Observations on damage to capsules were recorded in different treatments ten days after spraying. The results are presented in Table 72.

Table 72. Evaluation of *B. t.* formulation at reduced doses and their potentiation against *Helicoverpa armigera* on tobacco

Treatment	Mean no. of capsules damaged/plant
Dipel 0.5 kg/ha (*B. t. k*)/ha + Boric acid 0.025%	3.32
Delfin 0.5 kg/ha (*B. t. k*)/ha + Boric acid 0.025%	3.00
Centauri 0.5 kg/ha (*B. t. aiz*)/ha + Boric acid 0.025%	7.07
Dipel 0.5 kg/ha + HaNPV 125 LE	1.97
Bactospeine 0.5kg (*B. t. k*)/ha + HaNPV 125 LE	2.35
HaNPV 250 LE/ha	6.25
Endosulfan 0.05% control	7.40
SEm	1.19
CD at 5%	1.74
CV%	21.18

Dipel *B.t kurstaki* HD-1 strain at 0.5 kg/ha in combination with HaNPV @ 125 LE/ha was significantly superior to all other treatments followed by Bactospeine + HaNPV at same doses. Dipel and Delfin at 0.5 kg/ha in combination with boric acid 0.025% were significantly superior to Centari (*B.t aizawi*) 0.5 kg/ha + Boric acid 0.025%. Endosulfan 0.05% and HaNPV 250 LE/ha were on par . All the treatments were superior to control.

1.3.4.2 Evaluation of different formulations of *Bacillus thuringiensis* against *Helicoverpa armigera* (GAU, Anand)

To evaluate the different formulation of *B. thuringiensis* against *H. armigera* on tobacco (var. Anand 119)at Bidi Tobacco Research Station Farm, GAU, Anand during the year 1993-1994, the experiment was laid out with nine treatments at 0.05 kg/ha with four replications. The treatments were Bactospeine, Delfin, Dipel, Albeit, BARC strain, Biobit (BPM), BTK-I, BTK-II and control. Respective *B. thuringiensis* formulations were sprayed at the onset of flowering. Control plot was sprayed with water. Observations on bud, leaf and capsule, damage were recorded weekly from five randomly selected tagged plants. The results (Table 73) revealed that all the treatments were significantly superior over control . It was also observed that all the *B. thuringiensis* formulations remained at par.

Table 73. Effectiveness of bacterial preparation (*Bacillus thuringiensis*) against *H. armigera.*

Treatment	Capsule damage (%)	Leaf damage (%)
Bactospeine	18.43	14.12
Delfin	15.05	12.45
Dipel	18.38	12.90
Albeit	16.57	13.15
BARC Strain	17.13	11.97
Biobit	15.38	12.27
BTK-I	17.64	13.69
BTK-II	17.22	14.34

Control	27.06	22.82
S.Em.	1.340	1.338
CD at 5%	3.912	3.906
CV %	29.63	37.72

1.3.4.3 Studies on bioefficacy of *B.t.* strains at reduced doses and their potentiality against *Spodoptera litura* in tobacco nurseries (CTRI, Rajahmundry)

In tobacco nursery an artificial inoculation of twenty actively feeding *S. litura* larvae (early III instar) per bed of $1m^2$ size was made when seedlings were five weeks old. Immediately treatments were imposed with different potentiated formulations of *B.t.* Seven days after treatment observations on percentage of seedlings damaged were recorded and the results are presented in Table 74.

Table 74. Per cent seedling damage by *S. litura* in different *B. t.* treatments

Treatments	Seedling damaged per $1m^2$ nursery (7 days after spray)
Bactospeine (*B.t.k*) 0.5 kg/h + 0.025% Boric acid	22.92
Dipel 0.5 kg/ha (*B.t.k*) HD1) + 0.025% Boric acid .	18.96
Delfin 0.5 kg/ha (*B.t.k*) genotype a,b) + 0.025% Boric acid	19.90
Bactospeine 0.5 kg/ha + Sl NPV 125 LE	19.26
NPV 250 LE + 0.025% Boric acid	21.49
Centari (*B. t. aizawi*) 1 kg/ha	8.43
Control (No application)	37.28
SEm	1.93
CD at 5%	2.87
CV%	8.54

B.t. aizawi (Centari) @ 1.00 kg/ha was superior to all other treatments. Bactospeine 0.5 kg/ha and Sl NPV 125 LE/ha combination was superior to its boric acid combination. All the treatments were superior to control.

1.3.4.4 Integrated Management of *Spodoptera litura* in tobacco nurseries (CTRI, Rajahmundry)

Biocontrol agents, *Telenomus remus, Apanteles africanus* and *Chrysoperla carnea*, Biopesticides, SlNPV and *B.t.k*, NSKS and trap crop castor were integrated into a package in a sequence to effectively time the releases and to give the farmer a wider choice. In 0.5 ha nursery at Morampudi the IPM package was tested for the II year (1994-95) for confirmation.

The nurseries were sown on 28-8-94 . The parasitoid releases and the different components of IPM were implemented in the nursery plot in a systematic manner as per schedule given in Table 75. Three fortnightly releases of *T. remus*, an egg parasitoid, three fortnightly releases of *A. africanus* a braconid solitary parasite, a predator *Chrysoperla* along with 3 sprays of Sl NPV / *B. t.* was integrated . Two sprays of 2% NSKS an insect repellent was also integrated with the above bioagents along with castor raised around tobacco nursery.

The main advantage of IPM was trapping of more population of *S. litura* by castor than tobacco (Fig.9). The repellence of NSKS also diverted more population to castor. *S. litura* incidence reached a peak on castor during November in 1994-95 due to a cyclone in the 1st week of November. Parasitization by *Apanteles*, both natural and augmented, was more on castor. Besides released parasites/predators, other indigenous predators

conspicuously seen in IPM tobacco nurseries were praying mantids, reduvid bugs and predatory wasps. The absence of these natural enemies was conspicuous in chemical control plots. (Tables 76 to 80).

Table 75. Date wise schedules of natural enemy releases and other components in integrated pest management

Date of sowing of castor :14-8-94
Date of sowing of tobacco : 28-8-94

Month	Date	Biocomponent
September	28-09-94	*T. remus*
	30-09-94	NSKS
October	05-10-94	*Apanteles*
	07-10-94	*Chrysoperla*
	12-10-94	SlNPV
	14-10-94	*T. remus*
	15-10-94	NSKS
	20-10-94	*Apanteles*
	22-10-94	*Chrysoperla*
	26-10-94	*B. t. k.*
	31-10-94	*T. remus*
November	03-11-94	Sl.NPV
	05-11-94	*Apanteles*
	07-11-94	*Chrysoperla*
	11-11-94	*B. t. k.*

Natural enemy wise

	I	II	III
T. remus	28-09-94	14-10-94	31-10-94
Apanteles	05-10-94	20-10-94	05-11-94
Chrysoperla	07-10-94	23-10-94	07-11-94
NSKS	30-09-94	15-10-94	-
SlNPV	12-10-94	22-10-94	03-11-94
B.t.k.	26-10-94	-	11-11-94

Table 76. Fortnightly observations of parasitization by *Apanteles africanus* in castor and tobacco

Date of release	Date of observation	Parasitization (%)	
		Castor	Tobacco
05-10-94	20-10-94	55	26
20-10-94	05-11-94	30	5
05-11-94	20-11-94	65	20

Table 77. Observations recorded ten days after release of *Chrysoperla camea*

Date of release	Date of observation	No. of immature stages collected	
		Castor	Tobacco
07-10-94	17-10-9	40 larvae	Nil
23-10-94	03-11-94	Nil	Nil
07-11-94	17-11-94	Nil	Nil

Table 78. Observations recorded fifteen days after release of *T. remus*

Date of release	Date of observation	Number of egg masses
28-09-94	13-10-94	2
14-10-94	01-11-94	1
31-10-94	15-11-94	1

Table 79. Indigenous natural enemies recorded in IPM plot (castor and tobacco)

Sl.No.	Name of species
1.	*Apanteles africanus* Cameron
2.	*Apanteles ruficrus* Hal.
3.	*Charops obtusus* Mor.
4.	*Peribaeaorbata* Weid.
5.	*Chelonus formosanus* Sonan
6.	*Chrysopa* sp.
7.	*Harpactorcostalis* Stal
8.	*Micromus timidus* Hagen
9.	*Polistes* sp.

Table 80. Mean number of seedlings damaged by *Spodoptera litura* larvae and number of transplantable seedlings in tobacco nursery in Morampudi

	No. of the site	IPM plot	Chemical control plot
	1	52	147
	2	83	125
	3	50	174
	4	52	198
	5	42	185
	6	68	200
	7	65	190
	8	60	150
	9	45	155
	10	72	185
Total		589	1709
Average		59.00	171.00

The expenditure incurred and returns from the sale proceeds of seedlings for IPM demonstration plot as well as chemical control is given in Table 81. For chemical control the cost benefit ratio was 1 : 1.0. The cost benefit ratio for IPM was higher than chemical control (Fig.10).

Table 81. Cost benefit ratio of IPM Programme (Area 0.5ha)

Item	IPM (Rs.)	Chemical control (Rs.)
Pest Control	5,275	10,000
Labour charges	1,00,000	1,00,000
Fertilizers	6,000	6,000
Miscellaneous including fungicides	10,000	10,000
Expenditures	1,21,275	1,26,000
Transplantable seedlings (nos.)	40,500	30,25,200
Amount realized @ Rs.170 per 4000 seedlings bag	1,71,721	1,27,500
Actual C : B ratio	1 : 1.41	1 : 1.0

1.3.4.5 Evaluation of biocontrol agents against pink aphid *Myzus nicotianae* in tobacco (CTRI, Rajahmundry).

At the initiation of aphid incidence in tobacco pre- treatment counts were taken on five labelled plants per plot on top, middle and bottom leaves for each plant. Then the treatments were initiated. Seven days after treatment aphid counts were taken. The results are presented in Table 82.

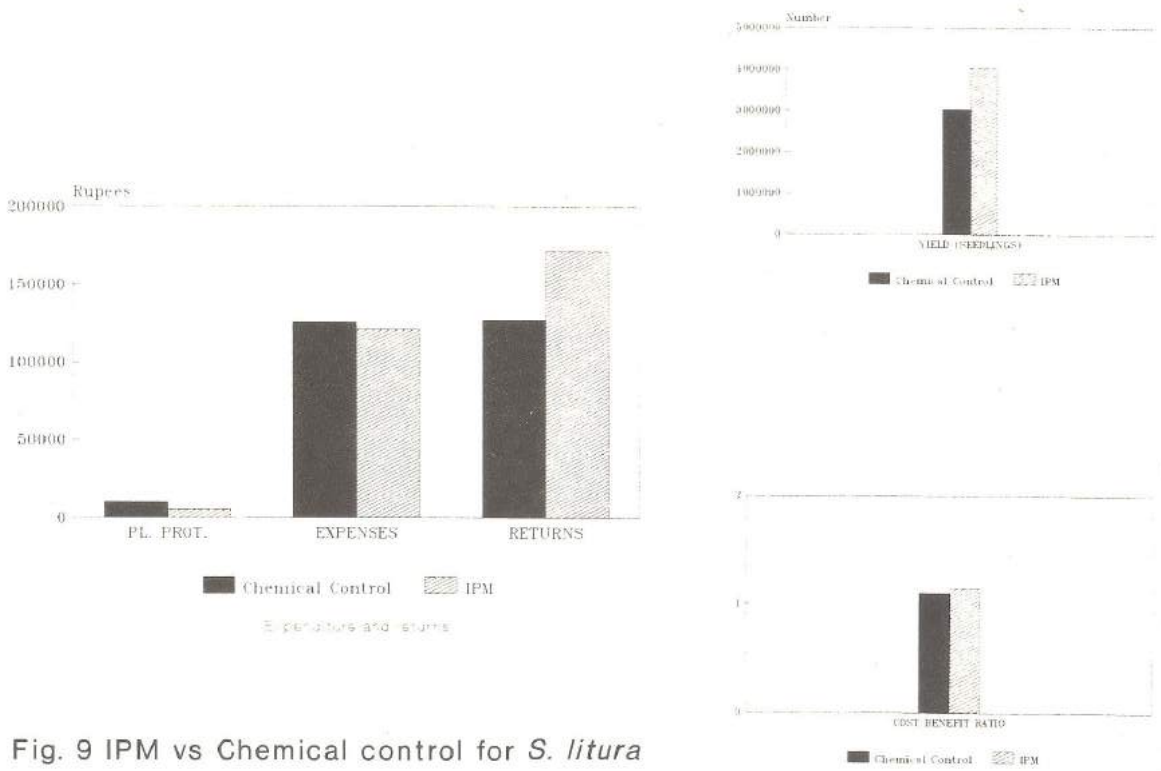

Fig. 9 IPM vs Chemical control for *S. litura* in tobacco nurseries

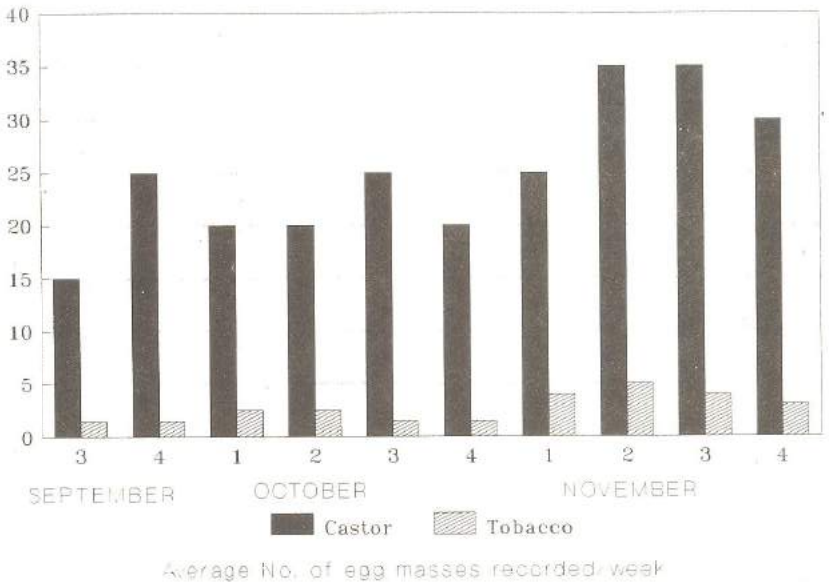

Fig. 10 Ovipositional trapping of *S. litura* by castor and tobacco

Table 82. Evaluation of biocontrol agents against pink aphid, *Myzus nicotianae* in tobacco

Treatment	Pre-spray count (no.)	7 days after spray (no.)
Methyl demeton (0.05%)	1009	1130
Bioline -I 1kg/ha (*Verticillium lecanii*)	546	1313
Bioline -I 2kg/ha	1253	2296
Bioline-II 1kg/ha (*Verticillium lecanii*)	680	1543
Bioline -II 2kg/ha	1439	2741
Control	1537	2686
SEm		10.54
CD at 5%		NS
CV%		24.20

The differences amongst treatments were not significant 7 days after spray. However, in methyl demeton increase in aphid population was marginal. Therefore, Bioline I & II (*Verticillium lecanii*) both at 1 kg and 2kg/ha were not effective. In laboratory experiment also, there was no mortality of aphids.

1.3.5 BIOLOGICAL SUPPRESSION OF PULSE CROP PESTS

1.3.5.1. Effectiveness of *Trichogramma chilonis* and NPV against *Helicoverpa armigera* in pigeonpea inter-cropped with sorghum (APAU, Hyderabad).

A trail was laid out during Kharif 1994 in Randomized block design with seven treatments replicated three times at Hyderabad (APAU). Pigeon pea was intercropped with sorghum in the ratio 1 : 2. The treatments included were

1.Release of *Trichogramma chilonis* @ 50,000/ha
2. Release of *T. chilonis* @ 1,00,000/ha
3.HaNPV @ 125 LE/ha and *T. chilonis* @ 50,000/ha
4. HaNPV @ 125 LE/ha
5. HaNPV @ 250 LE/ha
6. Endosulfan 0.07%
7. Control

Ranipal (0.01%) and jaggery (0.05%) were added to NPV before spraying. The treatments were imposed during evening hours at 10 days interval, three times, starting from flower initiation. The parasitized egg card bits were stapled on the lower surface of the leaves a day before their emergence to effect release of egg parasitoids. Observations were recorded from 5 plants at random on (i) the number of larvae of *H. armigera*, (ii) extent of egg parasitisation by *T. chilonis*, (iii) extent of larval mortality due to HaNPV, (iv) number of pods damaged by *H. armigera* at harvest and (v) yield. The results are presented in Table 83.

The incidence of *H. armigera* eggs and larvae was negligible on sorghum which was raised as an intercrop with pigeonpea. The sorghum crop reached maturity even before pigeonpea flowered. Since there was no synchronization of head formation in sorghum and flowering in pigeonpea, the influence of intercrop on the incidence of *H. armigera* in pigeonpea could not be assessed.

In pigeonpea, there was no significant reduction of larval population in any of the treatments 10 days after first round of application. However, there was a significant reduction of population 10 days after the second round of application of HaNPV @ 125 LE/ha, HaNPV @ 250 LE/ha, release of *Trichogramma* @ 1,00,000/ha and also HaNPV 125LE/ha + 50,000 *T. chilonis* /ha which were on par with each other. However, 10 days after third round of spraying, the treatments HaNPV @ 125 LE/ha, HaNPV @250 LE/ha were found to be superior with pod damage in untreated control being 45.25%.

Comparatively better yields were recorded in the treatment endosulfan(0.07%) (1590 kg/ha) followed by HaNPV @ 250 LE/ha (1560 kg/ha).

No establishment of egg parasitoid, *T. chilonis* was recorded in the plots where the egg parasitoids @ 50,000/ha and 1,00,000 /ha were released in pigeonpea inter-cropped with sorghum.

Considering the overall effectiveness of the treatments tested, three rounds of spray application of HaNPV @ 250 LE/ha at 10 days interval during evening hours from flower initiation was found to be better in suppression of *H. armigera* on pigeonpea.

1.3.5.2 Effect of *Trichogramma chilonis*, HaNPV and their combination on *Helicoverpa armigera* on pigeon pea inter-cropped with sorghum (TNAU, Coimbatore)

The per plant larval load of *H. armigera*, as recorded 110 days after sowing (DAS) ranged from 0.2 - 2.3 in different treatments (Table 84). The treatments showed no significant differences. Generally the trend of per cent pod borer damage was on the rise. (Fig.11). The differences among the treatments on 110 and 125 DAS was not significant. At 140, 160 and 175 DAS all the treatments were found to be significantly superior to untreated check. Among the treatments release of *T. chilonis* either at 1,00,000 or 50,000, HaNPV @ 250 LE and HaNPV @ 125 LE + *T. chilonis*

Table 83. Effect of *Trichogramma chilonis* and NPV against *H. armigera* in pigeonpea

Treatment	Pre-treatment (Average No.)		Mean larval population 10 days after spray			Mean larval mortality (%)	Mean pod damage	Yield kg/ha
	Eggs	larvae	I	II	III			
Trichogramma @ 50,000/ha	2.33	31.67	9.33	2.67 (1.46)	1.67 (1.46)	0.00	32.40 (34.34)	1320
Trichogramma release @ 1,00,000/ha	1.67	25.67	7.33	1.00 (1.22)	1.33 (1.29)	10.00	26.50 (30.47)	1320
HaNPV @ 125 LE/ha + 50,000 *Trichogramma*	1.00	15.33	3.33	0.00 (0.71)	0.00 (0.71)	64.14	28.50 (32.22)	1380
HaNPV @125 LE/ha	0.67	19.33	3.33	0.00 (0.71)	0.33 (0.88)	62.50	24.93 (29.83)	1440
HaNPV @250 LE/ha	1.00	22.67	2.00	1.33 (1.34)	0.00 (0.71)	69.05	17.62 (24.75)	1560
Endosulfan (0.07%)	0.33	32.33	2.33	0.67 (0.88)	0.00 (1.17)	0.00	15.21 (22.92)	1590
Control	1.33	29.00	11.33	3.67 (2.01)	3.67 (2.03)	0.00	45.21 (42.23)	1020
CD at 5%	NS	NS	NS	0.708	0.550		7.251	NS

Figures in parentheses are transformed values.

@ 50,000 were consistently superior to HaNPV @ 125 LE and endosulfan (0.07%) which were on par at 175 DAS. The order of superiority of yield in different treatments was *T. chilonis* @ 50,000 = HaNPV @ 125 LE and *T. chilonis* @ 50,000> HaNPV @ 125LE> *T. chilonis* @ 1,00,000> HaNPV @ 250 LE> endosulfan >check.

1.3.5.3 Effectiveness of *Trichogramma chilonis* and HaNPV against *Helicoverpa armigera* on pigeon pea (PAU, Ludhiana)

The experiment was conducted in the farmer's field at village Jalaldiwal (Ludhiana, Punjab). The HaNPV spray and *T. chilonis* releases were initiated during second fortnight of September and in all the treatments three sprays and /or releases were made each at 10 days interval. The pod damage from 10 randomly selected plants 10 days after the release or spray was counted.

The infestation by the pod borer complex was very low in the experimental plots (Table 85) which varied from 2.44 to 4.59 per cent in different treatments. Therefore, no valid conclusion could be drawn.

Table 84. Data on pod borer damage and yield of redgram (var.Co.6)

Treatments	Larvae/ plant 110 DAS	Pod borer damage (%) 125 DAS	140 DAS	160 DAS	175 DAS	Yield kg/ha
T. chilonis @ 1,00,000/ha	0.2 (0.0)	3.7 (0.4)	18.6^{a} (10.2)	33.9^{ab} (31.1)	26.7^{a} (20.2)	567^{c}
T. chilonis 5 times @ 50,000/ha	1.5 (2.2)	1.5 (0.2)	23.0^{ab} (15.3)	31.5^{ab} (27.3)	24.7^{a} (17.5)	67^{a}
HaNPV thrice @ 250 LE/ha	2.3 (2.9)	2.6 (1.1)	25.7^{ab} (23.3)	30.6^{ab} 18.8)	22.8^{a} (28.7)	533^{d}
HaNPV thrice @ 125 LE/ha	1.7 (2.9)	6.1 (1.1)	28.2^{bc} (22.3)	25.7^{a} (18.8)	32.4^{ab} (28.7)	733^{b}
HaNPV @ 125 + *T. chilonis* 50,000/ha thrice	1.1 (1.2)	1.6 (0.1)	25.8^{ab} (18.9)	35.1^{b} 3 (33.1)	0.3^{a} 7 (25.5)	67^{a}
Endosulfan (0.07%) thrice	0.8 (0.6)	5.3 (0.9)	22.2^{ab} (14.3)	30.8^{ab} (22.2)	35.1^{ab} (33.1)	500de
Control	2.0 (4.0)	6.2 (1.2)	35.2^{c} (33.2)	44.2^{c} (48.6)	49.4^{b} (57.6)	467^{e}
CD at 5%	NS	NS	8.3	8.2	18.9	33

Table 85. Effectiveness of *Trichogramma chilonis* and HaNPV against *Helicoverpa armigera* on pigeon pea

Treatment	Dosage/ha	Mean pod infested (%)
T. chilonis	1,00,000	2.44
T. chilonis	50,000	3.06
HaNPV	250 LE	3.07
HaNPV	125 LE	3.25
HaNPV + *T. chilonis*	125 LE + 50,000	3.28
Endosulfan	1 litre	3.30
Control	-	4.59
CD at 5%		NS

1.3.5.4 Evaluation of *Bacillus thuringiensis* formulations against *Helicoverpa armigera* on pigeonpea (APAU, Hyderabad)

A trial was laidout in farmer's field at Sankarapally (Andhra Pradesh) during Kharif 1994 in a randomized block design with nine treat-

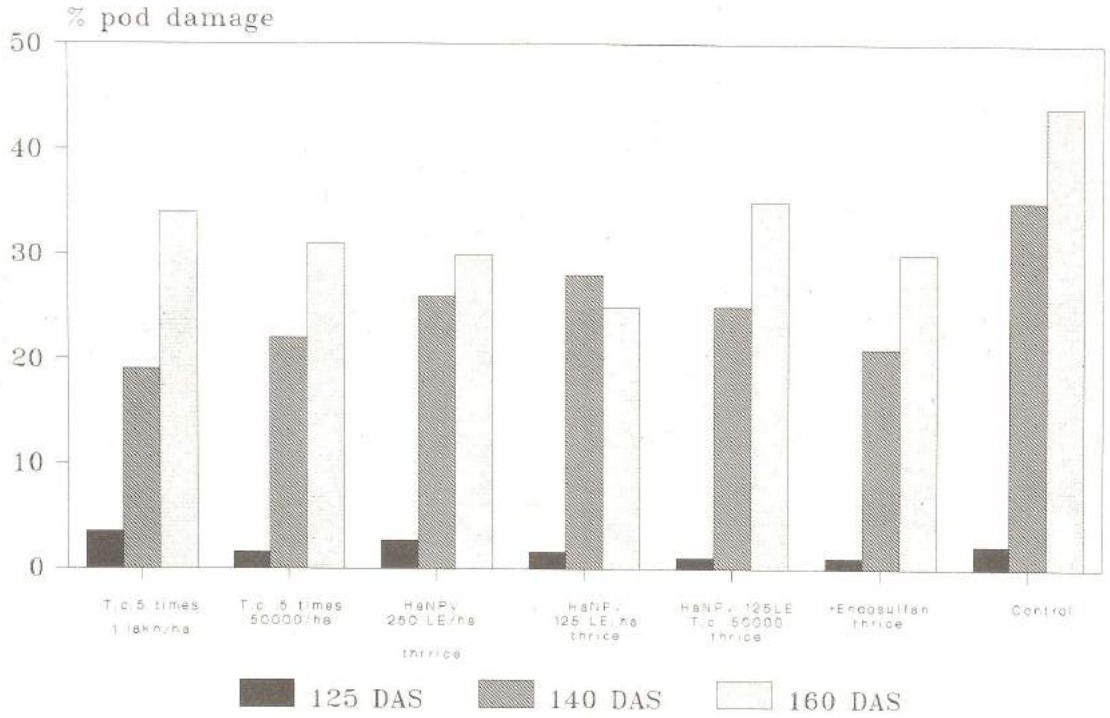

Fig. 11 Effect of *Trichogramma chilonis* and HaNPV on pod borer damage in redgram

ments replicated three times. The various formulations used were Dipel, Delfin, Biobit, BTK-I, BTK-II, BTT and Agree. Endosulfan (0.07%) treated plot and a control plot were also left for comparison. All the *B.t* formulations were applied at 1.0 kg/ha. The treatments were imposed after the early larval stages of population were recorded from five plants per treatment at random and also after each round of spray application. At harvest, total number of pods and the pods damaged by *H. armigera* and the yield were recorded.

The data presented in Table 86 indicate that all the treatments including endosulfan (0.07%) could not significantly reduce *H. armigera* population 10 days after the first application. However, all the *B.t* formulations applied at 1.0 kg/ha in the subsequent two applications at 10 days interval reduced the larval population significantly. BTK-II was found better followed by endosulfan (0.07%) in reduction of pest population in the two subsequent sprays combined. The mean per cent pod damage recorded at harvest were found to be high in all the treatments. However, significant differences were observed among the treatments. Lowest pod damage (24.80%) was registered with endosulfan (0.07%) followed by BTK-I (37.80%).

With regard to yield, there were no significant differences among the treatments. Comparatively better yields were recorded from endosulfan 0.07% (1717 kg/ha) followed by BTK-II (1680 kg/ha). Considering the overall performance of *B.t* formulations, BTK-II was found to be better in reduction of larval population and recording more yield.

1.3.5.5 Evaluation of *Bacillus thuringiensis* formulations against *Helicoverpa armigera* on pigeonpea (PAU, Ludhiana)

The experiment was conducted in a farmer's field at Jalaldiwal (Ludhiana, Punjab) on long duration variety T 21. The first spray of *B. thuringiensis* was given in mid September and subsequently two more sprays were given at 10 days interval. Nine formulations of *B.t* were tested in a randomized block design with three replications in a plot size of 50 m^2 each . The damage by pod borer complex was recorded from 15 plants selected at random in each treatment (Table 87). The pest damage in treated plots varied from 1.31 to 3.18 per cent as compared to 5.18 per cent in control and there were no significant differences between them.

1.3.5.6 Effect of *B. t.* formulations on the pod borer (TNAU, Coimbatore)

The larvae per plant on 125 DAS ranged between 0.0 and 0.9 with *B.t.*I and Agree showing significant superiority over the rest. However, Agree with endosulfan (0.07%) was on par with control. At 140 DAS endosulfan was superior to the rest followed by Agree, Agree + endosulfan, Biobit, *B.t.k.*1, Delfin, *B.t.k.*2 + endosulfan and *B.t.*I. More or less similar trend was observed on 160 DAS. At 175 DAS, however, Agree + endosulfan was outstanding followed by Agree, *B.t.k.*2 + endosulfan, Delfin and *B.t.*I. All the treatments barring Biobit + endosulfan were superior to control. In general all the treatments were superior except control and endosulfan. The yield was high (867 kg) in *B.t.k* 2 + endosulfan followed by both Biobit + endosulfan and Agree which were on par. The treatments *B.t.*I, *B.t.k.*1 and control were on par (Table 88 ; Fig.12.)

1.3.5.7 Effect of HaNPV and *B. t.* formulations against *Helicoverpa armigera* in chickpea (APAU, Hyderabad)

A field trial was conducted at APAU, Hyderabad with chickpea (variety : Annegiri) comprising of 10 treatments viz., HaNPV @ 250 LE/ha, HaNPV @ 125 LE/ha, endosulfan 0.07%, 0.035%, HaNPV @ 250 LE/ha+ endosulfan 0.035%, BTK-I @ 1 kg/ha, BTK-II @ 1kg/ha, BTT @ 1kg/ha, Dipel @ 1kg/ha and control, replicating each treatment thrice in a plot size of 50 m^2 . All the treatments were given in the evening hours starting from noticing the incidence of *H.armigera* in the field. Jaggery 0.05% and Ranipal 0.1% were added to HaNPV spray application. Spray application of these treatments were given for three

Table 86. Effect of *B. t* formulations (@ 1.0 kg/ha) against *H. amigera* on pigeonpea

Treatment	Pre treatment larval popula-tion /5 plants	Mean larval population in 5 plants 10 days after spray			Mean pods damaged (%)	Yield (kg/ha)
		I	II	III		
Dipel	15.33	19.33	1.33 (1.34)	0.67 (1.05)	41.15 (39.88)	1200
Delfin	19.67	9.00	0.67 (1.05)	1.33 (1.34)	41.96 (40.35)	1560
Biobit	19.00	15.33	1.67 (1.46)	1.00 (1.22)	41.81 (40.22)	1200
BTK-I	13.33	9.0	1.00 (1.22)	1.67 (1.46)	37.80 (37.91)	1170
BTK-II	21.67	9.67	0.00 (0.71)	1.00 (1.22)	43.70 (41.37)	1680
BTT	21.67	13.67	1.00 (1.22)	1.00 (1.46)	47.46 (40.71)	1560
Agree	18.33	9.67	1.00 (1.22)	1.67 (1.46)	42.60 (40.71)	1140
Endosulfan (0.07%)	26.67	8.67	0.67 (1.05)	0.67 (1.05)	24.80 (29.80)	1717
Control	25.67	12.67	4.33 (2.18)	4.33 (2.19)	45.02 (42.14)	933
CD at 5%	NS	NS	0.399	0.311	4.827	NS

Figures in parentheses are the transformed values.

rounds starting from noticing the incidence in the experimental plots. The observations were recorded on the population of larvae from 10 plants/ treatment selected at random before and 10 days after each spray application and the yield at the end.

The results presented in the Table 89 indicate that application of HaNPV @ 250 LE/ha, HaNPV @ 125LE/ha, endosulfan 0.035% and BTK-II at 1.0 kg/ha followed by endosulfan 0.07% and Dipel at 1.0 kg/ha were found to be superior in reducing the larval population after second round of spray. While after third round of spray application, HaNPV @ 250 LE/ha and HaNPV @ 125 LE/ha followed by endosulfan 0.035% were found to be best.

Table 87. Evaluation of *B. t* formulations (@ 1.0 kg/ha) for the control of *H. amigera* on pigeonpea

Treatment	Mean pod damage (%)
Dipel	2.32
Delfin	4.06
BTK-II	2.21
BTT	2.32
BT(BPM)	3.04
Biotex	1.31
Biolep	3.04
Agree	2.34
Endosulfan (0.07%)	2.13
Control	5.18
CD at 5%	NS

Table 88. Effect of *B.t.* formulations on pod borer of pigeonpea (var.Co.6)

Treatment	Larvae/ plant 125 DAS	Pod borer damage (%) 140 DAS	160 DAS	175 DAS	Yield kg/ha
Delfin 1 kg/ha	0.39^{bcd} (0.2)	21.6^{ab} (13.6)	38.7^{a} (39.1)	22.7^{ab} (14.9)	543.0^{cd}
*B.t.*I 1 kg/ha	0.19^{A} (0.0)	23.2^{ab} (15.5)	55.4^{ab} (67.8)	24.1^{ab} (16.7)	400.0^{d}
B.t.k 1 1kg/ha	10.16abc (0.0)	21.2^{ab} (13.1)	63.3^{bc} (79.8)	25.3^{b} (18.3)	417.0^{d}
Dipel 1kg/ha	0.01^{ab} (0.0)	21.2^{ab} (13.1)	49.4^{ab} (57.6)	26.1^{bc} (19.4)	527.0^{cd}
B.t.k 2 1 kg/ha	0.67^{c} (0.04)	25.8^{c} (18.9)	42.8^{a} (46.20)	27.4^{c} (21.2)	627.0^{bc}
B.t.k 2 1 kg/ha + Endosulfan (0.07%)	0.57^{d} (0.3)	22.3^{ab} (14.4)	39.8^{a} (41.90)	23.7^{abc} (14.2)	867.0^{a}
Biobit 1 kg/ha	0.55^{d} (0.3)	21.3^{ab} (13.2)	40.0^{a} (41.3)	32.6^{a} (29.0)	570.0^{cd}
Biobit 1 kg/ha + Endosulfan (0.07%)	0.26^{bcd} (0.01)	24.1^{ab} (16.7)	54.5^{a} (66.3)	32.1^{d} (28.2)	770.0^{ab}
Agree 1 kg/ha + Endosulfan (0.07%)	0.32^{e} (0.7)	21.2^{ab} (13.1)	60.0^{bc} (75.3)	20.2^{a} (11.9)	677.0^{bc}
Agree 1 kg/ha	0.61^{a} (0.4)	21.1^{ab} (13.0)	46.3^{a} (52.3)	22.0^{a} (14.0)	686.0^{ab}
Endosulfan (0.07%)	0.49^{cd} (0.2)	20.1^{a} (11.8)	48.5^{ab} (56.1)	27.4^{c} (21.2)	677.0^{bc}
Control	0.96^{e} (0.9)	28.2^{c} (22.3)	74.5^{c} (92.9)	32.8^{d} (29.3)	433.0^{d}
CD at 5%	0.38	3.4	16.8	4.6	

Table 89. Effect of microbial agents against *H. armigera* in chickpea

Treatment	Pretreatment larval population	Mean larval population / 10 plants			Mean pod damage	Yield kg/ha
		I	II	III(%)		
HaNPV 250 LE/ha	19.33	5.33	0.00 (0.71)	0.00 (0.71)	6.10 (14.29)	1307
HaNPV 125 LE/ha	14.00	10.00	0.00 (0.71)	0.00 (0.71)	6.21 (14.40)	1027
Endosulfan (0.07%)	16.67	8.00	0.33 (0.88)	1.33 (1.34)	7.83 (16.20)	1680
Endosulfan (0.035%)	17.00	11.67	0.00 (0.71)	1.00 (1.22)	8.16 (16.57)	840
HaNPV 125/LE + Endosulfan (0.035%)	15.67	7.33	1.33 (1.29)	1.67 (1.44)	7.05 (15.30)	1493
BTK-I 1kg/ha	17.33	10.33	1.33 (1.29)	1.33 (1.34)	8.58 (16.96)	1213
BTK-II 1kg/ha	12.67	9.67	0.00 (0.71)	1.67 (1.46)	16.05 (23.35)	1400
BTT 1kg/ha	16.00	8.00	7.67 (2.68)	1.67 (1.82)	14.85 (22.41)	747
Dipel 1kg/ha	16.00	8.33	0.67 (1.00)	5.33 (2.40)	18.86 (25.64)	840
Control	12.00	6.33	6.67 (2.60)	7.33 (2.78)	29.85 (33.15)	607
CD at 5%	NS	NS	0.944	0.469	4.324	569

Figures in parentheses are transformed values

Regarding the per cent pod damage, all the treatments were significantly superior over control. Among these treatments sprayapplication of HaNPV 250 LE/ha and HaNPV 125 LE/ha followed byHaNPV 125+ endosulfan 0.035% were found to better in reduction of pod damage. Of the *B.t* formulations, BTK-I at 1.0 kg/ha was found to be better and was on par with HaNPV 250 LE/ha.

In respect of yield, significant differences were recorded between the treatments. Highest yields were recorded between the treatments endosulfan 0.07% (1680 kg/ha) followed by HaNPV 125 LE + endosulfan 0.035% (1493 kg/ha) and BTK-II at 1.0 kg/ha (1400 Kg/ha). Lowest yields were recorded with the treatments BTT-I, Dipel and endosulfan 0.035%.

13.5.8 Effect of Ha NPV snd *B. t.* formulations on *Helicoverpa armigera* in chick pea (TNAU, Coimbatore)

The results of the trial conducted during Rabi 1994 are presented in Table 90 & Fig. 13. The larval load of (*H. armigera*) was not significantly different among the treatments on 30 DAS. It ranged from 4.4 to 7.8 per plant. On 40 DAS the order of superiority was endosulfan (0.0035), HaNPV 125 LE, endosulfan (0.07), endosulfan (0.0035) + HaNPV 125 LE followed by *B.t.* and HaNPV 250 LE. *B.t.*+ HaNPV was however, on par with control. On 50 DAS all the treatments were superior to the check. The treatments HaNPV 125 LE, endosulfan (0.035%) and *B.t.* were outstanding in recording only 3.3, 4.0 and

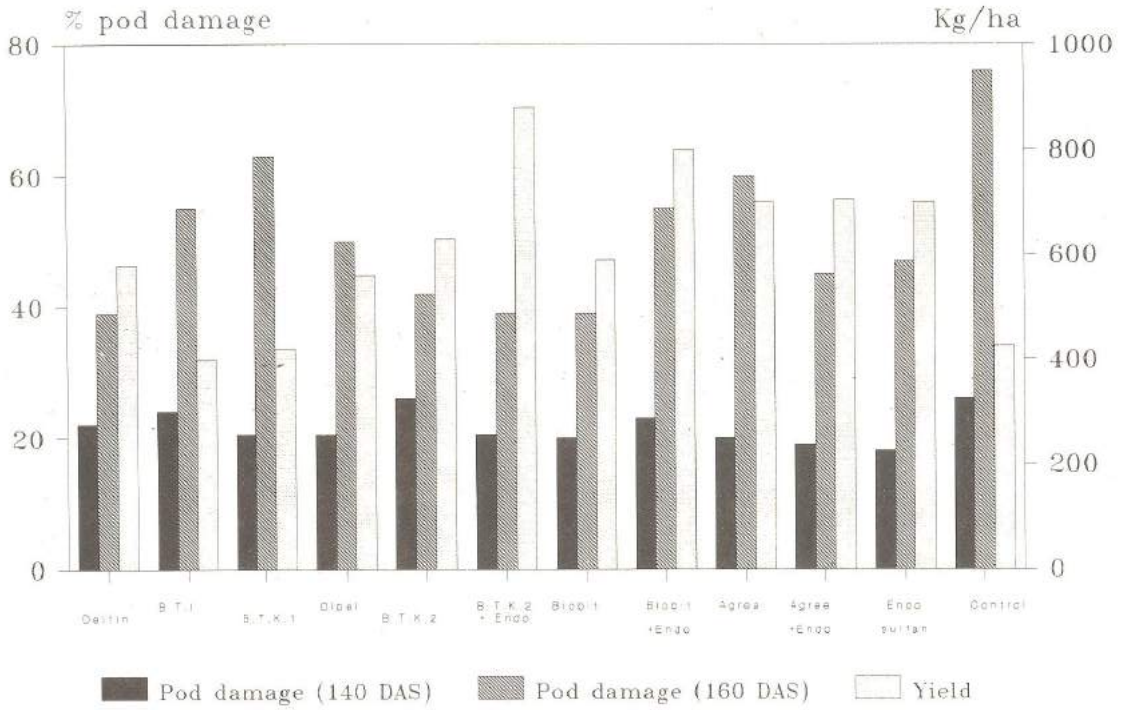

Fig. 12 Effect of *B.t.* formulations on the pod borer of red gram

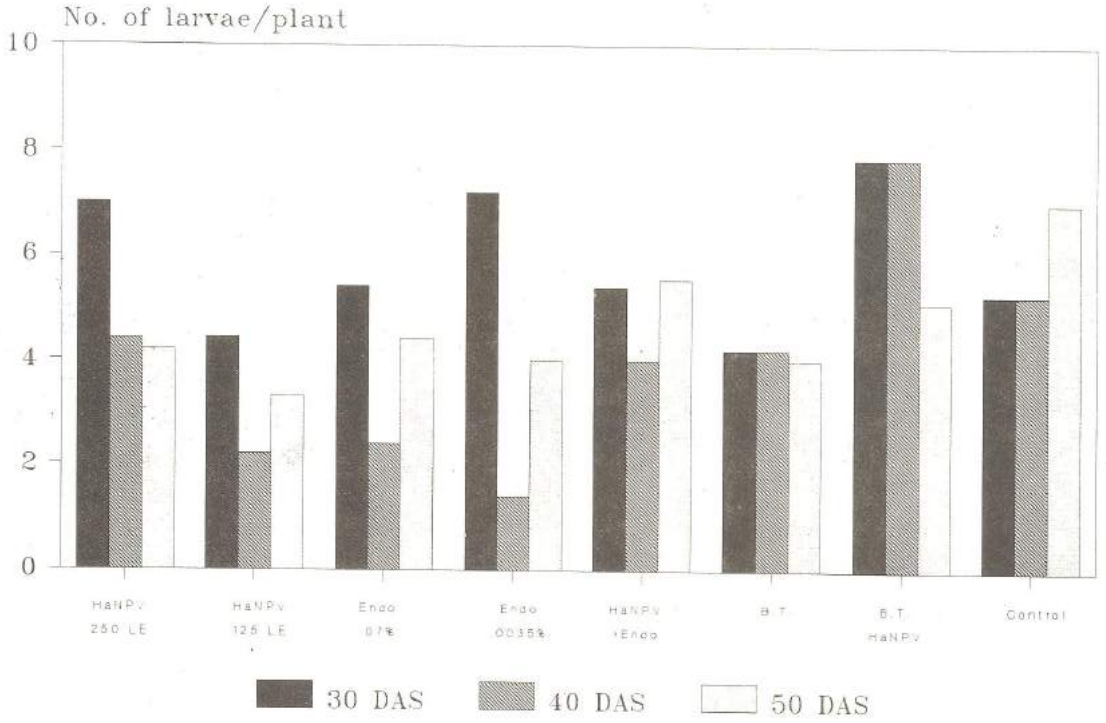

Fig. 13 Effect of HaNPV on *H. armigera* in chickpea

Table 90. Effect of Ha NPV and endosulfan spray on *H.armigera* (Chickpea - Rabi 94)

*Treatment	Number of larvae/plant			Pod damage 80 DAS (%)	Yield
	30 DAS	40 DAS	50 DAS		
Ha NPV 250 LE/ha	7.1	4.7^{ab}	4.3ab	2.87^{a}	1350^{bc}
Ha NPV 125 LE/ha	4.8	2.3^{a}	3.3^{a}	3.57^{ab}	67^{e}
Endosulfan (0.07%)	5.5	2.7^{a}	4.7^{ab}	3.50^{a}	1250^{cd}
Endosulfan (0.035%)	7.3	1.3^{a}	4.0^{a}	5.53^{c}	1250^{cd}
Endosulfan (0.035%)	5.5	4.0^{a}	5.7^{b}	3.70^{a}	1700^{a}
Ha NPV 125 LE/ha					
B. t. 1 kg/ha	4.4	4.4^{ab}	4.0^{a}	4.83^{bc}	383^{b}
B. t. + HaNPV 125 LE	7.8	7.8^{b}	5.3^{b}	5.57^{c}	1200^{d}
Control	5.7	5.7^{b}	7.3^{c}	8.27^{d}	1167^{d}
CD at 5%	NS	3.5	1.5	1.29	127

* DAS = Days after sowing

4.0 larvae per plant, respectively, compared to 7.3 in the control. The per cent pod damage (80 DAS) ranged between 2.9 and 8.3. The seed yield was high in the treatment endosulfan (0.035%) + HaNPV 125 LE (1700 kg/ha) followed by HaNPV 250 LE (1650 kg/ha) which were on par with *B.t.* (1583 kg/ha), *B.t.*+ HaNPV 125 LE (1300 kg/ha) and endosulfan (0.0035%) (1250 kg/ha). The yield in the check was 1167 kg.

1.3.5.9 Effectiveness of Ha NPV and *B. t.* formulations against *Helicoverpa armigera* on gram (PAU, Ludhiana)

The experiment was conducted in a farmer's field at Hambran (Ludhiana, Punjab)) in a randomized block design with four replications and 120 m^2 plot size. The first spray was given on January 20 and subsequently 4 sprays were given at 10 days interval. HaNPV (125 LE & 250 LE) was compared with endosulfan (Thiodan 35 EC , 1250 ml and 2500 ml/ha) and control . The population of the larvae was recorded from 15 plants selected at random 5 days after each spray.

All the treatments proved significantly better than control in all the sprays except after first spray when all the treatments were on par with control (Table 91). The two dosages of HaNPV were at par with two dosages of endosulfan but significantly better than control. The population of *H. armigera* was very low especially during February and March and consequently the pod damage was extremely low. The pod damage

Table 91. Effectiveness of HaNPV and endosulfan against *Helicoverpa armigera* on gram

Teatments *	**Mean number of larvae/15 plants (5 days after spray)						Per cent pods damaged (%)	Number of pods /10 plants
	I	II	III	IV	V	Mean		
HaNPV 125 LE	1.0	2.5	2.0	1.0	0.2	1.3	0.12	740.5
HaNPV 250 LE	2.2	1.4	1.0	1.5	0.0	1.2	0.10	727.2
Endosulfan (2.5 l/ha)	1.7	1.4	0.5	0.5	0.2	0.9	0.21	807.7
Endosulfan (1.25 l/ha)	1.2	2.0	0.5	0.5	0.2	0.9	0.14	858.7
Endosulfan (0.5 l/ha)+ HaNPV 125 LE	1.2	1.2	1.5	0.5	0.0	0.9	0.13	800.2
Control	3.0	4.5	4.2	2.7	1.2	3.1	0.55	661.7
CD at 5%	NS	2.9	0.6	1.4	0.8	0.7	NS	NS

* Five sprays at 10 days interval
** Mean of 4 replications
I to V indicate the number of sprays

varied from 0.10% in HaNPV 250 LE to 0.55 % in control and there was no significant difference between them (Table 91). The number of pods per plant were higher in the treated plots as compared to control but the differences were not significant.

1.3.6. BIOSUPPRESSION OF RICE PESTS

1.3.6.1 Evaluating the efficacy of parasitoid, *Trichogramma japonicum* against paddy stem borer (MPAU, Pune).

The experiment was conducted during Kharif, 1994 in cultivator's field in a RBD with 10 replications having a plot size 0.2 ha / treatment on late maturing variety Ambemohor-157.

The incidence of paddy stem borer was meager. No dead heart due to pest were noticed. The data given in Table 92 were on the white earheads caused by the stem borer.

Table 92. Evaluating the efficacy of *Trichogramma japonicum* against paddy stem borer.

Treatments	Mean infestation (%)	Control (%)
Biocontrol (Release of *T. japonicum*)	8.26	36.94
Chemical control (0.07% endosulfan)	6.31	51.83
Control	13.10	
SEm	1.13	
CD at 5%	3.36	

Both bio-control and chemical control treatments were statistically at par and significantly superior to untreated control. A reduction of pest infestation to the extent of 51.83% in chemical control and 36.94% in bio-control was observed.

1.3.6.2 Field evaluation of *Trichogramma japonicum* against yellow stem borer of paddy (PAU, Ludhiana)

Field experiment to evaluate the effectiveness of *Trichogramma japonicum* against stem borer of paddy, *Scirpophaga incertulas* was laid out near village Lassara (Jallandhur, Punjab). In one field, *T. japonicum* was released @ 50,000/ha 6 times from 3rd August to 22nd September, 1994. In another plot of the same stand, monocrotophos @ 1625 ml/ha was sprayed twice i.e. in the first and 3rd week of September. The third field was left without spray and release as check. The incidence of stem borer from all the three fields was observed from 10 units of 5 hills each. There were five replications.

The data in Table 93 indicated that the dead hearts due to *S. incertulas* varied from 2.1 to 6.0 per cent from 1st week of August to 1st week of October in plot receiving *T. japonicum*. The corresponding figures for insecticide treated and control plots were 2.0 - 3.9% and 2.1 - 9.9%, respectively. The recovery tests were also carried out in all the three plots by collecting egg masses during August and September. The egg masses were brought to the laboratory and reared till emergence of host larvae or parasitoids. The data (Table 94) indicate that 38, 51 and 59 egg clusters were collected from parasitoid - release insecticide - treated and check plots, respectively, during August and September with a corresponding parasitism of 90.5 to 96, 40 and 50.8 to 55.6 per cent, respectively.

It can be concluded that six releases of *T. japonicum* during August and September reduced significantly the incidence of stem borer in paddy.

1.3.6.3 Evaluation of *Allorhogas pyralophagus* against stem borer (AAU, Jorhat)

Allorhogas pyralophagus, an exotic larval parasitoid of Mexican origin, was tested against rice stem borer in the farmer's field located in Kakajan. The parasitoid was released @ 625 females per hectare commencing from 30 days upto 75 days after transplantation at fortnightly intervals. The data presented in Table 95 & 96 revealed that during Kharif 1994 the per cent dead heart in the parasitoid released plot ranged from

Table 93. Field evaluation of *Trichogramma japonicum* against *Scirpophaga incertulas*

Treatment	No. of parasitoids or dosage of insecticide/ha	Date of release or spray	*Mean cumulative incidence of *S. incertulas* during different months (per cent dead heart)		
			August	September	October
T. japonicum	50,000	3rd,16th,25th August, 1st, 12th, & 22nd September	2.4	4.9	6.0
Monocrotophos	1.6251	1st & 22nd September	2.4	4.3	5.9
Control	No release or spray		3.6	8.2	9.9

* Mean of 5 replications each comprising 10 units of 5 hill

Table 94. Recovery of parasitoids from eggs of *Scirpophaga incertulas*

Treatment	Egg clusters collected during						
	August			September			
	3	16	25	1	12	28	Total
T. japonicum	3(0)	4(0)	8(1)	8(2)	7(3)	8(2)	38(8)
% eggs parasitized	-	-	96	90.5	92.8	93.8	
Monocrotophos	3(0)	5(0)	9(0)	9(1)	12(0)	12(0)	51(1)
% eggs parasitized	-	-	-	40	-	-	
Control	2(0)	5(0)	10(0)	11(1)	15(1)	16(0)	59(2)
% eggs parasitized	-	-	-	55.6	50.8	-	

No. of egg clusters parasitized by *T. japonicum* are given in parentheses

Table 95. Evaluation of *Allorhogas pyralophagus* against stem borer (Kharif 1994)

Treatment	% Dead hearts recorded before release	Dead hearts at weekly interval (%)					heads (%)
		1st	2nd	3rd	4th	5th	
Allorhogas pyralophagus	8.39	5.35	5.84	2.50	3.10	2.90	2.15
Chemical control	11.23	5.74	6.50	3.98	4.25	3.85	5.57
Control	10.84	7.72	9.96	7.89	8.14	7.89	7.31

Table 96. Evaluation of *Allorhogaspyralophagus* against stem borer (Rabi 1994)

Treatment	Pre-release dead heart count (%)	Dead heart at weekly interval (%)					White ear heads (%)
		1st	2nd	3rd	4th	5th	
Allorhogas pyralophagus	6.19	2.76	6.68	2.31	4.42	1.92	1.93
Chemical control	3.18	4.03	4.47	4.90	4.80	3.67	5.91
Control	4.39	4.47	7.28	8.34	13.64	6.62	5.17

1.92 - 6.68% against 4.47%- 13.6% in the unreleased plot. The results showed that there was reduction in the per cent dead heart in the released plot in comparison to unreleased plots.

The same experiment was also conducted during Rabi 1994 and the same trend of reduction of dead heart population could be observed.

In order to examine recoveries of this exotic parasitoid the larvae of the stem borer were periodically collected and reared in the laboratory but the recoveries of the parasitoid could not be made during both the seasons.

1.3.6.4 Field evaluation of *Trichogramma chilonis* against paddy leaf folder, *Cnaphalocrocis medinalis* (PAU, Ludhiana)

Effect of releases of *Trichogramma chilonis* paddy leaf folder, *Cnaphalocrocis medinalis* was studied under field conditions near Lassara (Jallandhur, Punjab)). In one plot, 6 releases of *T. chilonis* were made from 3rd August to 22 September @ 50,000/ha. In another plot of the same size, monocrotophos @ 1625 ml/ha was sprayed on 1 and 22 September. The check plot was kept without any release and spray. The experiment was replicated four times. The incidence of leaf folder was recorded from 10 units of five plant each during August, September and October. The incidence of leaf folder in the parasitoid released, insecticide treated and check plots varied from 1.4 to 10.2%, 1.5 to 7.7% and 1.5 to 19.4%, respectively (Table 97)

1.3.6.5 Effect of *T. japonicum* release on rice stem borer and leaf folder (TNAU, Coimbatore)

The result of the trial showed that the release of *T. japonicum* either alone or supplemented with a spray of *B.t* could effectively check stem borer and leaf folder. *T. japonicum* + *B.t* (T_1) recorded a dead heart per cent varying from 0.78 to 1.38%, while parasitoid alone (T_2) recorded 1.97 to 2.12%, need based insecticide (T_3) recorded 2.5% to 3.55% and the check (T_4) 4.08% to 6.1%. The white ears were minimum in *T. japonicum* + *B. t* (T_1) (4.47%) and *T. japonicum* alone (T_2) (5.73%), while in the control (T_4) it was 9.4%. Similar trend was observed for the leaf folder. The yield of biocontrol plots was 3555 kg/ha and 3778 kg/ha for T1 and T2, respectively. Control recorded 2322 kg/ha (Table 98).

1.3.6.6 Field evaluation of *Trichogramma japonicum* against rice stem borer and leaf folder (AAU, Jorhat)

Field evaluation of *Trichogramma japonicum* against yellow stem borer and *T. chilonis* against rice leaf folder was made in farmer's field located in Kakajan (Assam). The inundative releases of *T. japonicum* were made @ 50,000/ha/week.

T. japonicum was released 30 days after transplanting. The observation on the occurrence of dead heart was taken at weekly intervals and a pre-harvest record in the form of white ear head was also taken to assess the infestation of stem

borer in the advanced stage of the crop. The results presented in Table 99 reveal that during Rabi 1994 the infestation of stem borer prior to field release of parasitoid ranged from 6.78% to 10.84%. The results showed that infestation of dead heart due to stem borer in the released plot ranged 1.04% to 4.47% in comparison with 7.72% to 9.96% in unreleased plot. The per cent white ears in the released plot was 1.26% against 7.31% in the unreleased plot. The application of insecticide alone or release of the parasitoid followed by application of insecticide did not make any difference in lowering the pest population.

Similarly, during Kharif 1994 field release of *T. japonicum* was made. The results presented in Table 100 revealed that the dead heart population was low in parasitoid released plot in comparison to unreleased plot. The dead heart population ranged from 1.53% to 4.93% in the released plot as against 4.47% -13.6% in the unreleased plot . The dead heart population in the unreleased plot was maximum (13.6%) during fourth week after field release but the per cent dead heart in the released plot was 4.04%. The mean per cent dead hearts in released plot was 1.61% against 5.17% in the unreleased plot . The use of phosphamidon @ 300 ml/ha in the released plot could not bring down infestation.

Table 97. Field evaluation of *Trichogramma chilonis* against *Cnaphalocrosis medinalis*

Treatment	No. of parasitoids or dosage of insecticide/ha	Date of release or spray	*Mean cumulative incidence of *C. medinalis* during different months (%)		
			August	September	October
T. japonicum	50,000	3rd,16th,25th August, 1st, 12th, & 22nd September	2.1	5.7	9.2
Monocrotophos	1.6251	1st & 22nd September	2.0	5.4	7.7
Control	No release or spray		7.5	13.3	19.4

* Mean of 5 replications each comprising 10 units of 5 plants each.

Table 98. Incidence of stem borer and leaf folder (IR 20).

Treatment	Stemborer dead heart(%) DAT			White ear (%) DAT	Leaf folder damage(%)DAT		Yield kg/ha
	30	45	60	110	60	70	
T1	0.78^{a}	1.07^{a}	1.38^{a}	4.47^{a}	1.27^{a}	1.53^{a}	3555^{b}
T2	2.00^{a}	1.97^{a}	2.12^{a}	5.73^{a}	2.10^{b}	2.35^{b}	3778^{a}
T3	2.50^{a}	3.03^{b}	3.55^{b}	7.33^{b}	3.57^{bc}	3.42^{bc}	2750^{c}
T4	4.08^{b}	4.37^{c}	6.17^{c}	9.40^{c}	4.77^{cd}	4.08^{cd}	2322^{d}

Table 99. Evaluation of *Trichogramma japonicum* against yellow stem borer (Rabi 1994)

Treatment	Dead heart (pre-release) (%)	Dead heart at weekly intervals (%)					White ear head (%)
		1st	2nd	3rd	4th	5th	
T. japonicum	9.18	4.47	2.94	1.04	2.01	2.31	1.26
Chemical control	11.23	5.74	6.50	3.98	4.25	3.85	5.57
T. japonicum + Chemical control	6.78	6.91	7.06	1.93	3.12	2.75	5.26
Control	10.84	7.72	9.96	7.89	8.14	7.89	7.31

Table 100. Evaluation of *Trichogramma japonicum* against yellow stem borer (Kharif 1994)

Treatment	Dead heart (pre-release) (%)	Dead heart at weekly intervals (%)					White ear head (%)
		1st	2nd	3rd	4th	5th	
T. japonicum	5.21	4.93	4.15	1.53	4.04	1.97	1.61
Chemical control	3.18	4.03	4.47	4.90	4.80	3.67	5.91
T. japonicum + Chemical control	2.85	2.17	1.36	2.68	3.75	2.61	2.59
Control	4.39	4.47	7.28	8.24	13.6	6.32	5.17

The per cent leaf folder population during rabi 1994 was low (Table 101) and the per cent damaged leaves due to leaf folder prior to field release of *T. chilonis* ranged from 3.28-5.10%. The per cent damaged leaves in the parasitoid released plot ranged from 1.37% to 3.44% as against 2.57% to 5.10% in the unreleased plot.

Similarly, the per cent leaf folder damaged leaves in the *T. chilonis* released plot during Kharif, 1994 was lower than in unreleased plots. The per cent leaf folder damaged leaves in the released plot ranged from 0.90 -1.89% in comparison to 3.36%-7.25 in the unreleased plot (Table 102).

Field recovery of *T. japonicum*

In order to test the field recoveries of *T. japonicum* the adult moths of yellow stem borer were collected and used to obtain egg masses. The egg masses along with the leaves were stapled on the leaves of rice plants in the parasitoid released plots. The egg masses were allowed to remain in the field for 24 hours for parasitisation. The egg masses were then kept in the laboratory for the emergence of parasitoid. The per cent recoveries of *T. japonicum* during rabi and kharif season were 22.7% and 32.13%, respectively.

Table 101. Evaluation of *Trichogramma chilonis* against rice leaf folder *Cnaphalocrosis medinalis* (Rabi 1994)

Treatment	*LFDL (pre-release) (%)	% LFDL at weekly intervals				
		1st	2nd	3rd	4th	5th
T. chilonis	5.10	3.44	1.74	1.37	2.03	2.25
Chemical control	4.42	3.12	4.38	3.04	4.03	3.50
T.japonicum + Chemical control	3.04	3.51	3.22	0.85	1.12	1.95
Control	3.86	4.27	3.91	2.57	4.85	5.10

* LFDL = Leaf folder damaged leaves

Table 102. Evaluation of *Trichogramma chilonis* against rice leaf folder *Cnaphalocrosis medinalis* (Kharif 1994)

Treatment	*LFDL (pre-release) (%)	LFDL at weekly intervals (%)				
		1st	2nd	3rd	4th	5th
T. chilonis	2.40	1.89	1.08	1.31	1.87	0.90
Chemical control	3.18	4.03	5.04	1.39	2.76	4.25
T. japonicum & Chemical control	2.26	5.70	1.82	1.28	2.17	1.52
Control	1.75	5.36	5.93	3.36	7.25	5.88

* LFDL = Leaf folder damaged leaves

1.3.6.7 Studies on *Trichogramma japonicum* and *T. chilonis* against stem borer and leaf folder (TNAU, Coimbatore)

The trial was conducted with two treatments viz., (i) parasite release (*T. japonicum* and *T. chilonis* released at weekly intervals, each three releases, @ 1,00,000 parasitoids/ha) (ii) untreated check. The variety used was Co.45. The observations were recorded on 30, 45, 55 and 110 days for stem borer damage, and 65, 75 and 85 DAT for leaf folder damage.

The results showed that the biocontrol plot recorded significantly low stem borer and leaf folder (Table 103).

1.3.6.8 Studies on *Trichogramma japonicum* and *Trichogramma chilonis* against stem borer and leaf folder (KAU, Trichur)

Field level trials using *T. japonicum* and *T. chilonis* for the biosuppression of paddy stem borer and rice leaf roller were conducted at Govt. Agricultural Farm, Mannuthy (Kerala) during

October-January, 1994-95. The results are presented in Table 104. No significant differences were noticed amongst the treatments.

1.3.6.9 Evaluation of the efficacy of mirid bug, *Cyrtorhinus lividipennis* against brown plant hopper, *Nilaparvata lugens* (TNAU, Coimbatore)

The treatments consisted of (i) release of 70 second instar nymphs/m^2 of *C. lividipennis* on 45, 55 and 65 DAT, (ii) soil application of carbofuran @ 1kg ai/ha and 44 DAT and (iii) untreated check. The trial was laid out at the wetlands of Agricultural College and Research Institute,Coimbatore using the variety IR 50. There were 8 replications. Observations were recorded on number of mirids and BPH per hill besides the grain yield at harvest.

The results revealed that the inundative release of the mirid bug thrice on 45th , 55th and 65th DAT @ 70/m^2 and application of carbofuran 3 G at 1 kg ai/ha on 45 DAT were on par with untreated check as regards the mirid population. The brown plant hopper population was the same in plots that received the mirid bug and carbofuran on 64 DAT but mirid released plot recorded significantly low BPH on 74 DAT. Both the treatments however, were superior to the check. The yield of grain was 5500 kg/ha in carbofuran treated plot, 5525 kg/ha in mirid released plot and 4500kg/ha in the check. The yield levels in mirid/carbofuran received plots were on par but superior to the check (Table 105).

1.3.6.10 Seasonal incidence of key natural enemies of rice hispa, *Dicladispa armigera* (AAU, Jorhat)

Survey of natural enemies of rice hispa was conducted in Nematighat, about 15 km away from AAU campus. The different stages of rice hispa were collected from the field and reared in the laboratory to observe emergence of natural enemies. Part of the leaves containing eggs were trimmed to small pieces and enclosed in glass vials (7 cm). The trimmed leaves containing the eggs were allowed to remain in contact with wet cotton. The vials were examined daily for parasitoids and the emerging parasitoids preserved in 70% alcohol. The data presented in Table 106 revealed the presence of both *Trichogramma* sp. and *Oligosita* sp.

Table 103. Evaluation of release of *T. japonicum* and *T. chilonis* against paddy stem borer and leaf roller

Treatment	Gross wt. of grain+straw.	Grain weight	Healthy ear-heads	White ear-heads	Total ear-heads
Biological control	975.83	445.00	279.17	31.33	310.50
Biocontrol + Chemical control	981.67	424.17	332.00	41.00	373.00
Chemical control	1001.67	457.50	323.17	25.17	348.33
Control	928.33	422.50	277.17	26.83	304.00
CD	174.67	56.22	47.05	17.02	54.66

Table 104. Effect of biocontrol agents on stem borer and leaf folder of rice

Details		Treatment	Control
Stemborer			
Dead heart	30 DAT	5.1[a]	7.6[b]
	45 DAT	2.8[a]	3.7[a]
	55 DAT	2.6[a]	4.4[b]
White ear	110 DAT	5.9[a]	7.5[b]
Leaf folder	65 DAT	0.7[a]	0.9[b]
	75 DAT	2.3[a]	4.6[b]
	85 DAT	4.5[a]	8.0[b]
Grain yield (kg/ha)		4461.0[a]	3961.0[b]

Same superscript in rows indicate parity (paired 't' test)

Table 105. Data on population of mirid bug, brown planthopper and yield

Treatment	Mirids/hill DAT			BPH/hill DAT		Yield (kg/ha)
	54	64	74	64	74	
Release of mirid bug	0.23[b]	0.24[c]	0.33[a]	0.31[a]	0.4[a]	5525[a]
Carbofuran 3G	0.71[a]	0.29[b]	0.43[a]	0.31[a]	0.49[b]	5500[a]
Control	0.71[a]	0.37[a]	0.44[a]	0.51[b]	0.54[b]	4500[b]

DAT = Days after transplanting

Table 106. Natural parasitism by *Trichogramma* sp. and *Oligosita* sp. on the eggs of *Dicladispa armigera*

Date	No.of eggs collected	No. of eggs parasitized		Parasitisation (%)	
		Tricho-gramma sp.	*Oligosita* sp.	*Tricho-gramma* sp.	*Oligosita* sp.
02-07-94	100	12	9	12	9
09-07-94	48	7	5	15	10
11-07-94	55	6	7	11	13
23-07-94	35	3	5	9	14

1.3.6.11 Field trial using the various formulations of *Bacillus thrungiensis* for the control of paddy pests (TNAU, Coimbatore)

Three trials were conducted, one during Kharif and two during Rabi 1994 seasons. The Kharif 1994 trial was conducted at Coimbatore and Rabi 1994 trials at Aliyarnagar. IR 50, IR 20 and Co 45 were the varieties used. There were nine treatments replicated thrice in all the experiments. The treatments were i) Dipel (1000ml/ha), ii) Delfin, iii) Bio-asp, iv) Bio-lep, v) Bio-tox, vi) Bio-bit, vii) Agree (all at 1kg/ha), viii) monocrotophos (1000ml/ha) and ix) an untreated check. The Rabi crop and the first Kharif received 3 rounds. The treatments were imposed when the ETL reached 10% at vegetative and 5% at flowering stage. The observations (prior to treatments and after imposing the treatments) made were on per cent leaves damaged, population of predators and per cent parasitism. The grain yield data was also collected.

1.3.6.11.1. Damage by leaffolder (Kharif 1994)

The results of the Kharif 1994 trial (Table 107) showed that all the *B.t* formulations were superior to the check in arresting the leaf folder damage. The damage rating before the treatment varied between 6.6. to 10.4%. The reduction in leaf damage, as recorded on 83 DAT varied between 28.75 in bio-bit to 64.1% in monocrotophos. Among the *B.t* formulations Agree, Bioasp and Bio-bit reduced the damage by 62.7, 62.1 and 61.4 per cent, respectively. The reduction in the leaf damage on 90 DAT was between 38.4% in Dipel and 60.9% in Bio-asp. In 97 DAT the per cent reduction in leaf damage ranged between 38.0 in Bio-bit and 73.8 in Delfin. Overall results showed that Bio-bit alone was inferior in reducing the damage (28.9 to 38.0%) while Bio-asp, Delfin and Bio-tox showed sustained effect.

1.3.6.11.2. Leaffolder damage (Rabi 1994)

The leaf damage reduced from 35.8% to 65.5% on 66 DAT, 42.0 to 75.9% on 73 DAT and 64.3 to 86.5% on 80 DAT in the first trial. Formulations like Bio-lep, Delfin, Bio-asp, Agree and Bio-tox showed sustained action. Unlike in the Kharif trial, the *B.t* formulations exerted equal effect on the pest as by monocrotophos. Delfin gave 4.1 tons of grain yield followed by Bio-asp, Bio-lep and Agree. Control recorded 2.9 t/ha (Table 108).

In the second trial also a similar trend is discernible. The treatments exerted greater influence 77 and 84 DAT than on 63 and 70 DAT. The data further reveals that all the *B.t* formulations were on par with monocrotophos in checking the leaf folder damage (Table 109).

1.3.6.11.3. Effect on natural enemies

The effect of *B.t* formulations on four predators *Lycosa pseudiannulata, Tetragnatha javana, Paederus fuscipes* and *Cheilomenes sexmaculata* showed that the formulations were absolutely safe to the predators. The insecticide monocrotophos alone was exerting a negative influence on these predators (Fig.14 & 15). Similar trend was seen in rabi trial also.

Natural parasitisation of the leaffolders by *Goniozus triangulifer, Cotesia flavipes* and *Trichoma cnaphalocrocis* was affected only in monocrotophos treatment while the *B.t* formulations supported their activity and was on par with the check (Fig. 16).

1.3.6.12 Evaluation of *Bacillus thuringiensis* formulations against *Cnaphalocrocis medinalis* (PAU, Ludhiana)

The experiment was conducted at village Lassara (Distt. Jallandhur) on paddy variety PR 106, in a randomized block design with three replications and 40 m plot size. Ten *B.t.* formulations were tested along with monocrotophos and untreated control. Two sprays were given at 21 days interval. The observations on the per cent leaves damaged were recorded from 5 units of 10 plants each selected at random in each treatment (Table 110). On September 12, the leaves damaged varied from 6.0 to 9.6 per cent and there was no

significant difference between them. The damage on September 28 was significantly low in insecticide treated plots as compared to control. Similar trend was observed on October 8. However, on October 28,all the treated plots showed significantly lower damage than control . All the biopesticide formulations except *B.t.*(BPM) were at par with control. It can be concluded that two sprays of *B.t* formulations reduced the damage by leaf folder.

1.3.6.13 Management of leaf folders with *B.t.* formulation (AAU, Jorhat).

The experiment was conducted during Kharif 1994 in the farmer's field located at Kakajan (Assam). The treatments were applied based on ETL of one damaged leaf per hill during both the vegetative and the flowering stages of the crop. The treatments were replicated thrice with a plot size of 40 m^2. The results presented in Table 111 revealed that among the treatments Biolep (BTK1) and BTT could reduce leaf folder damage (2.87% and 2.48%) as compared to control (5.66%). The performance of the remaining *B.t.* products could not be properly evaluated due to low population of leaf folder.

1.3.6.14 Survey of different rice growing tracts in Tamil Nadu for obtaining seasonal calendar of natural enemy complex of rice pests (TNAU, Coimbatore)

Spatial survey of rice growing tracts of Coimbatore, Aliyarnagar, Bhavanisagar areas showed that spider population was very high. The most common one seen was *Lycosa pseudannulata* whose population varied between 0.26 to 1.30 per hill. The maximum population was observed during September. The other spider observed was *Tetragnatha javana* and the rove beetle *Paederus fuscipes* which was maximum during October-November. The parasitoids *Goniozus inangulifer, Cotesia flavipes* and *Trichoma cnaphalocrocis* were observed to parasitize the leaf folder larvae during the Rabi 1994.

Table 107. Effect of *B.t* formulations against leaf folder (Kharif 1994)

Treatment	% leaf damage days after treatment (DATR)							Grain yield (t/ha)	Percent increase over control
	75(BT)	83	PR	90	PR	97	PR		
Dipel 1000 ml/ha	6.6	5.8^{c}	38.6	3.5^{abc}	38.4	1.6^{bc}	57.5	3.1^{cd}	6.5
Delfin 1kg/ha	9.6	5.5^{bc}	59.4	5.2^{e}	49.7	1.5^{a}	73.8	3.8^{ab}	29.0
Bio-asp 1kg/ha	9.5	5.1^{abc}	62.1	3.1^{ab}	60.9	2.0^{bc}	63.1	3.5^{bc}	19.5
Bio-lep 1kg/ha	6.6	5.0^{ab}	46.4	4.1^{bc}	27.9	1.2^{ab}	67.7	3.6^{ab}	23.2
Bio-tox 1kg/ha	6.9	3.8^{a}	61.4	3.0^{a}	48.9	1.2^{ab}	71.0	3.6^{ab}	23.2
Bio-bit 1kg/ha	7.8	7.9^{d}	28.9	4.3^{c}	35.7	2.8^{c}	38.0	3.1^{d}	4.8
Agree 1kg/ha	7.9	4.2^{ab}	62.7	4.2^{c}	39.2	1.9^{ab}	59.4	3.2^{cd}	8.5
Monocrotophos 100ml/ha	7.6	3.9^{a}	64.1	3.0^{a}	54.3	1.2^{ab}	73.6	4.0^{a}	35.8
Control	10.4	14.8^{e}	-	9.0^{d}	-	6.1^{d}	-	2.9^{e}	

BT: Before treatment; PR: per cent control

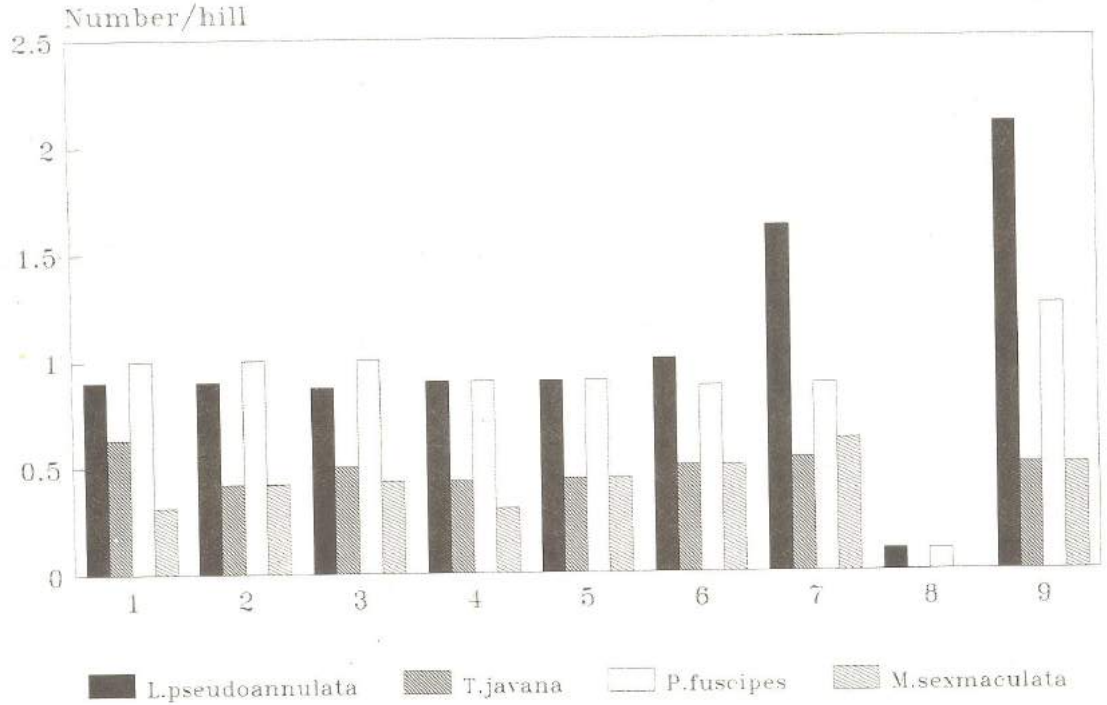

Fig. 14 Effect of *B.t.* on natural enemies of leaffolders (Kharif 1994)

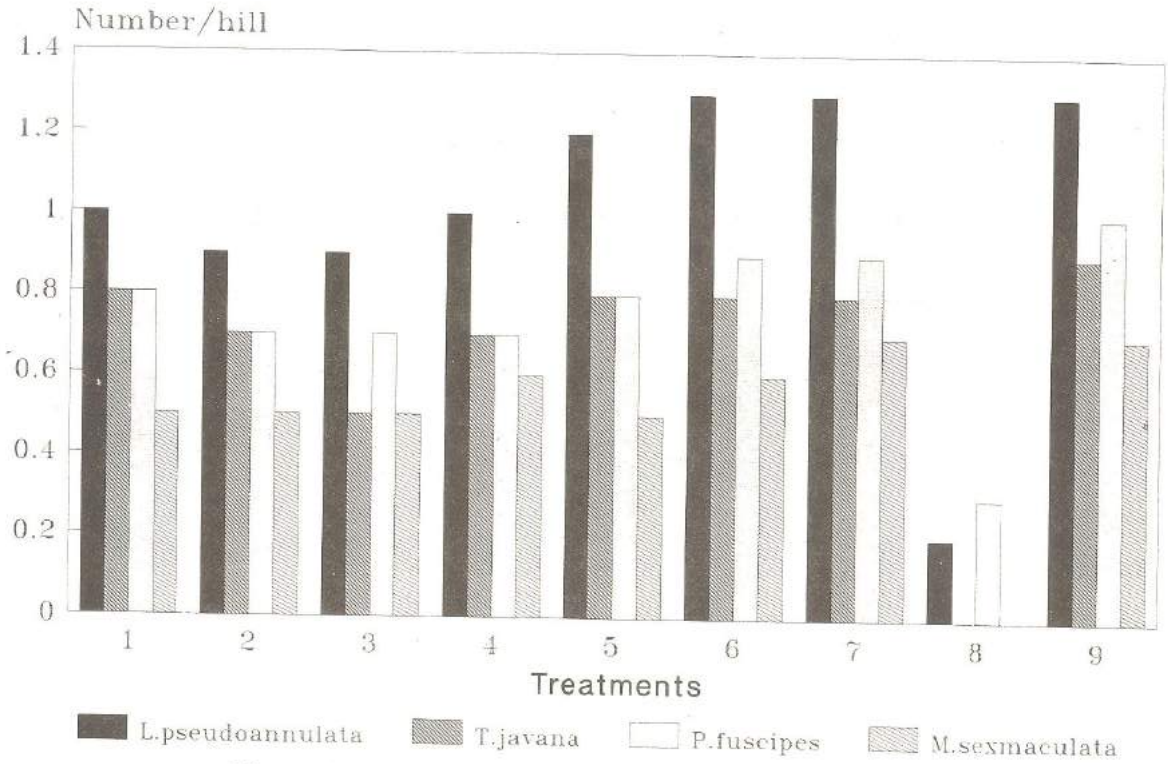

Fig. 15 Effect of *B.t.* on natural enemies of leaffolders (Rabi 1994) Experiment II

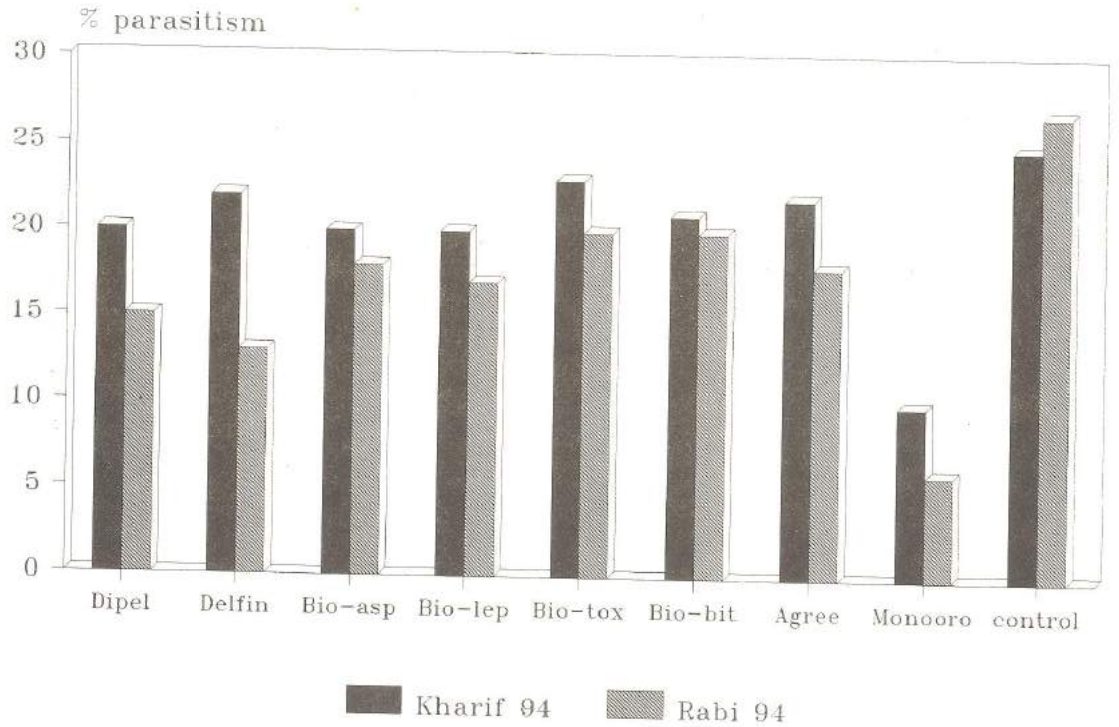

Fig. 16 Effect of *B.t.* formulations on the parasitoid complex of rice leaffolder

Table 108. Effect of *B.t* formulations against leaf folder (Rabi 1994) Experiment I

Treatment	% leaf damage days after treatment (DATR)							Grain yield (t/ha)	Percent increase over control
	59(BT)	66	PR	73	PR	80	PR		
Dipel 1000 ml/ha	13.2	9.3^{b}	49.1	8.5	42.0	5.1^{b}	69.1	3.5^{bc}	20.7
Delfin 1kg/ha	15.8	7.6^{a}	65.5	5.5	68.5	3.6^{a}	81.7	4.1^{a}	41.4
Bio-asp 1kg/ha	16.3	11.0	51.2	8.2^{bc}	54.6	5.9^{b}	71.0	3.6^{a}	24.4
Bio-lep 1kg/ha	21.0	13.6^{c}	53.3	5.6a	75.9	3.5^{a}	86.5	3.6^{ab}	24.4
Bio-tox 1kg/ha	17.2	12.6^{c}	48.1	6.5^{ab}	65.8	5.8^{b}	73.5	3.3^{bc}	13.8
Bio-bit 1kg/ha	18.6	16.6^{cd}	35.8	10.7^{c}	48.1	8.3^{c}	64.3	3.1^{bc}	6.9
Agrec	16.6	11.8^{d}	48.6	6.9^{ab}	62.5	3.7^{a}	82.1	3.6^{ab}	24.4
Monocrotophos 100ml/ha	19.0	15.2^{d}	42.3	7.9^{ab}	62.5	4.5^{ab}	81.0	3.7^{ab}	24.4
Control	15.7	21.8^{e}	-	17.4^{d}	-	19.6^{d}	-	2.9^{c}	-

BT: Before treatment; PR: per cent control

Table 109. Effect of *B.t* formulations against leaf folder (Rabi 1994) Experiment II

Treatment	% leaf damage days after treatment (DATR)									Grain yield (t/ha)	Percent increase over control
	55(BT)	63	PR	70	PR	77	PR	84	PR		
Dipel1000 ml/ha	19.6	16.7^{bcd}	15.6	10.0^{a}	39.1	7.8^{ab}	63.2	5.2^{ab}	78.1	4.2^{bc}	7.7
Dipel 1kg/ha	20.2	11.2^{a}	43.4	8.5^{a}	48.5	6.5^{a}	69.3	4.0^{a}	83.1	4.4^{a}	12.8
Bio-asp 1kg/ha	21.0	16.3^{bcd}	17.6	10.1^{a}	38.6	5.8^{a}	72.6	3.8^{a}	84.1	4.2^{b}	7.7
Bio-lep 1kg/ha	20.6	15.2^{abc}	15.6	8.5^{a}	48.3	7.9^{ab}	62.7	5.1^{ab}	78.5	4.1^{cd}	5.1
Bio-tex 1kg/ha	17.3	18.2^{cd}	8.1	10.3^{a}	37.5	9.0^{ab}	57.5	6.0^{ab}	74.7	4.1^{cd}	5.1
Bio-bit 1kg/ha	18.8	17.1^{cd}	13.6	11.3^{ab}	31.5	8.1^{ab}	61.7	7.0^{bc}	70.5	3.9^{d}	-
Agrec 1kg/ha	23.0	18.4^{cd}	7.1	9.8^{a}	40.6	6.5^{a}	69.3	5.7^{ab}	76.0	3.9^{d}	-
Monocrotophos 100ml/ha	22.4	13.1^{ab}	33.8	8.9^{a}	46.0	5.5^{a}	74.0	4.3^{a}	81.9	4.3^{ab}	10.3
Control check	19.2	19.8^{d}	-	16.5^{d}	-	21.1^{c}	-	23.8^{d}	-	3.9^{d}	-

BT: Before treatment; PR: per cent control

Table 110. Evaluation of *B.t.* formulations against leaf folder (Kharif 1994)

Treatment (@ 1.0 kg/ha)	LFDL (%)	% LFDL at weekly intervals (Mean of 3 replications)				Yield (kg/ha)
		1st	2nd	3rd	4th	
Biobit	5.07	3.83	5.86	2.28	2.35	5016
BT K I	6.18	4.10	2.87	1.77	1.50	5174
BT K II	5.24	4.41	4.11	2.96	2.16	5145
BTT	5.73	5.73	2.48	2.70	2.17	5034
Monocrotophos	6.33	6.33	2.89	2.88	2.04	4993
Agree 50wp	5.28	4.06	4.19	3.26	2.26	5105
Control	5.86	5.05	5.66	4.56	3.00	5083

Table 111. Comparative efficacy of *Bacillusthuringiensis* formulations against *Cnaphalocrosis medinalis*

Treatment	* Incidence of *C. medinalis* on different dates and months (per cent leaves damaged)					
	August	September			October	
	25	1	12	28	8	28
Biosap BTK-II	2.4	5.1	8.2	10.5	12.5	15.6
BTT	3.1	4.1	8.1	11.1	13.2	16.0
Delfin WG	2.8	4.4	8.0	10.3	13.2	15.8
Biolep BTK-I	3.0	3.4	8.1	10.5	12.3	16.3
Bioasp	2.5	4.5	8.2	11.0	13.3	15.6
Biotax 12G	2.3	4.4	7.8	10.3	13.3	15.7
Biolep	2.8	3.8	7.9	9.7	13.9	15.2
Agree 50 WP	2.0	5.1	8.0	10.5	13.3	15.5
Dipel 8 L	2.8	3.4	7.8	10.4	13.3	16.0
Bt (BPM)	3.0	4.0	8.3	11.1	12.9	17.3
Monocrotophos 36 WSC	2.8	4.1	6.0	7.3	9.0	13.5
Control	2.9	4.1	9.6	13.1	16.9	21.6
CD (p=0.05)	NS	NS	NS	3.6	4.5	3.5

Average of 5 units of 10 plants from three replications
Note : Dosages of *B.t* pesticides was 1.0 kg/ha and for monocrotophos 360 g ai/ha and were sprayed on 1st and 22nd September

1.3.6.15 Survey of spiders in rice ecosystem (AAU, Jorhat)

Survey of spiders in rice ecosystem was conducted in and around Jorhat district during Ahu and Sali season during 1993-94. The species of spiders is listed in Table 112. Among the spiders, *Zygoballus pashanensis, Oxyopes shweta, Tetragnatha* sp. and *Lycosa* sp. were predominant throughout the cropping season . The seasonal incidence of these dominant species were studied during Rabi, 1994. The population density of *Lycosa* sp. was initially low but subsequently increased rapidly and a high population of (0.93/hill) was seen in the second week of October, there after the population density declined.

1.3.6.16 Evaluation of biocontrol based IPM on rice (TNAU, Coimbatore)

A trial was conducted in a confounded block design at Agricultural Research Station, Aliyarnagar. There were three sets of treatments replicated 8 times. The plot size was 80 m^2 and the variety used was IR 50. The treatment structures were:

(i) Application of neem blended urea basally as well as for top dressing, release of *T. japonicum* against stem borer @ 1 lakh/release/ha thrice at weekly interval,three releases of *T. chilonis* @ lakh/ release/ha on noticing moth activity, spraying of *B.t.* @ 1kg/ha against leaf folder and spraying of NSKE 5% against earhead bug.

(ii) Need based protection (one round of phosphomidan @ 300ml /ha and two rounds of monocrotophos @ 1000ml/ha

(iii) Untreated Control.

A trial was conducted at ARS Aliyarnagar in which four treatments were compared. There were 10 replications of 20m^2 each. The variety used was IR 20. The treatments were:

(i) Basal and top dressing of neem blended urea, release of *T.japonicum* thrice @ 5 cc/ha at weekly interval followed by *B.t.* spraying against the leaf folder

(ii) Basal and top dressing of neem blended urea followed by release of *T. japonicum* (5 cc/ha/release; two releases)

(iii) Neem based application of monocrotophos

(iv) Untreated check

The treatment structure for another experiment on IPM in rice was

(i) Use of neem blended urea both for basal and top dressing, three releases each of *T. japonicum* and *T. chilonis* against the stem borer and leaf folder, respectively, use of *B.t* @ 1kg and NSKE 5% against earhead bugs

(ii) Spraying phosphamidon once @ 300 ml/ha and twice @ 1000 ml/ha of monocrotophos

(iii) An untreated check.

Observations were recorded on the population of thrips, dead heart percentage, leaf folder damage and grain yield.

The results indicated that the treatment combination comprising of application of neem blended urea (1:5) for basal and top dressings followed by the release of *T. japonicum* thrice at weekly intervals, against the stem borer, release of *T. chilonis*, thrice at weekly intervals, against the leaf folder followed by spraying of *B.t* @ 1kg/ha against leaf folder and NSKE 5% at flowering against earhead bug was superior to need based application of insecticides as well as the check. The yield levels, however, were statistically equal in the biocontrol based IPM and need based insecticidal protection (3900 kg and 4125 kg, respectively) while the control recorded 3175 kg/ha (Table 113).

Table 112. Spiders in rice ecosystem in Jorhat

Species	Family
Zygoballus pashanensis Tikader	Salticidae
Tetragnatha sp.	Tetragnathidae
Lycosa madani Pocek	Lycosidae
Pardosa birmanica Simon	Lycosidae
Neoscona theisi (Walck.)	Araneidae
Oxyopes shweta Tikader	Oxyopidae
Zygoballus sp.	Salticidae
Argiope catenulata (Dol.)	Araneidae
Neoscona mukerjei Tikader	Araneidae
Oxyopes sp.	Oxyopidae

Table 113. Effect of biocontrol based IPM on pest incidence and yield

Treatments	Thrips Number/ sweep	Stem borer (%) DAT after			Leaf folder damage(%)		Yield (kg/ha)
		37	44	51	at 50% flowering	10 days after	
Biocontrol based IPM	3.2[a]	0.6[a]	2.0[b]	2.1[a]	3.8[a]	5.8[a]	3822[a]
Need based insecticides	3.6[a]	2.9[b]	0.7[a]	7.7[b]	4.6[a]	8.4a[b]	3956[a]
Check	4.1[b]	2.5[b]	4.5[c]	8.8[b]	5.0[b]	10.8[b]	3175[b]

1.3.7. BIOLOGICAL SUPPRESSION OF OIL SEED CROP PETS

1.3.7.1. Seasonal abundance of natural enemies of mustard aphid, *Lipaphis erysimi* (PAU, Ludhiana)

To find out the natural enemies of mustard aphid (*Lipaphis erysimi*) surveys at different places in the Punjab were carried out from November, 1994 to March, 1995. The population of the mustard aphid was recorded from a 5 cm central twig from 2 plants each from 4 units in a field. The population of different stages of the predators was also recorded from two plants (5 cm twig) selected at random. All the aphids from these two selected plants were brought to the laboratory to find out per cent parasitization.

The mustard aphid appeared in the 2nd week of January (Table 114) and remained upto the 3rd week of January. It gradually increased and became quite high during middle of February to middle of March . The population of the mustard aphid was quite high in Hambran area (Ludhiana) than Nurmahal (Jalandhar) and Morinda (Ropar).

Table 114. Seasonal abundance of mustard aphid, *Lipaphis erysimi* on rapeseed and mustard at different places

Date	Place	Population of *L. erysimi* on two plants (5 cm central twig)				
		Unit I	Unit II	Unit III	Unit IV	Mean
04-11-94	Chakdana	0	0	0	0	0
08-11-94	Mullanpur	0	0	0	0	0
25-11-94	Jalandiwal	0	0	0	0	0
28-11-94	Pakhowal	0	0	0	0	0
01-12-94	Gujarwal	0	0	0	0	0
	Chakdana	0	0	0	0	0
13-12-94	Pakhowal	8	4	10	6	5.6
	Moai	8	10	9	7	6.8
12-01-95	Moai	15	17	19	21	14.4
18-01-95	Hambran	60	19	44	92	53.7
19-01-95	Nurmahal	44	108	176	185	128.3
20-01-95	Hambran	67	60	65	100	73.0
02-02-95	Hambran	180	157	95	110	133.0
07-02-95	Nurmahal	117	122	80	138	114.3
14-02-95	Hambran	214	155	217	254	210.0
06-03-95	Morinda	85	88	238	35	111.3
13-03-95	Hambran	230	255	189	327	250.3
22.3.95	Hambran	192	146	176	1234	159.3

Note: Units I to IV are four locations from one acre field

No predator or parasitoid was observed upto 2nd fortnight of January, 1995. Thereafter 1-3 coccinellid beetles were observed/ two plants upto the last week of March 1995 (Table 115)., The syrphids viz. *Episyrphus altemans, Metasyrphus confrater* and *Scaeva* sp. were observed from 1st week of February till middle of March. The parasitoid , *Diaeretiella rapae* was active during March and parasitism varied from 4 to 50% . Its peak was in the middle of March.

Table 115. Abundance of natural enemies of *Lipaphis erysimi* at different locations in the Punjab

Date	Place	Mean population/2 plants		Mean per cent parasitization by *D. rapae*
		C	S	
11-01-95	Sidhwan Bet	0	0	0
12-01-95	Moai	0	0	0
18-01-95	Hambran	0	0	0
19-01-95	Nurmahal	1	0	0
20-01-95	Hambran	0	0	0
02-02-95	Hambran	1	0	0
07-02-95	Nurmahal	1	2	0
14-02-95	Hambran	2	3	0
06-03-95	Morinda	3	2	4
13-03-95	Hambran	3	3	50
22-03-95	Hambran	2	0	18

Average of 5 units of 2 plants each

C- Coccinellids; S-Syrphids
Coccinellids : *Coccinella septempunctata*
Cheilomenes sexmaculatus

Syrphids : *Episyrphus alternans*
Metasyrphus confrater
Scaeva sp.

1.3.7.2. Testing of *Metarrhizium anisopliae* and *Bacillus popilliae* against white grub on ground nut (APAU, Hyderabad)

A trail was laid out with three treatments viz., (i) *M. anisopliae* @ 0.5 kg/ha, (ii) *B. popilliae* @ 0.5 kg/ha and (iii) control, replicating each treatment seven times with groundnut variety TMV-2. The treatments were given once in the furrow along with the seed by mixing with FYM. While ploughing, the initial grub population was recorded. The germination percentage, plant mortality due to grubs at 15 days interval and at the termination of experiment, the plant stand and yield were recorded (Table 116).

The data presented in Table 116 indicated that the plant mortality in the early stages of crop growth was found to be 1.10 to 1.52% and at later crop growth stages, it declined. At all crop growth stages combined, the plant mortality was found to be 5.63, 6.54 and 6.46% recorded in the plots treated with *M. anisopliae*, *B. popilliae* and control, respectively. There were no significant differences among the treatments with respect to plant stand and yield.

The infectivity tests made in the field as well as in the laboratory indicated that neither the treatment with *M. anisopliae* nor with *B. popilliae* were effective against white grub of groundnut at 0.5 kg/ha.

1.3.7.3 Testing of *M. anisopliae* and *B. popilliae* against whitegrub on groundnut (GAU, Anand)

No recovery was obtained in the release plots at Vijapur from both *M. anisopliae* and *B. popilliae* treated plots. White grubs infected by *M. anisopliae* and *B. popilliae* were collected from the areas where application of pathogens was made in the previous year. The percentage infection was 34 and 42%, respectively (Table 117).

Table 117. Monitoring of pathogens in release plots

Location (Farm)	Total number collected	Per cent grubs infested
Vatrak Seed	1240 (100 Sap)	34%
Vatrak Seed	690 (100 Sap)	42%

Table 116. Effect of *Metarrhizium anisopliae* and *Bacillus popilliae* against root grub in groundnut.

Treatment	Initial grub population (m^2)	Germination (%)	Mean % plant mortality/germination after days							Total mortality (%)	Plant stand (%)	Yield (kg/ha)
			7	15	30	45	60	5	90			
M. anisopliae	1.28	71.19	1.10	1.01	0.85	0.30	0.49	0.84	0.99	5.63	65.56	1100
B. popilliae	1.86	69.80	1.29	1.38	0.98	0.70	0.31	0.39	1.46	6.54	63.34	1046
Control	1.43	70.53	1.52	1.25	0.75	0.41	0.21	0.85	1.44	6.46	64.07	909
F- Test	NS	NS	-	-	-	-	-	-	-	NS	-	NS

1.3.8 BIOLOGICAL SUPPRESSION OF COCONUT PESTS

1.3.8.1 Mass multiplication of *Apanteles taragamae*

Mass rearing technique of an endoparasitoid, *A. taragamae* was standardized in laboratory conditions and also under field conditions using coconut seedlings in field cages at CPCRI, Kayangulam. The emerged adult parasitoids were used for field releases and for further evaluation. The number of days taken for adult emergence of a brood ranged from 10 to 24 days.

1.3.8.2 Field evaluation on the performance of laboratory reared larval, prepupal and pupal parasitoids of *Opisina arenosella*

a. Thodiyur (Kerala)

Field evaluation of *Goniozus nephantidis* @ 20.5%, *Elasmus nephantidis* @ 49.4% and *Brachymeria nosatoi* @ 31.9% in relation to the target stages of the pest population was continued at Kayangulam. The results are presented in Figure 17.

The results revealed significant reduction in the population of *O. arenosella* over the years (1990-91 to 1993- 94) as compared to the pre-release condition. The reduction obtained in the total population comprising the larva + pupa and the larval population alone was highly significant.

1.3.8.3 Studies on biological suppression of the lace wing bug *Stephanitis typicus*

a. *Stethoconus praefectus* (Miridae)

This predator was observed in the field throughout the year with peak population during March and August and low population in May and October at Kayangulam.

Wild arrow root plants were used for the mass rearing of *S. typica* and the predator *S. praefectus*. Field evaluation studies revealed that the predators are very efficient in bringing down the population of the lace wing bugs.

Population studies of the natural enemies of *Stephanitis typicus* was conducted at Thrissur (Kerala). The pest was at a low level throughout the year in the field. Among the natural enemies, the major ones recorded in the field included the mirid predator *Stethoconus praefectus* and salticid spiders. *S. praefectus* was identified as the most important natural enemy and it fed on the adults as well as the nymphal stages of the bug. The spiders preferred the adults of *S. typicus* and generally ignored the nymphal stages of the pest. *S. praefectus* consumed an average of 4.7, 5.4, 6.6, 6.7, and 5.4 nymphs during its development from nymph to adult in five days. Adult *Stethoconus* consumed an average of 4.6 *Stephanitis* adults per day and the adults lived for a maximum of five days in the laboratory. The adult mirid bug consumed nymphs of *S. typicus* also on an average of five nymphs per day.

Among the spiders at Thrissur, *Phidippus* sp. consumed an average of 3.5 adults of *S. typicus* / day whereas the salticid spiders consumed 2 to 3 adults per day.

A survey of the natural enemy complex of the tingid bugs was carried out at weekly intervals at Mannuthy and Irinjalakuda in Trichur district and Vytilla in Ernakulam district. *Stethoconus praefectus* was observed at Mannuthy and Vyttila but its population was too negligible to enable it to impose any check on the field population of *Stephanitis*.

b. *Ankylopteryx octopunctata octopunctata* (Chrysopidae)

The chrysopid predator appeared abundantly during all months with maximum population during April and low population from October to December.

Prey consumption studies revealed that the chrysopid larvae consumed on an average 12 ± 1 (range 6-39) lace bugs per day. The larvae also consumed *Corcyra* eggs @ 98.3 (range 11-185) per day. The predator completed its life cycle (larva to adult) in 22-27 days under laboratory conditions.

c. Predatory caterpillar

A caterpillar was collected from the colony of *S. typica* from the field. A fully grown larva was found capable of consuming 50-82 lace wing bugs per day, under laboratory conditions.

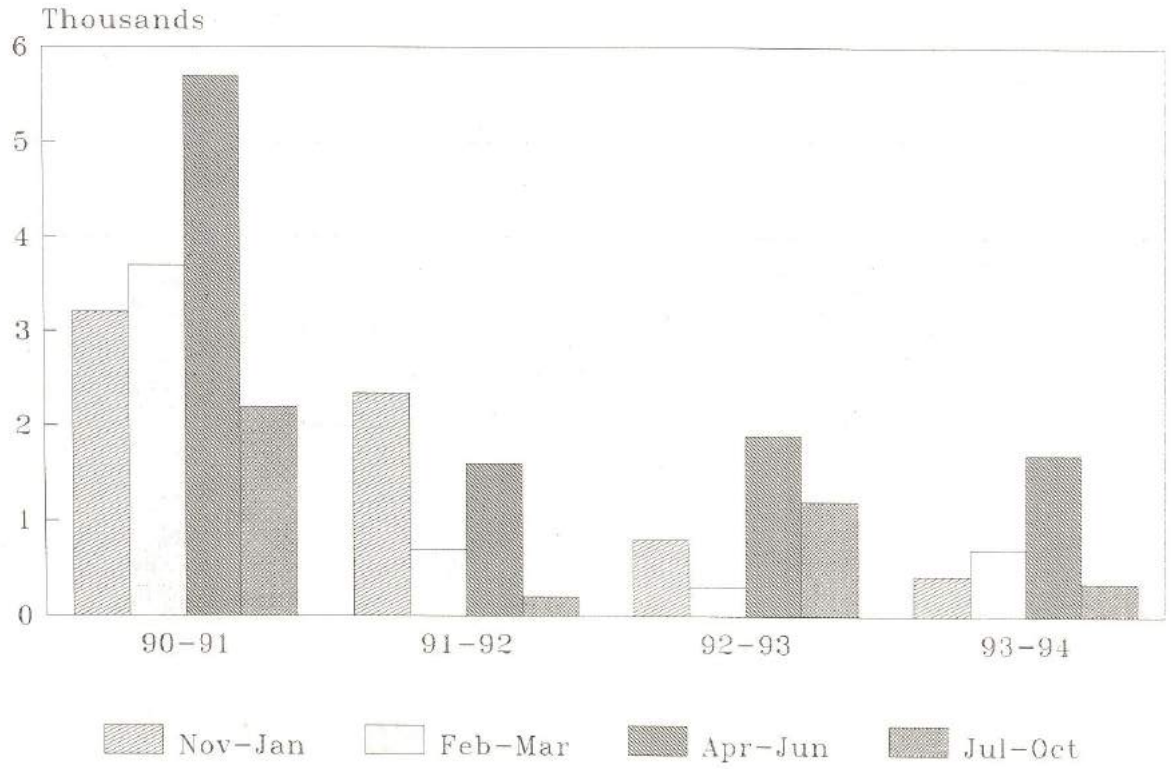

Fig. 17 Estimated total population of *Opisina arenosella* at Thodlyur

1.3.9 BIOLOGICAL SUPPRESSION OF FRUIT CROP PESTS

1.3.9.1. Collection of fruit crop pests and their natural enemies (IIHR, Bangalore)

Parasitoids and predators were collected from pests attacking pomegranate, mango, grapevine, citrus, banana and ber at Indian Institute of Horticultural Research, Hessaraghatta. A total of 24 natural enemies were collected during 1994-95 (Table 118). The mealybug *Ferrisia consobrina* was collected in large numbers on pomegranate at Rahuri but the parasitoid *Anagyrus* was collected only in negligible numbers. The scales *Hemiberlesia lataniae* and *Milviscutules mangiferae* were collected in large numbers on grapes and mango around Bangalore and Rahuri, respectively. On banana scale *Aonidiella orientalis*, three natural enemies viz., *Scymnus* sp., *Chrysoperla* sp. and *Aphytis* sp. were recorded. *Scymnus* sp., was collected relatively in more numbers. Among the natural enemies of citrus green scale, *Coccus viridis*, *Chilocorus circumdatus* was observed in very large numbers on the trunks in the pupal stage. *Aonidiella aurantii* was the major scale insect in Karnataka, Pondicherry, Tamil Nadu and Andhra Pradesh. A total of three parasitoids and 3 predators were recorded on *A. aurantii* (Table 118). Among them, *Aphytis melinus* and *Chilocorus nigrita* were of importance. The population of *A. aurantii* was found high from January to July and low during August to December.

Table 118. Collection of natural enemies of fruit crop pests

Crop / Pest	Natural enemy	Family
Pomegranate		
Aphis punicae		
	Scymnus sp.	Coccinellidae
Ferrisia consobrina		
	Anagyrus sp.	Encyrtidae
Siphoninus phillyreae		
	Encarsia inaron	Aphelinidae
Mango		
Rastrococcus mangiferae		
	Gyranusoidea tebygi	Encyrtidae
	Anagyrus mangicola	Encyrtidae
	Chartocerus walkeri	Signiphoridae
Vinsonia stellifera		
	Un-identified parasitoid	
Grapes		
Hemiberlesia latiniae		
	Signiphora sp.	Signiphoridae
Citrus		
Coccus viridis		
	Chilocorus circumdatus	Coccinellidae
C.nigrita		
	Encyrtus lecaniorum	Encyrtidae
Toxoptera aurantii		
	Cheilomenes sexmaculata	Coccinellidae
Papillio demoleus		
	Two unidentified hyperparasites	
Planococcus citri		
	Coccidoxenoides peregrinus	Encyrtidae
	Brumusoidea unfaciativentris	Encyrtidae
Aonidiella aurantii		
	Aphytis linganensis	Aphelinidae
	A. melinus	-do-
	Encarsia sp.	-do-
	Chilocorus nigrita	Coccinellidae
	Chrysoperla sp.	Chrysopidae
	Eryngiopus sp.	Stigmaeidae
Banana		
Aonidiella orientalis		
	Scymnus sp.	Coccinellidae
	Chrysoperla sp.	Chrysopidae

Aphytis sp.	Aphelinidae	
Ber		
Planococcus lilacinus		
Spalgis epius	Lycaenidae	

1.3.9.2. Predatory potential and development of *Cryptolaemus montrouzieri* on the mango green shield scale *Chloropulvinaria polygonata* (IIHR, Bangalore)

C. montrouzieri preferred to feed on the eggs of the mango scale. The ovisacs of *C. polygonata* were collected from the mango orchards. Newly hatched larvae of *C. montrouzieri* were kept individually in glass vials (15 x 2.5 cm) and fresh eggs of the scale were offered daily to the predatory larvae until pupation. The predator took a mean of 30 days to complete the life cycle on the eggs of *C. polygonata*. Male predators developed slightly faster than the females (Table 119).

Table 119. Duration of development of *Cryptolaemus montrouzieri* on *Chloropulvinaria polygonata*

Stages of *C. montrouzieri*	Developmental period (in days)		
	M	F	Mean
Egg	4.10	4.30	4.20
Grub			
I instar	4.20	4.40	4.30
II instar	2.40	2.60	2.50
III instar	3.60	3.70	3.65
IV instar	4.80	5.10	4.95
Total	15.00	15.80	15.40
Prepupa	2.10	2.20	2.15
Pupa	8.00	8.50	8.25
Total	29.20	30.80	30.00

The number of scale insect eggs consumed by the first, second, third and fourth instar larvae of *C. montrouzieri* averaged 200.65, 337.50, 743.45 and 1105.60, respectively (Table 120). A total of 2387 eggs of *C. polygonata* was consumed by a single predator during its larval development. Female predators consumed significantly more number of scale insect eggs than males.

Table 120. Predation *of C. montrouzieri* on the scale insect, *Chloropulvinaria polygonata*

C. montrouzieri larval instars	No. of scale insect eggs consumed by		
	M	F	Mean
I	190.50	210.80	200.65
II	302.60	372.40	337.50
III	706.30	780.60	7433.45
IV	1080.70	130.50	1105.60
Total	2280.10	2494.30	2387.20

M=Male ; F=Female

1.3.9.3. Efficacy of *Cryptolaemus montrouzieri* in the suppression of mango green shield scale (IIHR, Bangalore)

The scale insect appeared in severe form on mango at State Poultry Farm, Hessaraghatta in February, 1994. As many as 80 ovisacs of *C. polygonata* per shoot were observed. Only *C. montrouzieri* was observed feeding on the ovisacs of the scale insect. The other natural enemies collected in negligible numbers on the scale were *Metaphycus helvolus, Coccophagus bihittatus, C. nigricorpus* and *Mallada astur*. *C. montrouzieri* built up in large numbers on the scale and it was able to wipe out the pest population by the end of July. Maximum population of the predator was observed in May'94 (Table 121).

Table 121. Field population of *Chloropulvinaria polygonata and Cryptolaemus montrouzieri* on mango

Date of observation	Population / Shoot	
	C. polygonata	*C. montrouzieri*
04-02-1994	80.50	1.30
10-03-1994	74.30	5.40
14-04-1994	81.40	7.20
12-05-1994	67.20	10.40
08-06-1994	40.30	7.20
07-07-1994	15.00	4.60
04-08-1994	0.30	0.70

1.3.9.3.1. Field evaluation of *C. montrouzieri* against the green shield scale (IIHR, Bangalore)

The scale population appeared in very severe form on mango and infestation was usually confined to leaves, shoots and flower stalks. Due to heavy infestation of the scales, the plant parts were completely covered with sooty mould. Severe pruning of the trees was done in June, 93. Field releases of *C. montrouzieri* were initiated in February'94 and continued up to January'95. A total of 5835 larvae of *C. montrouzieri* were released in the field (Table 122). During this period, insecticidal applications were suspended. The study on the impact of the releases on the population of the scale is in progress.

Table 122. Release details of *C. montrouzieri* against mango green shield scale

Time of release	No.of *Cryptolaemus* larvae released
July ,1994	850
August,1994	900
September, 1994	1000
October, 1994	450
November, 1994	800
December,1994	950
January, 1995	885
Total	5835

1.3.9.4. Persistent toxicity of some insecticides to the ber wax scale parasitoid *Anicetus ceylonensis* (IIHR, Bangalore)

A. ceylonensis is a key parasitoid of the wax scale *Drepanococcus chiton* on ber. A total of 17 insecticides were studied for their persistent toxicity by exposing the adult parasitoids at 1, 7, 14, 21, 28, 35, 42 and 50 days after treatment. Mortality of the parasitoids was recorded after treatment. Dichlorvos, endosulfan and methyl demeton proved non-toxic to *A. ceylonensis* on 7th day after treatment. However, cypermethrin showed higher residual toxic activity (42-50 days) against the adult parasitoids. Dimethoate proved harmless on 14th day, while phosphamidon, chlorpyriphos and acephate were found to be safe to the parasitoid on 21st day after application.

1.3.9.5. Field evaluation of *Leptomastix dactylopii* against *Planococcus citri* on pomegranate (IIHR, Bangalore)

P. citri was observed in severe form on 100 pomegranate plants in June - July, 1994. Releases of *L. dactylopii* were initiated in August, 1994 and continued upto January'95. A total of 8650 adult parasitoids were released during the above period (Table 123). Prior to the release, 35.70% of fruits were infested in April, 1994 and post release assessment revealed the fruit infestation had come down to 2.40 in April, 1995.

Table 123. Field releases of *L. dactylopii* against *P. citri* on pomegranate

Month of release	No. of releases
August, 1994	1500
September, 1994	1400
October, 1994	1825
Novembe, 1994	900
December, 1994	400

January, 1995	1800
February, 1995	825
Total	8650

1.3.9.6. Development of resistant strain in *Leptomastix dactylopii* to carbaryl by selection (IIHR , Bangalore)

Adult parasitoids were exposed to carbaryl. At the end of 15th generation when the adults were tested, there was no mortality of adults emerged from the immature stages treated with carbaryl upto 5 hrs of exposure. But in the adults exposed to the treated surface over a period of time there was 60% mortality. The data indicated that *L. dactylopi* had not acquired any resistance even after 15 generations (Table 124).

Table 124. Effect of carbaryl on the mortality of *L.dactylopii* at 15th generation

Treaatment	Mortality of adult parasitoids (%)					
	Hours after exposure					
	1	2	3	4	5	24
Check	0	10	15	45	55	100
Adult exposure	0	0	5	40	60	100
Immature stage exposure	0	0	0	0	0	97

1.3.9.7. Longevity and fecundity of *L. dactylopii* and *C. montrouzieri* as influenced by selective Pesticides (IIHR, Bangalore)

1.3.9.7.1. *L. dactylopii*

A total of 5 pesticides which did not cause any mortality of *L. dactylopii* were included in this study. Adults were exposed in glass vials treated with the pesticides for 24 hrs. Then they were transferred to clean vials and fed with 50% honey solution. All the chemicals reduced the longevity of adults significantly (Table 8). Adults treated with dicofol, dichlorvos and diflubenzuron survived for 10.90 to 12.50 days, while the check batch lived for 18 days. After 24 hrs of pesticide treatment 30 males and 30 females were exposed to the mealybug infested pumpkin to study the progeny production. Fecundity was drastically reduced by all the pesticides included in the present study (Table 125). The progeny production from the pesticide treated batch ranged from 129.67 to 204.33 but the untreated batch yielded 715.00 adults.

Table 125. Effect of selective chemicals on the longevity and fecundity of *L. dactylopii*

Treatment	Longevity (days)			No. of progenies produced
	Male	Female	PM	
Dichlorvos	8.37	15.20	11.70	132.33 (4.89)
NSKE	9.80	18.80	14.30	193.00 (5.26)
Difl	7.90	17.10	12.50	129.67 (4.87)
Copper	16.40	17.10	16.75	204.33 (5.32)
Dicofol	10.70	11.10	10.90	136.33 (4.92)
Check	16.50	19.50	18.00	715.00 (6.57)
SEm	0.071	0.094		0.051
CD at 5%	0.210	0.280		0.156

PM = Pooled mean
(Figures in parenthesis are log transformed values)

1.3.9.7.2. *C. montrouzieri*

Effects of six chemicals namely dichlorvos, chlorpyriphos, neem seed kernel extract, diflubenzuron, dicofol and copper oxychloride on the longevity, progeny production and feeding potential of *C. montrouzieri* was studied. The

adults were exposed to pesticides for 24 hrs and then transferred to clean vials. Daily mealybugs were exposed to the adults for oviposition until they died. Though there was slight variation yet the chemicals did not reduce longevity (Table 126). The longevity ranged from 68.67 to 91.90 in the treated batches while untreated batches survived for 86 days. The progeny production was also not influenced markedly by pesticides except Diflubenzuron which recorded only 278.67 compared to 419 in the untreated batch.

Table 126. Effect of selective chemicals on the longevity and fecundity of *C. montrouzieri*

Treatment	Longevity (days)			No. of progeny produced	No. of mealybugs consumed
	M	F	PM		
Dichlorvos	35	138	86.50	412.33	96.20
Chlorpyriphos	45	138	91.90	428.33	142.80
NSKE	44	111	77.50	587.00	93.50
Diflubenzuron	46	136	91.00	278.67	95.40
Dicofol	32	105	68.67	442.00	90.40
Copper oxychloride	38	104	87.50	408.00	92.50
Control	40	132	86.00	419.00	93.50

M=Male ; F=Female ; PM=Pooled mean

The first instar larvae were exposed to leaves treated with pesticides in glass vials for 24 hrs., transferred into clean glass vials in which a single larva was maintained. The predatory larvae were fed with mealybug nymphs (10-15 days old) daily until pupation. The data indicated that the feeding potential of *C. montrouzieri* was not affected by the chemicals used in the present study. However, the larvae treated with chlorpyriphos consumed more number of mealybugs.

1.3.9.8. Studies on the natural enemies of vine scale, *Hemiberlesia lataniae* (IIHR, Bangalore)

The lantana scale *H. lataniae* was observed in severe from on Bangalore Blue grapes at Singanaikanahalli near Bangalore. Shoots, leaves and bunches were found infested with the scales during April'95. The scale infested samples were collected and kept in cloth walled wooden cages to record the emergence of natural enemies. Only *Signiphora* sp. was obtained from the scales. Parasitism ranged from 14.6% in September, 1994 to 20.65% in March, 1995. No other parasitoid or predator was collected from April, 1994 to March, 1995. During September, 1994 160 adults of the coccinellid predator *Chilocorus nigrita* were released in the scale infested garden and neem seed kernel extract (5%) was also sprayed. In March, 1995, there was no fresh scale infestation observed.

1.3.9.9. Impact of natural enemies on the population of citrus green scale, *Coccus viridis* (IIHR, Bangalore)

Heavy infestation of *C. viridis* was observed on four year old acid lime plants at IIHR Farm in June'94. The data on the population of the scale and its predators were recorded on 4 shoots/tree. In each shoot top five leaves were chosen to record healthy and parasitized scales for working out the per cent parasitisation. Three predators namely *Chilocorus nigrita, C. circumdatus, Cryptolaemus montrouzieri* and an encrytid parasitoid *Encyrtus lecaniorum* were observed during the period under study. Results revealed that the scale population build up was high in June-August (Table 127). The population of the predators was also more during this period. Due to the activity of predators especially *C. nigrita* and *C. circumdatus*, the scale population was brought down heavily from September onwards. The parasitism was very low throughout the study and it did not play any significant role in suppressing *C. viridis*. There was slight increase in scale population during November-December but the predators did not appear. Neem cake (5%) was applied to reduce the scale population in January, 1995.

Table 127. Population of citrus green scale, *Coccus viridis* and its natural enemies on acid lime

Date of observation	Population per tree (4 shoots)				
	I	II	III	IV	V
14-06-1994	240.30	9.40	6.80	4.50	5.50
11-07-1994	304.20	11.60	14.50	7.30	1.60
12-08-1994	253.60	16.90	30.70	3.40	4.50
09-09-1994	83.80	3.30	9.40	6.60	6.40
10-10-1994	12.40	2.10	4.30	2.10	5.80
14-11-1994	48.30	0	0	0	3.70
12-12-1994	53.50	0	0	0	5.60
09-01-1995	11.20	0	0	0	1.80

I-Healthy scales; II- *C. nigrita*; III-*C.circumdatus*; IV-*C. montrouzieri*; V- per cent parasitism by *E. lecanionum*

1.3.9.10. Biological control of the spherical mealybug, *Nipaecoccus viridis* on acid lime IIHR, Bangalore)

In March, 1994 several acid lime plants were found to be infested with *N. viridis*. The mealybug population ranged from 130 to 186 per plant (4 shoots). The predator *C. montrouzieri* was not observed. However, the activity of parasitoids chiefly *Anagyrus* spp. was noticed in March, 1994 (Table 128). *C. montrouzieri* was released on 3rd March @ 20-30 per plant. Insecticidal applications were suspended 15 days prior to the release of the predator. *C. montrouzieri* larvae were seen feeding on the mealy bugs on 16th March. Mean population of the predator was 10.6 per plant in March. The activity of the predator and the parasitoids was observed upto June, 1994. Due to the action of natural enemies the mealybug population declined from April onwards and mealybugs were in negligible numbers in June, 1994. The orchard was monitored upto March, 1995 but the spherical mealybug did not appear again.

Table 128. Population of spherical mealybug, *Nipaecoccus viridis* and its natural enemies on acid lime

Date of observation	Population/plant (4 shoots)		
	I	II	III
02-03-1994	148.8	5.0	0.0
16-03-1994	221.3	8.1	10.6
04-04-1994	94.2	7.4	7.3
15-04-1994	38.6	3.3	4.2
02-05-1994	64.4	1.6	2.4
16-05-1994	3.5	0.0	.7
10-06-1994	1.4	0.8	1.3

I- Mealy bug ; II-*Anagyrus* spp. ;
III- *C. montrouzieri*

1.3.9.11. Studies on the natural enemies of citrus red scale *Aonidiella aurantii* (IIHR, Bangalore)

1.3.9.11.1. Biological studies on *A. melinus* and *C. nigrita*

A. melinus is an ecto parasitoid completing its life cycle in 18.1 days on *A. aurantii* while the coccinellid *C. nigrita* took 29.5 days to complete one generation (Table 129).

Table 129. Development of *A. melinus* and *C. nigrita* on citrus red scale

Stage	Developmental period (days)	
	A. melinus	*C. nigrita*
Egg	2.8	6.3
Grub		
I instar	1.6	3.3
II instar	2.4	2.4
III instar	3.6	3.0
IV insta	-	5.1
Pupa	7.5	6.0
Total	18.1	29.5

1.3.9.11.2. Field evaluation of *C. nigrita* against *A. aurantii*

C. nigrita was released @ 15 adults/tree. Population of the scales in released and unreleased plots at different time intervals is given in Table 130. The scale population gradually reduced from 7.0 to 0.6 in 40 days after release. The scale population was much less in released trees than in unreleased trees.

Table 130. Efficacy of predator *C. nigrita* in controlling *A. aurantii* on acid lime

Days after release	Mean scale population/plant	
	Released	Unreleased
0	7.0	5.2
10	6.0	7.4
20	2.0	14.4
40	0.6	23.4
50	0.0	32.2

1.3.9.12. Role of *Spalgis epius* in controlling the Oriental mealybug, *Planococcus lilacinus* on ber (IIHR, Bangalore)

At IIHR Farm, severe infestation of *P. lilacinus* was observed in December, 1994 on ber in Block No.3 of IIHR Farm. The ant *Camponotus compressus* was found attending the mealybug in large numbers. Chlorpyriphos (0.50%) was applied in the soil around the tree to check the activity of ants. The lycaenid predator *Spalgis epius* was recorded on 4 shoots of 30 cm length per tree at fortnightly intervals and are presented in Table 131. Within a month, the mealybugs were cleared completely by *S. epius*. No other natural enemy was recorded during the study period (Table 131).

Table 131. Population of *Planococcus lilacinus and Spalgis epius* on ber

Date of observation	Population/shoot	
	P. lilacinus	*S. epius*
04-12-1994	45.50± 9.12	3.70± 0.52
20-12-1994	10.30± 5.60	1.50± 0.61
03-01-1995	0.40± 0.15	0.30± 0.20

1.3.9.13. Seasonal incidence of woolly apple aphid in relation to natural enemies (YSPUH & F, Solan)

Seasonal incidence of the woolly apple aphid (WAA) along with the natural enemy activity at Nauni, Solan, on marked branches of 8 trees was monitored at weekly interval throughout the year. The trees remained free from aerial- aphid infestation from March 24 to May 12, 1994. On an average, less than one colony per replicate was observed upto July-end. Collar region/base of the stem of some trees had scattered population of the WAA and amongst those, mummified bodies with and without exit holes of the parasitoid *Aphelinus mali* were noticed during third week of June and some adult parasitoids were also present in such colonies on the last day of June. Four new trees on which infestation had appeared were selected for observation on August 18, 1994. Parasitisation of the aphid on branches and twigs of the tree was noticed during July end but within a short period it was on its peak (mid August to mid September) when aphid population was also comparatively high (3-9 colonies/replicate, average colony size between 0.25 - 00.43 cm and coverage of the aphid being 0.8 - 3.6 cm per replicate).

From third week of September to end of November, there was incipient aphid population (0.13-1.38 aphid colonies of 0.01 - 0.2 cm in size) and despite this, upto 0.6 mummies/replicate were noticed on experimental trees. During December, 1994 to March, 1995, colony count was 0.0 - 1.13 and colony size was 0.02 - 0.12 cm. The adult of *A.*

mali emerged from the over wintering population on apple tree on March 9, 1995.

Mummified bodies of *Eriosoma lanigerum* were collected from Nagger (74 in number) and Bajaura (8) and from Solan (132) in November, 1994, and kept for emergence of *A. mali*. Emergence was very poor (35.7%) in Nagger stock, but was satisfactory from Bajaura (62.5%) and Solan (75.8%) stock. From the mummies collected from Nagger, 7.1% adults emerged by Dec. 10, and 28.6% emerged during March. In the mummies without exit hole, 69, 14 and 17% were having dead larva, pupa and adult, respectively. However, from most of the mummies brought from Bajaura, adult emergence occurred by early December. Only from one mummy, an adult emerged in March. On the other hand, adult emergence from Solan stock in December was negligible (3.8%) while in March adults emerged from 72% mummies. Out of 24.2% mummies without an exit hole, 16.2% had a dead larva and 8.1% had a dead pupa in them. At Nauni, adults of *A. mali* were also seen on apple trees in March, 1995.

1.3.9.14. Seasonal incidence of San Jose scale in relation to natural enemies (YSPUH & F, Solan)

San Jose scale incidence was noticed in almost all orchards but at a very low profile at altitudes above 1500 m in Solan, Kullu and Shimla districts. Samples of twigs collected from Shimla, Kullu and Solan districts, had parasitisation by *Aphytis* sp. (*proclia* group), and it ranged from 0 - 12.8, 0 - 8.8 and 0 - 4.4%, respectively. *Chilocorus bijugus* was noticed to predate on the scale but in low numbers at Kullu and Kotkhai. Adults when brought to laboratory in November-December from trees having high scale population, failed to survive. Adult beetles of *Pharoscymnus flexibilis* and *Sticholotis marginalis* were commonly observed predating on scale insects in these areas.

Local strain of *Aphytis* sp. (*proclia* group) was collected from Kullu which was found to be a solitary thelytokous ectoparasitoid of the San Jose scale. Adults were noticed throughout the year except during December - February. Overwintering occurred in prepupal stage. Adults formed from overwintering stages were active and searched actively for feeding on the hosts and used the ovipositor to make a puncture on the scaly armature. The haemolymph from the body of the scale was imbibed. Often, young scales were used for this purpose. The female laid eggs singly on the body of the scale insect under its scaly armature. Occasionally prepupal-males and II instar females, and mostly mature females were parasitized. Adult females fed on honey, survived for 8-35 days (depending upon temperature) but they survived for 2 days only when offered water alone.

1.3.10. BIOLOGICAL SUPPRESSION OF VEGETABLE CROP PESTS

1.3.10.1. Collection and identification of natural enemies of vegetable crop pests (IIHR, Bangalore)

Survey for collection of natural enemies from different pests of vegetable crops was undertaken. *Campoletis chlorideae* was the chief natural enemy that parasitized *Helicoverpa armigera* to the tune of 12-28% on tomato. *Carcelia illota* and *Goniophthalmus halli* produced 1-8% and 0-6%, respectively. *Cotesia plutellae* was similarly observed as a potential parasitoid of *Plutella xylostella*, producing 12.3 to 46.5% natural parasitism. Aphid parasitism was less under field conditions but, 25.93% parasitism was obtained under glasshouse conditions. Chow-chow was severely infested by the mealybug *Planococcus lilacinus*. Following withdrawal of insecticide natural enemies like chrysopids, drosophilids and a species of coccinellid have appeared in large numbers. Species level identification is yet to be made (Table 132).

Table 132. Collection of natural enemies from pests of vegetable crops

Crop /pest	Natural parasitism	Natural enemies
Field condition		
Tomato		
Helicoverpa armigera	12 - 28%	*Campoletis chlorideae*
	1 - 8%	*Carcelia illota*
	0 - 6%	*Goniophthalmus halli*
Cabbage		
Plutella xylostella	12.3 - 46.5%	*Cotesia plutellae*
Crocidolomia binotalis	-	-
Myzus persicae	-	-
Lipaphis erysimi	0 - 2.5%	*Aphidius* sp.
Chow- Chow		
Planococcus lilacinus	-	Undetermined species of chrysopids, coccinellid, drosophilid
Glasshouse condition		
Brinjal		
Bemisia tabaci	1%	*Encarsia* spp.
Chillies		
Myzus persicae	2.05-25.93%	*Aphidius* sp.

1.3.10.2. Large scale field trial with *Trichogramma pretiosum* against tomato fruit borer (IIHR, Bangalore)

Two field trials were conducted with *T. pretiosum* against *H. armigera* on tomato. Two release dosages were effected viz., 2.5 and 5 lakh adults/ha. A total of six releases were made at weekly intervals from the time of flower initiation. Observations were made on number of fruits damaged due to borer and the number of healthy fruits. The crop where 2,50,000 adults were released, had to be abandoned half way through as there was heavy incidence of leaf curl disease during the month of June, 1994 and chemical control measure had to be resorted to. However, the yield data (Table 133) revealed less degree of damage (7.72%) compared to control (12%). Borer damage was very less (3.66%) in the field where egg parasitoids were released at the rate of 5 lakh adults/ha. The mean per cent parasitism was 30.2 and 48.5 in 2.5 lakh and 5.0 lakh adults released fields, respectively. However, no parasitism was observed in control field. The result thus reflected reduced damage with increase in release numbers.

Table 133. Effect of release of egg parasitoid *T. pretiosum* in farmers' field against tomato fruit borer, *H. armigera*

T. pretiosum released/ha	No. of fruits		Damage (%)	Mean parasitism (%)
	D	H		
2,50,000	188	2435	7.72	30.2
5,00,000	112	3114	3.60	48.5
0 (Control)	264	2200	12.00	-

D=Damaged fruits ; H=Healthy fruits

1.3.10.3. Efficacy of *Trichogramma pretiosum* against *Helicoverpa armigera* in tomato (MPAU, Pune)

The experiment was conducted at the farm of College of Agriculture, Pune in Kharif 1994. Five releases of *T. pretiosum* were made @ 50,000 adults/ha/week after appearance of *H. armigera*. Observations were recorded on healthy and infested tomatoes of each picking. The data are presented in Table 134.

Table 134. Efficacy of *Trichogramma pretiosum* against *Helicoverpa armigera* on tomato

Treatment	Mean infestation (%)	Control (%)
Trichogramma pretiosum released @ 50,000/ha/week	9.38	68.26
Control	29.56	-

The data indicated that *H. armigera* infestation in tomato fruits was significantly reduced due to releases of *Trichogramma pretiosum*. The parasitoid suppressed the pest to 68.26% over untreated control.

1.3.10.4. Field evaluation of *Trichogramma pretiosum* against *Heliothis armigera* on tomato (GAU, Anand)

To evaluate the effectiveness of *Trichogramma pretiosum* against *H.armigera* in tomato an experiment was laidout at Agronomy farm, BA College of Agriculture, GAU, Anand in the year 1994. Five weekly releases of *T. pretiosum* @ 50,000 per hectare after appearance of *H. armigera* in the crop was compared with an unreleased plot.

a. Egg parasitism

The eggs of *H. armigera* were collected weekly, and were reared in the laboratory to record the per cent parasitism.

b. Population of *Cyrtopeltis tenuis*

The observations on *Cyrtopeltis tenuis* and *Nabis* sp. were also recorded at weekly interval by examining 20 terminals from 20 randomly selected plants.

c. Egg and larval population of *H. armigera*

20 plants were selected at random and were thoroughly examined for the presence of eggs and larvae of *H. armigera*. The data thus collected were represented as eggs / larvae plant.

d. Fruit damage and yield

At each harvest , a sample of 500 fruits was taken and per cent fruit damage by *H. armigera* was worked out. The yield of marketable fruit was also recorded from the net plot.

The results presented in Table 135 revealed that per cent parasitism by *T. pretiosum* was significantly higher (44.42%) in released plot as compared to check plot. The effectiveness of the releases was further substantiated by significantly lower counts of larval population of *H.armigera*.

Table 135. Effectiveness of inundative releases of *Trichogramma pretiosum* against *Heliothis armigera* in tomato

Character	Release plot	Check plot	SEd	t'	
				Cal.	Tab.
Egg parasitism (%)	44.42	6.06	7.52	5.10*	2.064
Number of *Cyrtopeltis tenuis*	1.00	1.08	0.14	0.56	2.074
Number of *Nabis* sp.	0.16	0.15	0.03	0.43	2.086
Number of *H.armigera* eggs	0.45	1.01	0.14	3.91*	2.056
Number of *H.armigera* larvae	0.06	0.20	0.38	3.67*	2.056
Fruit damage(%)	5.69	24.23			
Yield (q/ha)	21.81	19.04			

* Significant at 5%

The data on fruit damage also indicated that the release plot recorded much less damage (5. 69%) than control (24.23%). There was 2760 kg more fruit yield/ha an in release plot. The data on *C. tenuis* indicated that the predator could be conserved in nature.

1.3.10.5. Performance of the egg parasitoid *Trichogramma pretiosum* against tomato fruit borer, *Helicoverpa armigera* (YSPUH & F, Solan)

On seedlings of Solan Gola and Yashwant tomato cultivars, transplanted by mid March, *H. armigera* had laid sufficient eggs by the end of March. On April 2, about 41% seedlings were found to have on an average 1.1 eggs per plant. Releases of the parasitoids, *Trichogramma pretiosum* were made on the basis of 5000 parasitized *Corcyra cephalonica* eggs/ha in two 250 m^2 plots. A week after the release, 58.3% of eggs collected from the release-plots were parasitised while about 1km away from the release plot, natural parasitisation was upto 35%. The male : female sex ratio was 2.5 : 1. Second release was made 10 days after the first one, when egg-density/plant was 0.8-0.9 and the parasitisation recorded was 93.4% after a week of the second release. In the beginning of May, third release was made. From 20 plants observed at random 18 and 12 eggs were collected from these 2 plots and out of these 27.8% were parasitized. In the control plot also parasitisation was 30%. Three weeks later (end of May) egg density was very low (on 40 and 30 plants, hardly 18 and 14 eggs were seen). These eggs were marked and five days after the release, it was found that 37.5% of these eggs were parasitized. The male:female sex ratio of the parasitoid reared from these eggs was 2.1:1. In the control plot, no egg laying was observed.

The late second or early third instar larvae were also collected from the experimental plots and reared in the laboratory. 4.5 to 12 per cent of the larvae were found to be parasitized by the ichneumonid *Campoletis chlorideae*.

1.3.10.6. Studies on the parasitoid of tomato leaf miner *Liriomyza trifolii* (IIHR, Bangalore)

A survey to record the incidence of *Liriomyza trifolii* and collection of its parasitoids were made in and around Hessaraghatta. The incidence of the pest was very poor throughout the year and no natural enemy was collected from the pest held in chest chambers. The natural incidence of the pest was ranging from 0.83 to 4.70%.

1.3.10.7. Control of aphids on capsicum by releasing *Chrysoperla carnea* (IIHR, Bangalore)

A preliminary pot culture study was conducted under glass- house conditions to fix the dosage of *C. carnea* to be released under field conditions. Capsicum plants were raised in pots and held

under glasshouse. *M. persicae* was artificially released for 24 h before releasing the predator *Chrysoperla carnea* @ 1:5, 1:10, 1:15, 1:20, 1:25 and 1:50 of the aphids. Observation on the number of aphids consumed and the number of aphids alive 3 days after predator release was made and per cent reduction worked out.

The data presented in Table 136 revealed that the maximum reduction of aphids was observed in treatment where the predator prey ratio was 1:5. However , around 50% reduction was obtained with treatment upto 1:20. Other treatments viz., 1:25 and 1:50 produced 46.39 and 37.00% reduction in aphid population.

Table 136. Effectiveness of releases of *Chrysoperla carnea* against aphid *M. persicae*

Ratio of *C. carnea* released	Population reduction after 3 days (%)
1 : 5	80.34
1 : 10	61.59
1 : 15	55.93
1 : 20	49.31
1 : 25	46.39

1.3.10.8. Evaluation of *Cryptolaemus montrouzieri* and *Leptomastix dactylopii* against mealybug in chow- chow (IIHR, Bangalore)

A chow-chow garden severely infested by the mealybug *Planococcus lilacinus* despite heavy dose of insecticide was selected for the trial. No natural enemy was observed in the field. The farmer was advised to stop the insecticidal application to facilitate release of biocontrol agents. *C. montrouzieri* and *L. dactylopii* were found established in the garden following weekly inoculative releases of them 21 days after stopping insecticides. Native natural enemies such as green lacewings, drosophilid and a coccinellid had appeared later in large numbers which also helped finally to check the mealybug menace on chow-chow.

1.3.10.9. Field evaluation of integration of release of *Trichogramma pretiosum* and sprays of NPV for the control of *H. armigera* (IIHR, Bangalore)

Tomato variety Arka Sawrab was transplanted in the month of December with four plots of size of 5 x 5m. A total of 4 treatments viz., i) Parasitoid released alone at the rate of 5,00,000 adults/ha; ii) 5,00,000 adult/ha + HaNPV sprayed at 250 LE/ha; iii) 5,00,000 adult/ha + HaNPV at 12.5 LE/ha and iv) endosulfan (0.07%) and parasitoids at 5,00,000 adults/ha.

A control plot was maintained at a different place in the same block. Parasitoid releases were kept common because pure chemical control plot or HaNPV plot could not be maintained in the same area.

A total of six releases of parasitoid were made from the flower initiation period at weekly intervals. Similarly, HaNPV and endosulfan were sprayed at 8 and 10 days interval, respectively, from the date larval incidence was observed. A total of 4 sprays of HaNPV and 3 sprays of endosulfan were made for the control of *H.armigera*. In each treatment, six replications were maintained and 3 plants/plot or replication were observed for the incidence of eggs, larva, parasitized eggs, diseased larva, etc. Finally , healthy and damaged fruits due to borer were separated and weighed to work out the per cent borer damage.

The parasitism was nil before release of the parasitoid. The incidence of borer was also very low during this period which ranged between 0.0 to 22.0%. This has amply reflected on the level of parasitism in the field. Post- release count showed 0.0 to 0.40% parasitism. However, very few larvae were observed.

The data on the average per cent borer damage in each treatment are presented in Table 137. The control plot had 12.0% borer damage whereas the lowest damage of 3.58% was observed in the plot where both parasitoid and HaNPV at 250 LE/ha were used. This was however, on par with parasitoid alone, parasitoid and HaNPV at 125

LE/ha and endosulfan treated plot, where the borer damage was 3.60, 4.02 and 4.72%, respecuvely, which were significantly less than control.

Table 137. Effect of integration of both *Trichogramma pretiosum* and HaNPV against *H. armigera*

Treatment	Borer damage (%)
5,00,000 adults/ha	3.60
5,00,000 adults/ha+ HaNPV 250 LE/ha	3.58
5,00,000 adults/ha+ HaNPV 125 LE/ha	4.02
Endosulfan at 0.07% + parasitoid @ 5,00,000 adults/ha	4.72
Control	12.00

1.3.10.10. Parasitisation of *Pieris brassicae* (YSPUH & F, Solan)

On cauliflower the first egg cluster of *P. brassicae* was noticed on March 8, 1994, the tenth standard week. Three egg clusters containing 341 eggs could be observed on 180 plants kept under observation. Larva hatching from these eggs were allowed to feed on plants '*in situ*' till end second instar/early third instar and then these were brought to the laboratory for further rearing. The dead larvae were daily dissected to know the cause of death. Majority of the larvae (80.6%) died due to parasitism by the braconid *Cotesia (Apanteles) glomeratus*. The ichneumonid *Hyposoter ebeninus* caused the death of 4.7% larvae in the fourth instar and 11.8 % larvae died due to bacterial infection. There was extensive hyperparasitisation of larvae of both the parasitoids by the eulophid *Baryscapus (Eutetrastichus*) species. While no adult of *H. ebeninus* could be reared, those of *C. glomeratus* started emerging from cocoons formed from the larvae of the butterfly of the first generation by the first week of April. The adult emergence of the butterfly began a week later. Thus by the time egg laying by the second generation adults (only 3% adults formed from 341 eggs) commenced. *C. glomeratus* adults were already active for parasitisation of young larvae of the butterfly.

From 15th March onwards, 180 plants were thoroughly observed almost on alternate days till maturity of the seed crop i.e. 10th May, 1994. The freshly laid egg-clusters were marked and numbered to record the rate of larvae developing from these eggs. From 11th standard week, eggs were laid and maximum (54.8% of the total) number of clusters were laid in 14th standard week, when the per cent infested plant averaged 1-1.6. During this egg laying period, butterflies exploited 63 of 180 plants and on 36, egg laying occurred. The average number of eggs/cluster was 80.4 ± 4.2.

The adult wasps of *C. glomeratus* were present nearby the egg cluster, waiting for them to hatch. As soon as the eggs hatched parasitization began. Such larvae which were young and heavily stung by the parasitoids often died due to superparasitisation. Some of them contained as many as 10 eggs of the parasitoid. Eggs were also damaged by predatory insects (wasps *Polistes* sp. and coccinellids mainly *Coccinella septempunctata*). Egg predation was upto 11.7%. Most of larvae from egg clusters kept under observation died by the II or III instar (36.9 and 31.1%). Mortality also occurred in the I (10.7% of the egg clusters), IV (6.8%) and V instar (2.9%). Thus natural parasitisation took a heavy toll of the *Pieris brassicae* larvae. These parasitoids in turn were heavily parasitized by the secondary parasitoid *Baryscapus* sp. as stated earlier, thus putting a check on multiplication of the parasitoids.

1.3.11. BIOLOGICAL SUPPRESSION OF POTATO PESTS

1.3.11.1 Efficacy of parasitoids and microbial agents (alone and in combination) in comparison with recommended insecticide for the control of potato tuber moth, *Phthorimaea operculella*

The parasitoids, *Chelonus blackburni* and *Copidosoma koehleri* and Granulosis virus (GV) were tested alone and in combination in comparison with 0.05% endosulfan as a recommended insecticide during kharif and rabi seasons in cultivator's fields in the district of Pune in a randomized block design with three replications.

The various treatments were started after appearance of the potato tuber moth which was noted with the help of pheromone baited traps. In parasitoid alone treatment 4 releases at weekly interval were made. In case of parasitoid and microbial agent combination treatments, two releases of parasitoids and two sprays of GV were given alternately. In case of microbial treatments, 3 sprays were given at 10 days interval and endosulfan at 0.05% was applied as recommended by the Department of Agriculture, Maharashtra state.

Observations were made on recovery by placing laboratory reared host egg cards, retrieved after 2 days and reared further for working out per cent parasitization. At harvest the count on healthy and infested tuber were taken in each treatment plot. The results are presented in Table 138.

The results on per cent control achieved were non- significant during Kharif. However, the treatment with release of *C. blackburni* in combination with GV reduced the infestation of potato tuber moth to 60.00% under field conditions followed by *C. koehleri* +GV (58.46%), *C. blackburni* (55.8%) and *C. koehleri* (50.045).

During Rabi season the treatment with *Chelonus blackburni* + GV was found to be effective in reducing the potato tuber moth infestation under field conditions. It suppressed the pest to an extent of 50.08 per cent over control and was at par with *C. blackburni* alone, *C. koehleri* + GV. *C. koehleri* alone and GV. The per cent parasitization on retrieved egg cards by *C. blackburni*, *C. koehleri* and *T. chilonis* were 70.00, 66.7 and 63.35, respectively.

1.3.11.2 Efficacy of biotic agents against potato tuber moth in country store (Arni)

A laboratory experiment was conducted between 9th February and 31st March, 1995. The rabi harvested potatoes were used @ rate of 20 kg healthy potatoes/treatment. Microbial agents viz., Granulosis virus (GV) and *Bacillus thuringiensis (B.t)* of BARC, Bombay, strains and formulations, were used @ 1gm/kg of potatoes. The potatoes along with requisite quantity of GV & *B.t.* were shaken well in plastic tub to smear them all over the potatoes. Then 50 pairs of potato tuber moth were released on each treatment for 2 days and then miniature 'Arnies' were constructed. The parasitoids were released as per treatments after this.

Observation were recorded on 31st March, 1995 on healthy and second generation infested tubers. The data recorded along with treatment details are given in Table 139.

Both the parasitoids *Copidosoma koehleri* and *Chelonus blackburni* were found promising in suppression of the pest to the extent of 67.75 and 62.70 per cent, respectively, over control. The microbial agents Granulosis virus and *Bacillus thuringiensis* were found ineffective against potato tuber moth under stored conditions.

1.3.11.3 Occurrence of natural enemies on potato tuber moth in different seasons

Collection of larvae mining into potato foliage and infested tubers at harvest were periodically

Table 138. Efficacy of parasitoids and microbial agents for the control of potato tuber moth

Treatment	Kharif 1994			Rabi 1995		
	Mean infestation	Control (%)	Recovery	Mean infestation	Control (%)	Recovery
Chelonus blackburni @ 15,000 adults / ha / release	5.77	55.80	66.7	9.20	49.78	70.00
Copidosoma koehleri @ 50,000 adults / ha / release	6.52	50.04	53.3	5.14	50.08	-
Trichogramma chilonis @ 1.5 lakh adult / ha / release	7.61	41.68	46.7	9.58	47.67	66.70
Granulosis virus @ 500 Le / ha / spray	5.77	55.78	-	10.23	44.12	-
Bacillus thuringiensis @ 1.10×10^9 spores / ml	7.31	43.98	-	12.03	34.29	-
Endosulfan (0.05%)	8.68	33.48	-	13.73	25.01	-
Chelonus blackburni @ 15,000 adults / ha / release Granulosis virus	5.22	60.00	-	13.98	23.64	63.35
Copidosoma koehleri + GV ha / release	5.42	58.46	-	15.30	16.43	-
Control	13.05	-		18.31	-	-
SE ±		2.01			0.98	
CD at 5%		NS			2.75	

Table 139. Efficacy of parasitoids and microbial agents against potato tuber moth in country store (Arni)

Treatments	Dose	Infestation (%)	Control (%)
Copidosoma koehleri	50 adults/kg	30.76	67.75
Chelonus blackburni	10 adults/kg	35.86	62.70
Granulosis virus	1 gm/kg	86.95	8.84
Bacillus thuringiensis	1 gm/kg	89.71	5.97
Control		95.39	-

obtained from four villages in potato growing areas of Pune and Satara and reared in the laboratory.

Two parasitiods, *Apanteles* sp. and *Bracon* sp. emerged from the larvae feeding on foliage in rabi season of 1994- 95

1.3.11.4 Storage studies on *Chelonus blackburni*

C. blackburni pupae of uniform age were kept in the incubator at 10°C temperature on 1st August, 1994. From the stock, 5 pupae were taken out and observed for adult emergence at various periods of storage.

Adult emergence was 100% from pupae stored upto 7th day. The pupae were viable even after 17 days of storage at 10°C but no emergence was observed after the 17th day.

The experiment was repeated in October, 1994 and the results were found to be in conformity with the first trial.

1.3.11.5 Storage studies on *Trichogramma chilonis*

A laboratory experiment was conducted to study the viability period and days required for adult emergence of *Trichogramma chilonis* stored at 10°C. From the stock daily a piece of trichocard was removed and kept for adult emergence. The observations were recorded on per cent emergence and days required for emergence of adults after exposure of stored trichocard.

It was observed that the emergence of *Trichogramma chilonis* adults was more than 50 per cent upto 35 days from the date of storage of trichocards at 10° C temperature. About 3 days were required for emergence of adults after removal of trichocards from storage.

1.3.11.6 Host searching capacity of Trichogramma chilonis

In order to distribute the parasitoid evenly, it is necessary to place trichocards at definite interval in the field. It was therefore, felt necessary to study the host searching capacity of *Trichogramma chilonis.*

In a potato growing area of Pune district ten different fields were selected and were ascertained for absence of *T. chilonis* by placement of host egg cards from 1 to 10 metres at four (East, West, North & South) directions. Then about 100 *Trichogramma chilonis* parasitoids were liberated from the centre, each in ten different potato fields. The egg cards were retrieved 2 days after liberation of *T. chilonis* and kept in the laboratory for further observations on parasitization. The data recorded are presented in Table 140.

Table 140. Host searching capacity of *Trichogramma chilonis*

Distance from parasitoid liberation point (m)	Parasitization (%)			
	East	West	North	South
1	68.51	50.0	62.68	43.90
2	51.66	29.03	33.53	49.50
3	39.39	32.43	36.59	36.95
4	22.22	15.0	21.42	17.18
5	11.36	10.25	8.77	10.20
6	5.76	5.55	7.40	5.20
7	8.21	6.09	3.12	3.14
8	4.16	2.56	3.92	1.56
9	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0

The data in Table 140 indicates that the parasitoid, *Trichogramma chilonis* is able to locate its host up to a distance of 8 metre from the point of release. However, maximum percent parasitization was observed at shorter distance and it decreases away from the release point. It was also noted that the percent parasitization was more towards east which is the wind ward direction.

1.3.12. BIOLOGICAL SUPPRESSION OF WEEDS

1.3.12.1. Evaluation of biological control of parthenium (IIHR, Bangalore)

Observations were continued on the role of *Zygogramma bicolorata* in suppressing parthenium infestation in a 7500 sqm plot in the IIHR campus. The above plot, which was fully under parthenium cover was allotted in June, 1992 for demonstrating the effect of the beetle.

During 1994, parthenium infestation was found to have increased slightly, along the border to cover about 5% of the total area. The rest of the area was covered mainly by grasses and hardly any parthenium plants could be located in the middle of the plot. Due to an increase in the population of the beetle during July, the weed was defoliated completely by September, 1995.

The present studies clearly demonstrate the effectiveness of *Z.bicolorata* in suppressing parthenium weed in uncultivated horticultural fields. It thus appears that the best way of controlling parthenium in waste and fallow lands, is to leave the weed stand undisturbed so that *Z. bicolorata* can suppress it and encourage the growth of competing vegetation. It has already been demonstrated that manual and mechanical control operations encourage renewed weed growth.

The area of dispersal of *Z. bicolorata* is estimated to be around 200,000 sqkm in the southern states of Karnataka, Tamil Nadu and Andhra Pradesh. The insect is also reported to be spreading around Vindyachalnagar in Sidhi district of Madhya Pradesh (It is likely to disperse into the bordering states of Bihar and Uttar Pradesh during 1995). Confirmation of establishment of the insect has been received from Patiala and Chandigarh in Punjab.

1.3.12.2. Surveys in farmer's fields in and around Bangalore for feeding by *Z. bicolorata* on sunflower (IIHR, Bangalore)

During July 1994, based on a report by the Assistant Director of Agriculture (AA0),Kadur Taluk, Chickmagalur district, the project leader visited Kadur along with scientists from the Project Directorate of Biological Control, Bangalore. As per the information provided by the AAO a total of 10442 ha area was under sunflower crop during Kharif, 1994. Among these feeding by the beetle was noticed in five fields with a total area of two ha.

During the field visit it was noticed that parthenium plants throughout Kadur taluk were defoliated by *Z. bicolorata* and also that the majority of sunflower fields were affected by the beetle. It was also observed that the affected fields had defoliated parthenium stands adjoining them.

During a subsequent visit in September 1994 as part of the ICAR fact finding Committee on parthenium the AAO of Kadur informed that the beetles had moved away from the crop in the affected fields within 2-3 weeks and no further feeding was noticed. Slight feeding was noticed in a half acre field at Ajampur which was surrounded by defoliated parthenium stand.

In August, 1994 the parthenium infested areas and sunflower fields in Hunsur taluk and Mysore, district were surveyed. The observations in Hunsur were contrary to what was observed in Kadur, with respect to feeding by the beetle on sunflower, when pre-flowering sunflower crop and defoliated parthenium stands are located side by side. Population explosion of *Z.bicolorata* was noticed in both areas.

Although feeding by *Z. bicolorata* on sunflower under field conditions is an established fact, observations over the past 3 years clearly show that damage caused is not alarming. This is borne out by the fact that there was no increase in feeding on sunflower reported in spite of its dispersal from 50,000 sqkm in 1992, to more than 200,000 sqkm

in 1994. Further, feeding has so far not been reported at the same location in different years.

1.3.12.3. Seasonal incidence of natural enemies of *Z. bicolorata* (IIHR, Bangalore)

During 1993 a larval pupal parasitoid (?) *Chaetexorista* sp. (Diptera: Tachinidae) was recorded for the first time from *Z. bicolorata*. Weekly surveys were carried out during June-November, 1994 to study its seasonal incidence. Eggs and all larval stages of the beetle were collected from the field and kept under observation in the laboratory for recording parasitoids.

No parasitoids were noticed to emerge from the egg or larval stages of the beetle. The tachinid parasitoid pupated inside the pupal chamber of the host and emerged as adults about 3-7 days after emergence of unparasitised host adults.

Seasonal incidence studies carried out by collecting larvae at weekly intervals from the field revealed that the incidence of the parasitoid was noticed in the last week of August. The maximum period of activity (7.8-11.4% parasitism) was between September and November (Table 141).

Table.141. Parasitism of *Z. bicolorata* by *Chaetexorista* (?) sp.during June-November 1994.

Month	Larvae collected	Number parasitized	Parasitism (%)
June	238	0	0
July	224	2	0.89
August	340	7	2.08
September	360	44	11.38
October	283	22	7.77
November	179	19	10.61

1.3.12.4. Studies on the factors responsible for low egg hatchability of *Z. bicolorata*

Laboratory studies carried out during the previous year using individual females indicated that single mated females produced more fertile eggs compared to multiple mated ones. Confirmatory studies were carried out involving mass reared adults. The various treatments involved were unmated, once mated as well as females and males in the ratios 5:2, 3:3 and 3:6 per cage.

Observations over a period of one month revealed that significantly more eggs were laid by adults with sex ratios of 3:3 and 3:6 compared to other treatments. It was also observed that the number of eggs laid by once mated females was on par with those laid by 5:2 treatment. Unmated females were also capable of laying eggs although the number of eggs laid was very low (Table 142). Not much variation between the various treatments was noticed during the present studies .

1.3.12.5. Studies on diapause in *Z. bicolorata* (IIHR, Bangalore)

During the period under report laboratory studies were carried out on the factors inducing diapause and the physiological changes associated with diapause in *Z.bicolorata*. As earlier studies had indicated that adults are capable of undergoing diapause even when conditions are favorable for reproduction, monthly observations were carried out with field collected adults. The adults were released in diapause cages with a column of moist soil. Fresh leaves of parthenium were provided as food and the number of adults that entered the soil for diapause was recorded. Five replications involving 10-25 adults per cage were maintained.

The studies revealed that the adults collected in June did not diapause. This is probably due to the fact that the field population consisted mostly of adults that had emerged from diapause, indicating that they diapaused only once in their life span. About 10% of the adults were noticed to enter into diapause during July, which increased gradually and peaked at 71.43% in December (Table 143).

Table 142. Effect of frequency of mating on hatchability of Z. *bicolorata* eggs

Status		Eggs / Female	Hatching (%)
Unmated	1	14	0
	2	44	0
	3	33	0
	Mean	30.33± 15.18	0
Once mated	1	211	72.43
	2	282	51.23
	3	192	55.26
	Mean	228.33± 47.48	59.64 ± 11.26
5 Females : 2 Males	1	397 54.98	
	2	328	62.39
	3	177	59.93
	Mean	30.67 ± 125.52	59,10 ± 3.77
3 Females : 3 Males	1	537	56.38
	615	60.57	
	3 589	58.13	
	Mean	583.33± 41.02	58.36 ± 2.10
3 Females : 6 Males	1	513	55.96
	2	596	51.30
	3	523	51.97
	Mean	544.00 ± 45.31	53.07 ± 2.52

Table 143. Incidence of diapause in field collected adults of Z. *bicolorata* during different months in 1994.

Month	Number of adults	Number diapaused	Diapause (%)
*June	100	0	0
July	100	12	12.00
August	96	27	28.12
September			
October	45	9	20.00
November	94	33	35.12
December	70	50	71.43

* Adults not available in the field at Hessaraghatta as there was no rain

In another experiment field collected adults were released in rearing cages without soil. They were provided fresh leaves of parthenium once every 2 to 3 days for a month and then released into two cages. Fresh green leaves of parthenium were provided in one and dry twigs in the other, simulating depletion of food. These studies clearly established that the percentage of diapause increased significantly in the absence of food.

For observations on the effect of diapause on indirect flight muscles, build up of fat body reserves and development of ovarioles and testes both diapausing and non- diapausing adults from the previous experiment were collected and preserved separately in alcohol. Dissection of these adults revealed that in diapausing adults the

indirect flight muscles were thin stranded as compared to well developed flight muscles in the case of non-diapausing adults. This study indicates that diapausing adults are incapable of flight.

Marked differences were also observed in the maturation of reproductive organs. Thus the testes of diapausing adults had a shrivelled appearance as compared to active ones. Similarly the ovarioles in diapausing adults were found to be in the pre-vitellogenesis phase. It was also observed that the fat bodies were well developed in diapausing adults, while only traces could be located in non-diapausing ones

1.3.12.6 Biological control of water hyacinth by releases of *Neochetina eichhorniae*, *N. bruchi* and *Orthogalumna terebrantis*

1.3.12.6.1 PAU, Ludhiana

In a pond near Ludhiana where releases of *Neochetina eichhorniae*, *N. bruchi* and *Orthogalumna terebrantis* were made during 1992 to control water hyacinth , the breeding of the first two species was observed. The damage to leaves and petioles by the weevils was also observed at different sites in the pond. The pond dried up during the winter but fresh growth has again started with the onset of summer. So far , the weevils have failed to control the weed in spite of their presence and feeding.

1.3.12.6.2. AAU, Jorhat

In Disangmukh area of Sibsagar district about 5000 bighas of water hyacinth have been cleared off by this exotic insect species. The weevils have now dispersed through rivers or by aerial migration to about 200 km upto Nagaon in the West and Dibrugarh in the eastern direction from the initial release site (AAU campus). The population build up and intensity of damage was recorded in these newly migrated areas (Tables 144 & 145).

1.3.12.6.3 KAU, Kerala

Sampling of water hyacinth plants from Alleppey, Kottayam, Ernakulam and Calicut was done and the details are presented in Table 146.

1.3.12.6.4. MPAU, Pune

The culture of *Neochetina* spp. from IIHR Bangalore, was mass multiplied in a fresh pond and then collected and released in 4 different water hyacinth infested ponds @ 2000 adults/pond in Pune.

Observations were recorded twice at 3 monthly intervals on feeding scars on 25 leaves on the basis of scale 0-4 suggested (0-nil, 1-25% leaf area damaged, 2-50%, leaf area damaged, 3 -75% leaf area damaged, 4 - above 75% leaf area damaged). Observations were also recorded on the population build up by randomly sampling 25 plants in each pond. The adult weevils were counted per plant.

The data indicated (Table 147) that the weevils, damaged the water hyacinth from 25 to 50 per cent within the plant period of six months and an average of 1.79 and 2.35 weevils were recorded in first and second observations, respectively, taken at three months interval, indicating the development and multiplication of the weevils under Pune conditions.

1.3.12.6.5. GAU, Anand

Releases of the weevils were made in ponds in GAU (Gujarat) infested with water hyacinth on 27.6.1992.

Periodical observations have revealed that the weevils have adopted to the new environment very well as evidenced by the presence of larvae and adults in the bulbs and fresh damage on the leaves. The adult count varied from 0 to 7.80 per plant, and 0 to 231.8 per leaf (Table 148) . The weevils have been collected from the ponds which are 10 km. away from the original release site indicating the migration of the weevils.

Table 144. Establishment of *Neochetina eichhorniae* and *N. bruchi* in Assam

Location	No. of adults			Intensity of leaf damage			No. of scars/ leaf		
	July/94	Dec/94	July/95	July/94	Dec/94	July/95	July/94	Dec/94	July/95
Tocklai river	1.92	1.76	1.28	0.88	1.52	1.36	84.44	82.08	95.12
Alengmara	1.84	1.76	3.88	1.36	1.52	0.72	94.84	139.20	19.40
Disangumukh	4.04	2.16	2.60	2.40	1.88	1.80	230.00	184.52	207.36
Nimati	0.80	1.84	2.24	1.36	1.72	0.32	90.76	91.04	43.28
Kakajan	2.32	2.20	2.68	1.88	0.80	0.28	205.84	100.64	26.72

Intensity of leaf damage 0-4 scale . 0-Nil,1=25% leaf area damaged 2=50% leaf area damaged, 3=75% leaf area damaged. 4 above 75% leaf area damaged.

Table 145. Establishment of *Neochetina eichhorniae* and *N. bruchi* in different locations

Location	No. of adults	Intensity leaf damage	No. of scars/ leaf
Bokakhat	1.56	1.52	144.56
Nowgaon (Marikilong)	1.32	1.48	114.48
Dibrugarh (Bairagimoth)	1.48	1.28	42.32

Large scale preliminary survey of water hyacinth weevil was carried out between 11.1.95 to 10.2.95 in Kheda district. Two persons independently recorded the weevil as well as visual counts of scars caused by the weevil per leaf.

The weevils could migrate long distances as the infestation was observed in 23 ponds located 50 km away from the original site (Table 148).

1.3.12.7 Monitoring and evaluation of *Orthogalumna terebrantis* (Galumnidae : Acarina) (KAU,Trichur)

Field releases of *O. terebrantis* commenced during 1990 and during the last four years, the mite has established well over the release sites. It has also reached some new locations like Cochin city, about 50 kms from the original release site at Alleppey.

Almost 100 per cent plants show the mite infestation in all the released locations. However, the brownish or yellowish streaks which are typical symptoms of the mite infestation are confined to older leaves of old plants.

In spite of the widespread establishment of the mite the overall impact on *Eichhornia* stand is not very satisfactory. This is probably because of the quick regrowth and multiplication of the weed.

Table 146. Population of *N. eichhomiae* and morphological parameters of water hyacinth at different locations in Kerala

Location	Month	No. of leaves	Length of leaves (cm)	Breadth of leaves (cm)	No. of weevils	No. of scars
Alleppey	June '94	6.50	56.06	2.81	0.88	67.75
do-	December '94	7.00	64.70	13.95	0.90	25.00
Kottayam	June '94	7.00	54.35	9.30	0.30	0.00
do-	December '94	7.10	45.20	7.93	0.60	0.20
Ernakulam	June '94	7.00	59.20	11.25	9.80	92.50
-do-	December '94	6.70	60.20	10.65	8.50	102.50
Calicut	June '94	All the plants dried up				
-do-	December '94	7.10	44.40	9.75	2.20	95.56

Note 1. All figures are the means of 10 plants each
2. All leaf measurements relate to the fourth leaf

Table 147. Biological control of water hyacinth using *Neochetina* spp.

	Area of the damaged leaf (0-4 scale)	Mean no. of weevils /plant	Average leaf area damaged (0-4 scale)	Mean no. of weevils /plant
1.	1.50	2.25	1.75	3.00
2.	1.25	2.00	1.25	1.50
3.	1.00	1.25	1.25	3.25
4.	1.00	1.25	1.00	3.75
5.	1.50	0.50	1.50	3.00
6.	1.25	2.25	2.00	0.50
7.	0.75	2.25	2.00	3.00
8.	1.25	2.25	1.25	25
9.	1.00	2.00	1.75	2.25
10.	1.00	0.50	1.50	0.75
11.	1.25	1.75	1.50	0.75
12.	1.75	4.75	1.25	5
13.	1.00	0.75	2.00	1.75
14.	1.00	2.00	1.50	75
15.	1.50	1.24	2.00	5
16.	1.00	1.00	1.00	5
17.	1.25	1.75	1.25	
18.	1.75	2.25	1.00	0.00
19.	1.00	2.00	1.50	1.50
20.	1.00	1.00	1.25	0.25
21.	1.25	1.00	1.25	1.75
22.	1.00	1.50	1.25	0.75
23.	1.00	1.25	1.50	1.75
24.	1.25	2.00	1.25	3.00
25.	2.50	4.00	1.50	3.50
Average	1.22	1.79	1.45	2.35

The data on monitoring the field population of *Orthogalumna* at Alleppey, Moncompu, Kumarakom, and Trichur are presented in Table 149.

Table 148. Occurrence of *Neochetina* spp. in water hyacinth infested ponds in and around Anand.

Sr. No.	Location	Weevils per plant	No. of scars per leaf
1.	Lambhwel	1.12	37.58
2.	Boriavi	0.78	63.54
3.	Kanajari	1.04	52.36
4.	Sandhana	0.00	0.00
5.	Pariej	0.00	0.00
6.	Tarapur	0.88	4.48
7.	Bhanderaj	0.00	0.00
8.	Mobha	0.92	27.64
9.	Raghvanaj	0.96	26.76
10.	Haranjan	0.44	14.56
11.	Traj	0.56	7.84
12.	Vankdaloli	0.00	0.00
13.	Jichka	0.00	0.00
14.	Nar	0.84	19.28
15.	Pandoli	7.80	231.80
16.	Petlad	1.96	96.32
17.	Samarkha	0.32	2.60
18.	Pansora	1.56	123.68
19.	Khandhali	1.32	62.56
20.	Napa	0.72	7.72
21.	Lingada	0.60	25.52
22.	Thasara	0.84	46.76
23.	Umarethaj	1.08	41.16
Mean		1.03 ± 1.57	38.79± 53.32

1.3.12.8 Monitoring and evaluation of *Pareuchaetes pseudoinsulata* (Arctiidae : Lepidoptera) (KAU, Trichur)

Due to frequent incidence of NPV, the whole culture of *P. pseudoinsulata* at Vellanikkara (Kerala) was lost during May-June, 1994. So an extensive survey trip was undertaken in Mangalore, Puttur, Sulia and Guttigar in Dakshina Kannada district of Karnataka State. Eight caterpillars from athin stand of *Chromolaena* in a rubber plantation in Sulia taluk, Dakshina Kannada district was obtained on 25th August, 1994.

Table 149. Field population of *Orthogalumna* in Kerala

Month	Mite population (average of 20 leaves)				
	Allep-pey	Kum-arak-om	RRS	Monc-ompu	Trichur
			in-side	out-side	
April '94	81.00	6.25	7.45	13.55	73.45
May	95.90	3.15	6.50	25.20	119.60
June	79.30	5.40	6.15	30.95	129.00
July	53.55	-	8.65	6.20	89.30
August	32.20	8.85	10.50	29.60	178.40
September	228.95	19.00	10.60	29.05	65.95
October	75.75	25.70	30.25	40.90	144.95
November	93.20	18.00	25.80	70.95	103.45
December	132.20	27.35	7.75	59.95	74.60
January '95	86.50	21.55	59.55	6.60	91.45
February	46.45	2.35	9.35	43.70	102.85
March	87.25	34.95	8.75	33.35	85.75

- indicates that water hyacinth plants were not available for sampling during the month.

The caterpillars were multiplied in the laboratory and field releases commenced in November, 1994. Details of the release are presented in Table 150.

Table 150.Details of releases made in Trichur

Date	Number	Location
Caterpillars		
02-11-94	500	Velluppadam
09-11-94	1000	Vellanikkara
Moths		
19-11-94	235	Vellanikkara
03-12-94	1500	Vellanikkara
10-12-94	550	Vellanikkara
Total	3550 + 235	

An experiment was carried out in mosquito net field cages of 3 m height and 1m diameter. Uniform sized *C. odorata* plants were selected from the field for releasing the larvae. Third instar larvae were released on the plant in varying numbers of 0 (control), 4, 6, 8, 10, 12 and each treatment was replicated thrice. Leaf samples were drawn before release of the larvae and on 4th, 6th, 8th, 10th, 12th and 15th day after release for analysis. Nitrogen content of the leaves was analyzed by the microkjeldhal method (Piper, 1966) and the results presented as per cent nitrogen in the leaves on dry weight basis (Table 151,152, & 153).

Table 151. Change in total nitrogen content in *C. odorata* due to the feeding of different number of *Pareuchaetes* caterpillars

Site No.	Number of larvae released	Total nitrogen
1	Control	2.608
2	4	2.683
3	6	2.605
4	8	2.581
5	10	2.526
6	12	2.471

Table 152. Changes in total nitrogen content in *C. odorata* on various days after the release of *Pareuchaetes* larvae

Site No.	Days after release	Total nitrogen (%)
1	Before release	2.755
2	4 days	2.667
3	6 days	2.823
4	8 days	2.509
5	10 days	2.398
6	12 days	2.324
7	15 days	2.202

Table 153. Changes in total nitrogen content in *C. odorata* due to the feeding of different number of *Pareuchaetes* larvae on various days

Site No.	Number of larvae released and days after release	Total nitrogen (%)
1	Control x Before release	2.764
2	Control x 4 days	2.525
3	Control x 6 days	2.307
4	Control x 8 days	2.730
5	Control x 10 days	2.529
6	Control x 12 days	2.610
7	Control x 15 days	2.215
8	4 Nos. x Before release	2.759
9	4 Nos. x 4 days	2.675
10	4 Nos. x 6 days	3.387
11	4 Nos. x 8 days	2.430
12	4 Nos. x 10 days	2.909
13	4 Nos. x 12 days	2.450
14	4 Nos. x 15 days	2.169
15	6 Nos. x Before release	2.765
16	6 Nos. x 4 days	2.587
17	6 Nos. x 6 days	2.905
18	6 Nos. x 8 days	2.414
19	6 Nos. x 10 days	2.587
20	6 Nos. x 12 days	2.597
21	6 Nos. x 15 days	2.380
22	8 Nos. x Before release	2.759
23	8 Nos. x 4 days	2.789
24	8 Nos. x 6 days	2.939
25	8 Nos. x 8 days	2.554
26	8 Nos. x 15 days	2.125
29	10 Nos. x 4 days	2.324
31	10 Nos. x 6 days	2.982
32	10 Nos. x 8 days	2.669
33	10 Nos. x 10 days	2.420
34	10 Nos. x 12 days	2.310
35	10 Nos. x 15 days	1.862
36	12 Nos. x Before release	2.754
37	12 Nos. x 4 days	2.159
38	12 Nos. x 6 days	2.940
39	12 Nos. x 8 days	2.515
40	12 Nos. x 10 days	2.475
41	12 Nos. x 12days	2.377
42	12 Nos. x 15 days	2.462

Total nitrogen content in the plant was assessed after releasing 0, 4, 6, 8, 10 and 12 numbers of larvae and it was found that there was significant differences between the six treatments. In control, the nitrogen was 2.608 per cent. Maximum nitrogen content was when four larvae were released (2.683%) and minimum when 12 were released (2.47%) and it was generally a decreasing trend with increasing number of insects.

When total nitrogen content present in the plant was analyzed by drawing the leaf samples before release, 4, 6, 8, 10, 12 and 15 days after release, it was maximum (2.755 per cent) but again increased to 2.823 per cent on sixth day. Thereafter a decreasing trend was observed for 8th, 10th, 12th and 15th day after release. The interaction study shows that N content was maximum on sixth day when four larvae were released (3.387%) and was always on the higher side on every sixth day after release of the caterpillar. From eighth day onwards, it showed a decreasing trend with increasing number of larvae and days after release.

1.3.12.9 Monitoring and evaluation of *Cyrtobagous salviniae* (KAU, Trichur)

Field releases of *Cyrtobagous* weevils continued from the College of Horticulture, Vellanikkara, Rice Research Station, Moncompu and the Regional Agricultural Research Station, Kumarakom.

Samples of *Salvinia* were collected from Alleppey, Kottayam, Trichur, Palghat and Malappuram to assess the field population of *Cyrtobagous* weevils, larvae and pupae and the results are given in Table 154.

Table 154. *Cyrtobagous* population and weight of *Salvinia* per m^2 (average of five samples)

Place	Month	Larva	Pupa	Adult	Wt.(g)
Alleppey	May '94	0.00	0.00	0.00	1155
	December '94	0.00	6.80	10.80	4203
	February '95	0.00	0.00	0.00	972
Trichur	May '94	3.60	3.60	14.40	927
	September'94	20.00	4.44	77.78	12800
	February '94	0.00	0.00	4.50	5783
Malappuram	May'94	0.00	0.00	0.00	2567
	July'94	0.00	2.00	11.00	11550
	February '94	0.00	0.00	36.00	5418
Kottayam	May '94	3.00	3.00	10.00	1200
	December '94				
	February '95	0.00	0.00	7.2	5373
Palghat	May '94	0.00	1.00	1.00	1256
	December '94				
	February '95	0.00	1.00	1.25	820

1.3.12.10 Supply of natural enemies of weeds (IIHR, Bangalore)

During the period under report 1125 adults of *Neochetina eichhomiae* and *N. bruchi* were supplied for releases against water hyacinth in Madurai and Periyar districts in Tamil Nadu. Similarly, a total of 750 adults of *Cyrtobagous salviniae* were supplied for carrying out releases against *Salvinia molesta* in Shimoga and Goa.

STAFF

Project Directorate of Biological Control, Bangalore

Dr.S.P.Singh	Project Director
Dr.K. Narayanan	Principal Scientist (Agri.Ento.)
Dr.N.S.Rao	Senior Scientist (Agri.Ento.)
Mr.S.R.Biswas	Scientist SG (Agri. Stat.)
Mr.B.S.Bhumannavar	Scientist SG (Agri.Ento.)
Dr.N.Bakthavatsalam	Scientist SS (Agri.Ento.)
Mr.S.Ramani	Scientist SS (Agri.Ento.)
Mr.S.K.Jalali	Scientist SS (Agri.Ento.) (on study leave w.e.f.30-5-1994)
Mrs.C.R.Ballal	Scientist SS (Agri.Ento.) (on study leave w.e.f.14-02-1994)
Dr.(Mrs.) N. A. Pushpalatha	Scientist (Agri.Ento.)
Mr.Sunil Joshi	Scientist (Agri.Ento.) (w.e.f.04-11-1994)
Dr.T.Venkatesan	Scientist (Agri.Ento.) (w.e.f.29-10-1994)
Mr.M.Kalidurai	Scientist (Agri.Micribiology) (w.e.f.19-11-1994)
Mr.M.Narayana Rao	Technical Officer(T-5)
Mrs.S.K.Kadam	Technical Officer(T-5)
Mr.C.B.Dasan	Technical Officer(T-5)
Mr.P.K.Sonkusare	Technical Assistant(T-4)
Miss.Y.Lalitha	Technical Assistant T-II-3
Mr.B.K.Choubey	Technical Assistant T-II-3
Mr.Satendra Kumar	Technical Assistant T-II-3
Miss.S.K.Rajeshwari	Technical Assistant (T-2)
Mr.P.Raveendran	Technical Assistant (T-2)
Mr.P.Vanaraju	Senior Clerk
Mr.K.N.Visweswara	Junior Stenographer
Mr.Chandrappa	Driver
Mr.P.Madanathan	Driver
Mr.G.V.Sharma	Messenger
Mr.M Muniswamy	Mali
Mr.Ramakrishnaih	Mali
Mr.M.Kariappa	Safaiwala

Central Plantation crops Research Institute, Kayangulam

Dr.(Mrs.)S.Sathiamma	Senior Scientist (Agri.Ento.)
Mr.C.P.Ramachandran	Scientist SS (Agri.Ento.)
Mr.A.S.Sabu	Technical Assistant (T4)
Mr.V.Chandrasekharan	Supporting staff

Central Tobacco Research Institute, Rajahmundry

Mr. R.S.N. Rao	Scientist SG (Agri.Ento.)
Mr. G. H. Mohanacharu	Technical Assistant (T-2)

Indian Agrilcultural Research Institute, New Delhi

Dr.K.L.Srivastava	Senior Scientist (Agri.Ento.)
Mr.Ravi Kumar Palta	Technical Assistant (T4)
Mr.Manohar Singh	Technical Assistant (T1)

Indian Institute of Horticultural Research, Bangalore

Dr.M.Mani	Senior Scientist (Agri.Ento.)

Dr.K.P.Jayanth	Senior Scientist (Agri.Ento.)
Dr.A.Krishnamoorthy	Senior Scientist (Agri.Ento.)
Mr.C.Gopalakrishnan	Scientist SG (Plant Pathology) (on study leave w.e.f.01-04-1994)
Mr.R.Asokan	Scientist (Agri.Ento.)
Mrs.P.N.Ganga Visalakshy	Scientist (Agri.Ento.)
Mr.G.L.Pattar	Technical Officer(T-5)
Mr.S.Hanumantharaya	Technical Assistant (T1)
Mr.N.Subbaiah	Technical Assistant (T1)
Mr.N.Chandrasekar	Technical Assistant (T1)
Mr.Anjanappa	Mali

Indian Institute of Sugarcane Research, Lucknow

Dr.Ashok Varma	Principal Scientist (Agri.Ento.)
Dr.N.K.Tiwari	Senior Scientist (Agri.Ento.)
Dr.R.K.Tanwar	Scientist (Agri.Ento.)
Mr.R.B.Jadhav	Technical Officer(T5)
Mr.Hari Lal	Technical Officer(T5)
Mr.D.C.Rajak	Technical Assistant(T4)
Mr.C.L.Gupta	Technical Assistant T-II-3
Mr.B.L.Maurya	Technical Assistant T-II-3
Mr.Niranjan Lal	Technical Assistant T-II-3
Mr.N.M.Wadekar	Technical Assistant (T2)
Mr.K.V.Rao	Technical Assistant (T2)
Mr.J.C.Tewari	Technical Assistant (T2)

Sugarcane Breeding Institute, Coimbatore

Dr.S.Easwaramoorthy	Senior Scientist (Agri.Ento.)
Mr.J.Srikanth	Scientist (Agri.Ento.)
Mr.N.K.Kunjukrishna Kurup	Technical Officer(T-5)
Mr.M.Shanmuga-sundram	Technical Assistant(T-4)
Mrs.G.Santhalakshmi	Technical Assistant(T-4)
Mr.Raghawendra Kumar	Technical Assistant T-II-3

Assam Agricultural University, Jorhat

Dr.A.Basit	Entomologist
Mr.M.K.Rahman	Field Assistant
Mr.A.K.Bordoloi	Technical Assistant

Andhra Pradesh Agricultural University, Hyderabad

Mr.A.Ganeswara Rao	Entomologist
Mrs.Ramila Saxena	Assistant Entomologist
Mr.T.Ramesh Babu	Assistant Entomologist
Mr.A.Krishnamurthy	Sub Assistant
Mr.R.Prasad	Sub Assistant
Mr.E.L.John,	Sub Assistant
Mr.Srinivas	Sub Assistant

Gujarat Agricultural University, Anand

Dr.D.M.Mehta	Associate Research Scientist (Entomology)
Mr.J.J.Jani	Associate Research Scientist (Microbiology)
Mr.P.H.Godhani	Sr. Research Assistant
Mrs.Kamala Chhaiya	Sr. Research Assistant
Mr.A.G.Sukhadia	Sr. Research Assistant
Mr.K.P.Parmar	Agricultural Assistant
Mr.N.P.Sodhaparmar	Agricultural Assistant
Mr.B.M.Patel	Driver

Kerala Agricultural University, Trichur

Dr.P.J.Joy	Professor (Entomology)
Mr.N.V.Sathesan	Assistant Professor
Mr.K.V.Dinesan	Technical Assistant
Mr.T.R.Radhakrishnan	Farm Assistant (Gr.I)
Mr.T.Varghese	Farm Assistant (Gr.I)

Mahatma Phule Agricultural University, College of Agriculture, Pune

Dr.B.G.Awate	Entomologist
Mr B.A.Bade	Technical Assistant
Mr.P.M.Kurhade	Field Assistant

Punjab Agricultural University, Ludhiana

Dr.Maninder	Assistant Entomologist
Mr.Ram Kishan Ram	Laboratory Attendant
Mr.Rajinder Singh	Laboratory Assistant

Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar

Dr. G.M. Zaz	Entomologist
Mr.Abdul Majid Bhat	Assistant Entomologist
Mr.R.K.Tickoo	Sr. Technical Assistant
Mr.Ab.Hamid Bhat	Laboratory Assistant

Tamil Nadu Agricultural University, Coimbatore

Dr.J.Chandrasekaran	Professor (Entomology) (w.e.f.28-02-1995)
Mr.S.Balakrishnan	Agricultual Supervisor
Mr.P.K.Marimuthu	Agricultural Assistant
Mr.M.Munusamy	Laboratory Assistant

Dr.Y.S.Parmar University of Horticulture & Forestry, Solan, Nauni

Dr.P.R.Gupta	Entomologist
Mr.Anil K.Sood	Technical Assistant
Mr.Sat Pal Verma	Technical Assistant
Mr.Vidya Dhar	Field Assistant

Budget Provision

Name of the centre	Amount sanctioned (lakhs)	Total expenditure (lakhs)
PDBC, Bangalore	100.00	87.00
CPCRI, Kayangulam	*	
CTRI, Rajahmundry	*	
IARI, New Delhi	*	
IIHR, Bangalore	*	
IISR, Lucknow	*	
SBI, Combatore	*	
AAU, Jorhat	5.44	2.53
APAU, Hyderabad	3.14	4.21
GAU, Anand	4.46	3.64
KAU, Trichur	2.63	3.08
MPAU, Pune	2.12	1.95
PAU, Ludhiana	4.45	3.17
SKUAS & T, Srinagar	2.15	2.75
TNAU, Coimbatore	3.15	2.75
YSPUH & F, Nauni, Solan	3.26	2.69
GBPA & T, Pantnagar	-	-

* Since the project has been merged with Non-Plan no separate budget account has been maintained by ICAR Institute based Centres

LIST OF PUBLICATIONS

Andhra Pradesh Agricultural University, Hyderabad

1.Ganeswara Rao, A, Krishnaiah, K., Cork, A. and Hall, D.R. 1994. Disruption of sex pheromone mediated communication in yellow stem bore, *Scirpophaga incertulas* Walker with a controlled release pheromone formulation. *Journal of Entomological Research*, **18**(3) : 287-288.

2.Ramamohan Rao, T. and Ganeswara Rao, A. 1994. Record of *Stibaropus tabulatus* Schiod as a pest of Banana. *Indian Journal of Plant Protection*, **22**(1) : 132.

Assam Agricultural University, Jorhat

3. Basit, A. 1994. Parasitism of *Trichogramma japonicm* Ashmead as effected by colour and egg placement pattern on egg card *Corcyra cephalonica*. *Journal of Agricultural Science Society for North Eastren Region*, **7**(1) : 100-102.

4. Basit, A. 1994. Life table studies of *Trichogramma japonicum* and *T. chilonis*. *Journal of Applied Zoological Research*, **5**(2).

Gujarat Agricultural University, Anand

5. Patel, I.S. and Yadav, D.N. 1995. Susceptibility of *Amrasca biguttula* and *Chrysopa scelestes* in cotton (*Gossypium* spp.) to three systemic insecticidees. *Indian Journal of Agricuuultural Sciences*. **65**(4): 308-309.

6. Patel, M.S., Yadav, D.N. and Rai, A.B. 1994. Neemark (Azadriactin) as ovipositional deterrent against cotton pests, *Pestology*, **18**(8):

7. Parashrya, B.M., Dodia, J.G., Mathew, K.L. and Yadav, D.N. 1994. Natural regulation of white grub (*Holotrichia* sp.) by birds in agroecosystem. *Journal of Bioscience*, **19**(4)

8. Parasara, U.A. and Yadav, D.N. 1995. Predatory potential of *Nesidiocoris tenuis* Reuter (Hemiptera : Miridae) and its role in natural suppression of *Helicoverpa armigem*. Abstracted in Tobacco symposium held at Rajahmundary, 1-3 Feb. 1995.

Kerala Agricultural University, Trichur

9. Joy, P.J., Satheesan, N.V. and Lyla, K.R. 1990. Biological control of aquatic weeds in Kuttanad, Kerala. Proceedings of the National Symposium on Rice in Wetland Ecosystem. 153-155pp.

Punjab Agricultural University, Ludhiana

10. Doomra, S., Shenhmar, M. and Varma, G.C. 1994. Studies on the effect of *Trichogramma japonicum* Ashmead (Hymenoptera : Trichogrammatidae) Padan and *T. japonicum* + mechanical control on the *Scirpophaga excerptalis* Fabricius (Lepidoptera : Pyralidae). *Biological Control Insect Pest* (U.P. Zool. Soc. Muzaffarnagar).

11. Mannan, V.D., Varma, G.C. and Brar, K.S. 1995. Seasonal fluctuations and host predator relationship of *Chrysoperla carnea* (Stephens) (Chrysopidae : Neuroptera). *Indian Journal of Ecology*, **21**(1) (In press).

12. Shenhmar, Maninder and Varma, G.C.(1994). Laboratory studies on the comparative efficacy of different formulations of *Bacillus thuringiensis* Berliner for the control of *Chilo auricilius* Dudgeon. *National Symposium on Emerging Trends in IPM* Solan, p. 39 (Abstract).

13.Shenhmar, Maninder and Varma,G.C. 1994. Field evaluation of *Trichogramma japonicm* for the control of rice stem borer *Scripophaga incertulas*. *Ibid*, p. 40 (Abstract).

14.Shenhmar, Maninder and Varma,G.C. 1994. Laboratory studies on the effect of release of *Epiricania melanoleca* cocoons for the control of *Pyrilla perpusilla*. *Ibid* , p. 41 (Abstract).

15.Varma,G.C., Gill, J.S., Shenhmar, Maninder and Tanda, A.S. 1993. Manipulation of natral enemies in the management of insect pests of sugarcane and cotton in Punjab *Journal of Insect Science* . **6**(2) 173-180.

16.Varma, G.C. and Shenhmar, Maninder. 1994. Comparative efficacy of two strains of *Cotesia flavipes* (Cameron) for the control of sugarcane borers. *National Symposium on Emerging Trends in IPM* , Solan, 35 (Abstract).

17. Varma, G.C. and Shenhmar, Maninder. 1994. Role of parasitoids and predators in the insect pest mana- gement. *Biological Control of Insect pests*, 5 : 1

18. Varma, G.C., Vyas, R.S. and Brar, K.S. 1993. Biology of *Menochilus sexmaculatus* (Fabricius) (Coccinellidae : Coleoptera). Journal of Research, PAU, Ludhiana, **30** (1 & 2) : 27-31.

Dr. Yashwant Singh Parmar University of Horticulture & Forestry, Nauni, Solan

19. Gupta, P.R. and Bhalla, O.P. 1993. Conservation of biotic agents in apple orchards in Himachal Pradesh. *Journal of Insect Science*, **6**(2) : 204 - 206.

20.Gupta, P.R. and Singh, I. 1995. Predation preference and reproductive performance of the coccinellid *Chiloconus bijugus* Mulsant on San Jose scale. Presented in *National symposium in 'Biological and cultural control of Agricultural and Medical Pests'* held at Xavier's College (Autonomous), Palayankottai, Tamil Nadu, February 22-24,1995, Abstract pp. 40-41 (Abstract no. E-0-4).

Central Plantation Crops Research Institute, Regional Station, Kayangulam

21. Danger, T.K., Solomon, J.J. and Pillai, G.B. 1994. Infection of the coconut palm beetle, *Xylotrupes gideon* (Coleoptera : Scarabaeidae), by a nonoccluded baculovirus. *Journal of Plant Diseases and Protection*, **101** (6) : 561 - 566.

22. Sathiamma, B. and Nair, C.P.R. 1994. Biological control of pests of coconut. *Kerala Karshakan*, November, 1994 (in Malayalam).

Central Tobacco Research Institute, Rajahmundry

23. Chari, M.S., Rao, R.S.N., Sreedhar, V. and Gunneswara Rao, S. 1994. Bioenvironmental control of *Heliothis armigera* in FCV tobacco. *Tobacco Research*, **20**(1) : 36-39.

Indian Institute of Horticultural Research, Bangalore

24. Ganga Visalakshy, P.N. and Jayanth, K.P. 1994. *Stethoconus praefectus* (Distant) , a predator of *Teleonemia scrupulosa* Stal in Bangalore, India. *Entomon* **19** : 177-178.

25. Jayanth, K.P. 1993. Biological control of weeds by insects - Concepts and Practice. *Agricultural Reviews* **14** : 160-168.

26. Jayanth, K.P. and Ganga Visalakshy, P.N. 1994. Field evaluation of sunflower varieties for susceptibility to the parthenium beetle *Zygogramma bicolarata*. *Journal of Biological Control*, **8**:48-52.

27. Jayanth,K.P. and Ganga Visalakshy, P.N. 1994. Dispersal of the parthenium beetle *Zygogramma bicolarata*. (Chrysomelidae) in India. *Biocontrol Science and Technology*, **4** : 363-365.

28. Krishnamoorthy, A. and Mani, M. 1994. Manage the mealybug in citrus orchards. *Indian Horticulture* **39**(1) : 12-13.

29. Mani, M. 1994. Control of dryland fruit crop pests. *Proceedings of National Seminar on Dryland Fruits*, 5th-8th Oct. 1993, pp.48-51.

30. Mani, M. and Krishnamoorthy, A. 1993. Status of mealybug species and their biological control in vineyards. A global view. Proceedings of the International symposium on Recent Advances in Viticulture & Oenology, February 14-17, 1992, Hyderabad, India, p. 330-442.

31. Mani, M.and Krishnamoorthy, A. 1993. Controlling the citrus mealbug, Hindu, 117:28.

32. Mani, M., Krishnamoorthy, A. and Srinivasa Rao, M. 1993. Toxicity of different pesticides to the exotic parasitoid, *Leptomastix dactylopii* (Hymenoptera : Encyrtidae). *Indian Journal Plant Protection*, **21** : 98-99.

Project Directorate of Biological Control, Bangalore

33. Bakthavatsalam, N. , Singh, S.P., Pushpalatha, N.A. and Bhumannavar, B.S. 1994. Life tables of four species of chrysopids (Neuroptera Chrysopidae). *J. entomol. Res.*, **18**(4): 357-360.

34. Ballal,C.R. and Ramani, S. 1994. Studies on four geographical strains of *Campoletis chlorideae* Uchida (Hymenoptera : Ichneumonidae) *Biological control of Insect Pests* (Ed. S.C.Goel), U.P.Zoological Society, Muzaffanagar, pp. 87-90

35. Jalali, S.K. and Singh, S.P. 1994. Effect of *Aphis gossypii* Glover number on *Mallada astur* (Banks) and *Cheilomenes sexmaculata* (Fabricius). *Biological Control*, **4** :45-47.

36. Narayanan, K. 1994. Insect tissue culture: History development and its application towards microbial control of insect pests Abstract 62. p. 42-43 *Proc. Second National Conference of Applied Zoologists Research Association on 'Recent trends in plant animal and human pest management; Impact on Environment* . Madras College Tambaram, Madras. December

27-28, 1994.

37. Narayanan, K. and Vennila, S. 1994. Studies on the live larval sexing of some lepidopterans with particular reference to its impact on the vivo multiplication of nuclear polyhedrosis viruses of *Spodoptera litura* for its control. Abstract 61 p.42. *Proc. Second National Conference of Applied Zoologists Research Association on "Recent trends in plant animal and human pest management; Impact on Environment"* held at Madras Christian College Tambaram, Madras December 27-29, 1994.

38. Narayanan, K. 1994. Microbial control of insect pests problems and prospects, pp. 32-33. *Proc. National Symposium on "Emerging Trends in Pest Management"* held at Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, 28-30 June, 1994.

39. Narayanan, K. 1994. Advances in the microbial control of insect pests. pp. 47-54. *Proc. Summer Institute "Advances in Agricultural Microbiology with Special Reference to Mycorrhizal Symbiosis and their role of Crop Productivity.* Dept. of Agrl. Microbiology. Univ. Agrl. Sci; G.K.V.K. Bangalore During August, 22 Sept. 10, 1994.

40. Narayanan, K. 1994. Role of biotechnology in effective utilization of insect pathogens in integrated pest management in India, pp. 37-47. In "*Biological control of Insect Pests*" (ed). S. Goel. Uttar Pradesh Zoological Society, Muzaffarnagar, India.

41. Pushpalatha, N.A., Singh, S.P., Bakthavatsalam, N. and Bhumannavar, B.S. 1994. Semi synthetic larval diet for *Chrysoperla_carnea* (Stephens) (Neuroptera : Chrysopidae). *Journal of Biological Control* **8**(1) : 54-56.

42. Ramani,S. and Ballal, C.R. 1994. Influence of change of host on handling time and its variation in *Chelonus blackburni* Cameron (Hymenoptera : Braconidae) *Biological Control of Insect Pests* (Ed. S.C.Goel), U.P.Zoological Society, Muzaffanagar, pp. 81-86

43. Singh, S.P. 1994a. Introduction to production of predators and parasitoids, p 1-3. In *Group Meeting cum Training on Mass Production and Utilisation of Biotic Agents* (22-25th February, 1994) - *Compendium of Lectures.* Project Directorate of Biological Control (ICAR), Bangalore, 48 pp.

44. Singh, S.P. 1994b. Bio-intensive integrated pest management in cotton, pp.126-139. *Proceedings National Seminar on Cotton Production. Challenges in 21st Century* (18-20th April, 1994). CCS Haryana Agric. Univ. Hissar, 189 pp.

45. Singh, S.P. 1994c. Biological suppression of *Lantana camara* in India, 8 pp. Paper presented at *Hill Weed Management Conference* held at Palampur on 16th April, 1994.

46. Singh, S.P. 1994d. Biological control of insect pests of pulse crops. 21pp. Paper presented at *International Symposium on Pulses Research* (2-4 April, 1994), New Delhi, India.

47. Singh, S.P. 1994e. Biological control of mustard aphid- problem and strategies, pp.1-3. *All India Coordinated Research Project on Rapeseed-Mustard.* Jawahar Lal Nehru Krishi Vishwavidyalaya, Gowalior (August 17-20, 1994).

48. Singh, S.P. 1994f. Use of parasitoids and predators as promising non-pesticide method of pest management, pp. 48-49. *National Workshop on 'Non-Pesticidal Approach to Pest Manage-*

ment-A New Direction, held at NAARM, Hyderabad from 20-22 September, 1994, 64 pp.

49. Singh, S.P. 1994g. Toxicity to natural enemies of crop pests, pp. 283-323. In: Kothari's Desk Book Series - The Pesticide Industry. H.C.Kothari Group Publication Division, Kothari Buildings, Madras, India. 464 pp.

50. Singh, S.P. 1994. Technology for production of natural enemies. Project Directorate of Biological Control (ICAR), Bangalore, India. *Tech. Bull.* (4)225 pp.

51. Singh, S.P. 1994. Fifteen years of AICRP on biological control. Project Directorate of Biological Control (CAR), Bangalore, India. *Tech. Bull.* (8)323 pp.

52. Singh, S.P. 1994. Final Technical Report (March, 1989 to September, 1994). Department of Biotechnology funded project-Genetic Improvement and Pilot Plant Production of *Trichogramma* and *Chrysoperla*, 57 pp.

53. Singh,S.P. and Bakthavatsalam, N. 1994. Management of *Amsacta* spp. (Lepidoptera: Arctiidae)- *The Present Status*. Project Directorate of Biological Control, Bangalore, India. *Technical Document* No. 42. 19 pp.

54. Singh, S.P., Bhumannavar, B.S., Jalali, S.K., Bakthavatsalam, N. and Pushapalatha, N.A. 1994. *Chrysopids and Trichogrammatids strain selection and utilization*. Project Directorate of Biological Control, Bangalore, India. *Technical Bulletin* No. 9. 45pp.

55. Singh, S.P., Bhumannavar, B.S., Jalali, S.K., Baktavatsalam, N. and Pushpalatha, N.A. 1994. Demonstration of biological control system through utilisation of *Trichogramma* egg parasitoids and chrysopid predators, p 53. National Workshop on *'Non-Pesticidal Approach to Pest Management - A New Direction*, held at NAARM, Hyderabad from 20-22 Sept., 1994, 64 pp.

56. Singh, S.P., Jalali, S.K., Bhumannavar, B.S., Bakthavatsalam, N. and Pushapalatha, N.A. 1994. *Production and use of Chrysopid predators*. Project Directorate of Biological Control, Bangalore, India. *Technical Bulletin* No. 10, 14 pp.

57. Singh, S.P., Jalali, S.K., Bhumannavar, B.S., Bakthavatasalam, N. and Pushpalatha, N.A. 1994. *Production and use of Trichogrammatid egg parasitoids*. Project Directorate of Biological Control, Bangalore, India. *Technical Bulletin* No. 11, 16 pp.

58. Singh, S.P. and Ramani, S. 1994. Status of coffee berry borer, *Hypothenemus hampei* (Ferrari), (Coleoptera : Scolytidae). PDBC, Bangalore, India. *Technical Document* No.41, 21p.

59. Singh, S.P. and Rao, N.S. 1994. Research Highlights. Project Directorate of Biological Control, Bangalore, India. *Tech. Bull.* No.12, 13pp.

VISITORS

Project Directorate of Biological Control, Bangalore

Mr. N.S. Talekar, AVRDC, Taiwan on 15-04-94

Dr.Ali Asghar Hashmi, Chief Scientific Officer, National Agricultural Research Centre, Park Road, Islamabad (Pakistan) on 13-09-94

Mr.T.J.Labuschagne, Institute for Tropical & Subtropical Crops, P.B.Ag X11208, Nelspruit 1200, South Africa on 30- 06-94

Mr.M.G.Dhanapala, Research Officer Regional Agricultural Research Centre, Bandarawela, Sri Lanka on 29-09-94

Mr.Yaoya Prasad Giri, Entomologist, Nepal Agriculture R. Council, Entomology Division, Rhomaltar, Kathmandu, Nepal on 29-09-94.

Prof. Chong-Yao-Shen, FAO Regional Office for Asia and the Pacific, 39, Phra Atit Road, Bangkok, 10200, Thailand on 19-11-94

Dr. S. Sithanantham, Senior Scientist, ICIPE, Box 16, Kikambala, Mombasa, Kenya on 5-01-95

Dr. D.N. Mehto, Sr. Scientist (Ento.) T.C.A., Dholi (Muzaffarpur), Bihar on 23-05-94

Dr.R.K.Akhauri, Jr. Scientist (Ento.) T.C.A. Dholi (Muzaffarpur), Bihar on 23-05-94

Dr.V.N.Shroff, Dean (Agriculture) College of Agriculture, Indore on 27- 05-94

Mr.M.M. Muthanna, General Manager (P), C.C.Limited, Pollibetta, Kodagu on 31-05-94

Mr.K.M.Subbaiah, Manager (Research), C.C.Limited, Pollibetta, Kodagu on 31- 05-94

Dr.H.R.Kalia, Ex. Vice Chancellor, HPAU, Palampur (HP),on 7- 09-94

Dr.L.K.Hazarika, Department of Plant Protection, Tocklai Experimental Station, Jorhat on 27-10-94

Dr.P.C.Deka, Professor, Department of Agriculture Biotechnology, Assam Agricultural University, Jorhat on 27-10-94

Dr.B.G.Unni, Department of Biochemistry, Regional Research laboratory, Jokhat-785066, Assam on 27-10-94

Dr.K.S.Sharma, Agriculture Research Officer (Entomology) Department of Agriculture, Directorate of Agriculture Rajasthan, Jaipur-302004 on 28-10-94

Prof.S.Jayaraj, ICAR National Professor, M.S.Swaminathan Research Foundation, Madras 600113 on 22-11-94

Dr.A.K. Karel, Principal Scientist, NCIPM, Faridabad 121001 on 9-12-94

Dr.(Mrs) Saroj Singh, Sr. Scientist (PP), NCIPM, Faridabad 121 001 on 9-12-94

Dr.S.S.Lal, Principal Entomologist, IIPR, Kanpur 208024 on 9-12-94

Dr. A. Ahmad, Deputy Director General (Education), ICAR New Delhi on 6-01-95

Dr.M.V.Rao, Vice Chancellor, Dr.I.V.Subba Rao, Director of Research and seven Associate Directors of A.P. Agricultural University, Hyderabad (AP) on 6-01-95

Mr. Nattalie Seghers, Trainee, ICRISAT, Patancheru on 10-01-95

Dr.E.A. Siddiq, Deputy Director General (Crop Sciences), ICAR, New Delhi on 11-01-95

Dr.R.Ramalingam, Plant Protection Officer, Director of Agriculture, Trivandrum 33 (Kerala) on 16-02-95

Mr.Subhash Garg IAS, Director (Agriculture), Government of Rajasthan, Jaipur on 25-02-95

Mr.I.S.Malhi, Joint Secretary, Ministry of Agriculture Government of India, New Delhi on 1-03-95

Mr.J.Venkateswaralu, Consultant (Watershed), 26, SBI Colony, New Bakaram, Hyderabad 500 380 on 9-03-95

Andhra Pradesh Agricultural University, Hyderabad

Dr.A.Rameswar, Associate Director of Research (Southern Telangana Zone, APAU, Hyderabad on 23-06-94

Dr.S.P.Singh, Project Director, Project Directorate of Biological Control, Bangalore on 20-07-94

Dr.O.P.Dubey, Principaal Scientist, ICAR, New Delhi on 22-12-1994

Dr.G.C.Tiwari, Principal Scientist, ICAR, New-Delhi on 22-12-1994

Dr.C.P.S.Yadav, Scientisat and President, Society for Applied Ornithology, on 22-12-1994

Gujarat Agricultural University, Anand

Mr. Gordhanbhai Patel, Assistant Manager, The Cotton Corporation of India Ltd.,Ahmedabad on 05-08-94

Mr. M.F.Peelizar, G.S.L.D.C., Bombay on 19-08-94

Dr.R.S.Kureel, Assistant Director, Mini. of Agri. Govt. of India, New Delhi on 20-08-94

Dr.U.R.Patel, Memorial University of Naofound Land, Sr John's NF, Canada on 14-09-94

Mr. Natubhai B.Patel, Super Industry, Ahmedabad on 20-12-94

Dr.P.D.Sharma, Sr. Entomologist, HAU, Hissar on 18-01-95

Prof Gajendra Singh, Deputy Director General (Agri. Engg.), ICAR, New Delhi on 31-01-95

Dr.M.G.Lande, Additional Commissioner, MOA, GOI, New Delhi on 31-01-95

Dr.S.N.Puri, Director NCIPM, New Delhi-12 on 31-01-95

Dr.B.D.Rana, Dr.C.P.S.Yadav, Dr.Basu, Members from ICAR, New Delhi on 31-01-95

Mr. N.K.Tyagi, C.S.S.R.I., Karnal on 01-02-95

Mr. B.K.Goswami and Mrs.Uma Rao Department of Nematology, IARI, New Delhi on 03-02-95

Central Tobacco Research Institute, Rajahmundry

Dr.L.Klein & G.Kelman, Dead Sea Brome Group, Israel

Dr.Roger Cace, Uganda KAMPALA

Dr.E.A.Siddique, Deputy Director General(CS), ICAR, New Delhi

Dr.A.K.Raheja, Asst.Director General (Ento. & Biocontrol), ICAR, New Delhi

Dr.O.P.Dubey, Principal Scientist, ICAR, New Delhi

Dr.G.C.Tiwari, Principal Scientist, ICAR, New Delhi

Dr.(Mrs.) Seema Wahab, Principal Scientific Officer, DBT, New Delhi

Dr.H.N.Singh, Professor of Entomology, Institute of Agriculture, Varanasi

Dr.S.P.Singh, Project Director, PDBC, Bangalore

Dr.B.R.K.Naidu, Chairman Tobacco Development, Madras

Dr.J.N.Sachan, Head, Division of Entomology, IIPR, Kanpur

Dr.S.S.Lal, Principal Scientist, IIPR, Kanpur

Dr.A.Raghupathy, Professor, Department of Entomology, TNAU, Coimbatore

Dr.R.Tuli, Deputy Director, NBRI, Lucknow

Central Plantation Crops Research Institute, Regional Station, Kayangulam

Justice K.G. Balakrishnan, Judge, High Court of Kerala, Ernakulam on 12-04-94

Justice Sujatha Manohar, Chief Justice, High Court of Kerala, Ernakuulam on 21-04-94

Hon'ble Minister for Local Administration Mr. C.T. Mohammed Ali, Govt. of Kerala, Trivandrum on 03-07-94

Dr.A.M.Michael, Vice Chancellor, Kerala Agricultural University, Vellanikkara, Thrichur on 26-08-94

Dr.P.Rethinam, Assistant Director General (Plantation Crops) ICAR, New Delhi on 27-10-94

Mr. Nandiyod Rajan, Chairman, TRCMPU, Thiruvananthapuram on 27-01-95

Dr.Gopal Swarup, Retired Professor and Head, Division of Nematology, Indian Agricultural Research Institute, New Delhi on 07-02-95

Dr.Y.S.Rao, Retired Head, Division of Entomology and Nematology, Central Rice Research Institute, Cuttack on 07-02-95

Dr.B.S.Yadav, Retired Professor, Department of Nematology, Udaipur Agricultural University, Udaipur on 07-02-05

Dr.Sivagami Vadivelu, Professor and Head, Department of Nematology, Tamil Nadu Agricultural Univerity, Coimbatore on 07-02-95

Dr.D.C.Gupta, Professor Department of Nematology, Haryana Agricultural University, Hissar on 07.02.95

Dr.R.V.Singh, Principal Scientist, Division of Nematology, Indian Agricultural Research Institute, New Delhi on 07-02-95

Dr.Mohammed Said El-Garhy, Senior Research Worker, Agricultural Research Centre, Plant Protection Research Institute, Cairo, Egypt on 21-03-95

Kerala Agricultural University, Trichur

Dr. M.Swamiappan, Professor Department of Entomology, TNAU, Coimbatore on 02-04-94

Dr.A.Chaudhury, Deputy Director, Central Silk Board, Mysore, on 01-07-94

Mahatma Phule Agricultural University, Pune

Mr. Umeshchandra Sarang, Commissioner (Agriculture), Govt. of Maharastra, Pune

Dr.H.D. Rananavare, Scientist, BARC, Bombay

Dr.S.P.Singh, Project Director, PDBC, Bangalore

Sugarcane Breeding Institute, Coimbatore

Mrs. N.T.Loc, G.B.Pant University, Pantnagar on 29-04-94

Dr. S.P. Singh, Project Director, PDBC, Bangalore on 16- 09-94

Dr.Ann. Burnell, St.Patrick's College, Maynooth,Ireland on 25-03-94

METEOROLOGICAL DATA

Central Tobacco Research Institute, Rajhamundry

Month/Year (1994-95)	Temperature (°C)		Relative humidity (%)		Rain-fall (mm)	Number of rainy days
	Maximum	Minimum	7 hrs	14 hrs		
April	36.7	26.1	89	54	4.6	1
May	38.6	26.8	85	48	14.21	1
June	35.8	26.3	89	59	72.8	4
July	31.1	24.6	93	76	256.9	21
August	29.7	24.6	92	77	239.8	18
September	32.2	24.7	91	65	80.8	9
October	30.5	23.3	93	77	357.8	10
November	29.1	19.9	93	60	111.7	3
December	29.4	15.3	91	59	-	-
January	27.7	16.2	93	80	50.7	3
February	30.9	18.3	90	79	Nil	-
March	34.2	21.3	90	57	Nil	-

Assam Agricultural University, Jorhat

Month/Year (1994-95)	Temperature (°C)		Relative humidity (%)		Rain-fall (mm)
	Maximum	Minimum	7 hrs	14 hrs	
April	19.6	28.6	87	64	100.7
May	22.7	31.9	85	66	132.9
June	24.8	32.3	87	71	246.5
July	25.0	33.5	86	70	246.5
August	25.8	33.6	86	71	218.8
September	25.0	32.3	85	71	375.7
October	20.9	28.9	89	75	161.9
November	15.5	26.5	91	70	15.1
December	10.2	24.5	95	71	3.5
January	10.2	22.2	92	64	1.1
February	11.9	23.1	91	66	49.7
March	16.2	27.9	87	65	12.9

Central Plantation Crops Research Institute, Regional Station, Kayangulam

Month/Year (1994-95)	Temperature (°C)		Relative humidity (%)		Rain-fall (mm)	Sun-shine (hrs)
	Maximum	Minimum	7 hrs	14 hrs		
March	33.8	24.2	87	59	4.6	6.3
April	33.9	24.1	83	61	111.4	9.9
May	29.7	22.8	94	83	392.8	1.6
June	31.1	23.3	93	71	365.4	5.2
July	28.5	22.3	96	81	737.4	1.1
August	30.2	23.4	97	76	262.0	3.2
September	31.9	23.5	92	62	123.4	6.8
October	30.2	22.9	96	73	768.4	4.5
November	33.0	23.7	92	58	110.6	9.6
December	34.0	20.5	86	47	0.0	9.8
January	33.6	21.4	90	48	24.2	9.5
February	33.9	22.4	95	56	4.4	9.3

Punjab Agricultural University, Ludhiana

Month/Year (1994-95)	Temperature (°C)		Relative humidity (%)		Rain-fall (mm)	Sun-shine (hrs)
	Maximum	Minimum	7 hrs	14 hrs		
April	32.5	16.2	67	27	0.0	9.4
May	39.1	23.7	47	24	9.1	10.5
June	38.7	26.6	59	35	0.0	9.5
July	33.0	27.1	85	72	56.6	5.7
August	32.6	26.0	90	73	153.9	6.8
September	33.0	22.0	89	56	318.5	9.6
October	31.4	15.0	96	32	74.0	11.1
November	28.8	10.4	94	36	0.0	9.0
December	20.9	7.3	92	48	0.0	7.7
January	17.6	4.9	96	57	49.6	7.6
February	20.1	8.2	94	54	51.1	7.7

Kerala Agricultural University, Thrissur

Month/Year (1994-95)	Temperature (°C)		Relative humidity (%)		Rain-fall (mm)	Sun-shine (hrs)
	Maximum	Minimum	7 hrs	14 hrs		
April	24.4	34.9	88	59	165.2	8.0
May	24.7	33.6	88	61	124.2	8.0
June	22.9	28.9	96	83	955.1	2.1
July	22.4	28.6	96	85	1002.1	1.4
August	22.8	30.0	95	75	509.2	3.0
September	23.2	31.8	92	64	240.5	7.3
October	22.7	32.3	92	68	358.2	6.7
November	23.3	31.8	77	58	125.3	8.1
December	22.2	32.2	71	45	0.0	10.6
January	22.4	32.9	76	41	0.0	9.6
February	23.4	35.4	79	41	0.5	10.0

Indian Institute of Sugarcane Research, Biological Control Centre - Sardar Nagar

Month/Year (1994-95)	Temperature (°C)		Avearage relative humidity (%)	Rain-fall (mm)
	Minimum	Maximum		
April	27.0	39.0	49.5	3.11
May	27.0	41.0	60.7	3.30
June	27.0	39.0	61.0	8.89
July	26.0	35.0	82.0	21.81
August	26.0	36.0	79.5	31.89
September	24.1	32.4	85.7	50.91
October	19.1	31.2	79.7	51.20
November	18.0	31.0	78.4	51.20
December	12.9	26.0	78.0	-
January	12.7	25.6	78.0	-
February	13.7	28.2	78.0	-
March	15.9	33.7	78.0	-

Indian Institute of Sugarcane Research, Biological Control Centre - Pravaranagar

Month/Year (1994-95)	Temperature (°C)		Relative humidity (%)		Rain-fall (mm)	Number of rainy days
	Maximum	Minimum	7 hrs	14 hrs		
April	19.4	36.6	54.6	37.8	17	2
May	21.0	39.7	55.4	34.1	32	2
June	21.9	35.9	80.1	67.1	65	9
July	21.5	30.4	86.6	81.2	63	9
August	21.3	32.0	87.5	79.3	42	5
September	20.7	33.1	82.8	79.1	27	4
October	18.5	32.7	71.1	73.0	17	4
November	14.3	29.4	71.8	55.0	18	2
December	10.4	28.9	67.5	35.0	-	-
January	10.4	27.1	76.7	51.8	7	3
February	12.3	30.1	76.2	40.8	-	-
March	15.8	36.1	67.4	43.2	-	-

Andhra Pradesh Agricultural University, Hyderabad

Month/Year (1994-95)	Temperature (°C)		Relative humidity (%)		Rain-fall (mm)	Sun-shine (hrs)
	Maximum	Minimum	7 hrs	14 hrs		
April	36.5	23.0	68.8	33.2	32.4	8.9
May	40.4	26.3	54.7	24.2	13.9	10.5
June	34.7	24.4	74.1	45.4	47.7	6.6
July	30.2	22.5	85.6	61.8	118.2	3.3
August	30.0	22.3	82.8	54.9	153.2	3.9
September	31.3	21.5	79.5	50.8	47.7	7.2
October	30.1	21.0	84.2	59.0	236.8	6.8
November	27.9	15.5	81.2	53.4	24.6	7.9
December	27.9	9.2	79.6	33.9	0.0	10.1
January	27.2	12.8	85.0	42.0	17.4	8.4
February	32.1	16.1	78.0	30.0	0.0	10.5
March	35.2	20.0	74.0	34.0	49.4	10.3

Dr.Y.S.Parmar University of Horticulture & Forestry, Nauni, Solan

Month/Year (1994-95)	Temperature (°C)		Relative humidity (%)		Rain-fall (mm)	Sun-shine (hrs)
	Maximum	Minimum	7 hrs	14 hrs		
April	24.6	12.5	71	44	85.8	8.0
May	31.1	18.3	63	37	23.8	10.0
June	32.1	20.9	69	47	121.6	7.5
July	27.5	21.3	93	79	370.8	3.3
August	26.9	21.1	96	84	210.2	3.4
September	27.1	18.2	90	65	57.6	7.1
October	25.9	11.5	76	42	3.4	9.5
November	22.7	8.3	76	41	0.0	8.5
December	18.6	5.0	78	44	19.1	5.8
January	15.4	2.6	82	45	77.0	6.3
February	17.1	5.1	80	41	92.7	5.8
March	22.1	9.0	72	41	60.7	7.4

Tamil Nadu Agricultural University, Coimbatore

Month/Year (1994-95)	Temperature (°C)		Relative humidity (%)		Rain-fall (mm)	Sun-shine (hrs)
	Maximum	Minimum	7 hrs	14 hrs		
April	33.9	23.4	82	47	138.3	7.5
May	35.0	23.6	78	48	31.1	8.9
June	31.1	22.3	70	52	28.0	3.8
July	30.1	22.3	74	58	125.8	2.4
August	31.1	22.3	81	50	2.0	4.1
September	32.1	22.0	82	53	48.9	6.7
October	30.6	22.1	87	63	256.6	5.9
November	28.1	20.5	88	68	171.9	4.3
December	28.8	16.1	86	55	1.8	7.7
January	29.6	19.1	87	51	3.8	6.1
February	32.6	20.4	84	45	0.0	8.8
March	34.8	20.9	73	36	0.0	9.2

Mahatma Phule Agricultural University, Pune

Month/Year (1994-95)	Temperature (°C)		Relative humidity (%)		Rain-fall (mm)	Sun-shine (hrs)
	Maximum	Minimum	7 hrs	14 hrs		
April	32.1	23.0	81	86	12.6	4.4
May	27.3	21.2	86	79	8.6	3.0
June	26.8	21.6	87	78	5.4	2.3
July	27.7	21.2	91	80	5.2	2.3
August	30.2	16.8	89	48	0.2	7.5
September	31.0	17.8	91	42	3.6	7.8
October	29.3	13.6	92	38	2.3	8.8
November	27.9	9.2	92	28	0	8.3
December	26.8	9.5	94	38	1	8.7
January	31.1	12.4	89	10	0	9.8
February	33.7	12.9	80	23	0	9.6

MISCELLANEOUS INFORMATION

Participation in Seminar/Meeting/Symposium/Training programmes

Andhra Pradesh Agricultural University, Hyderabad

A.Ganeswara Rao, Entomologist presented a paper on "Apiculture in orchards " at the workshop on Horticultural Development in Mahabubnagar district held at Palem on 18-2- 1995 and also attended Workshop on Biological Control held at Bangalore during 17-10-94 to 19-10-94

Assam Agricultural University, Jorhat

Dr.A.Basit attended (i) Kharif and Rabi workshop on package of practice at AAU, Jorhat, (ii) Annual Research Committee Meeting AAU,Jorhat (iii) ZREAC Meeting RARS, Titabar and also (iv) attended Workshop on Implementation of IPM project.

Central Plantation Crops Research Institute, Kayangulam

Dr.B.Sathiamma, Senior Scientist participated in technology disseminated programmes developed on Pest Management in the Karshaka Seminar organized by the Rashtradeepika and Karshaka Vikasana Samiti and also attended the Workshop on Biological Control held at Bangalore during 17-10-94 to 19- 10-94

Gujarat Agricultural University, Ananad

Dr.D.N.Yadav attended meetings organized by DBT to finalise technical programme of Farm Projects (Asian Biotechnology and Biodiversity programmes) on 26-09-94; Workshop on Biological Control held at Bangalore during 17-10-94 to 19-10-94; Workshop on Production and Application of Biocontrol Agents at Beijing, China from 28-11-94 to 17-12-94; All India Workshop on Acrology held at Navsari 06-02-95 to 07-02-95 and Seminar on Innovative farmers of Gujarat organized by Gujarat State Cooperative Bank Ltd. Ahmedabad 22-10-94 to 23-10-94 at Gandhinagar.

Central Tobacco Research Institute, Rajhamundry

Mr.R.S.N.Rao attended National Symposium on Emerging Trends in Pest Management at Dr.YSPUH & F. Nauni, Solan Himachal Pradesh in June 1994; Second conference of Applied Zoologists Research Association on Recent Trends in Plant, Animal and Human Pest Management and Impact on Environment, held at Madras Christian College, Madras from 27-12-94 to 29-12-94; Tobacco Symposium on 'Search for High Quality" Held at CTRI, Rajhamundry, 01- 02-95 to 03-02-95; Fourth Biocontrol Workers Group Meeting held at Project Directorate of Biological Control, Bangalore from 19-10-94 to 20-10-1994; Second National Conference of Applied Zoologists Research Association Recent Trends in Plant Animal and Human Pest Management and Impact on Environment held at Madras Christian College Madras from 27-12-94 to 29-12-94 and Tobacco Symposum in Search For High Quality held at CTRI, Rajhamundry, 01-02-95 to 03-02-95.

Kerala Agricultural University, Trichur

Dr.P.J.Joy attended Board of Studies meeting of the Kerala Agricultural University on 16-08-1994; Fourth Biocontrol Workers Group Meeting at Project Directorate of Biological Control, Bangalore from 18-10-94 to 19-10-1994 and Fifth meeting of the Kerala State Insecticide Selection Committee at Agricultural College, Vellayani on 22-11-94

Indian Institute of Horticultural Research, Bangalore

Dr.M.Mani, Dr.K.P.Jayanth, Dr.A.Krishnamoorthy, Mrs.P.N.Gan- gavisalakshi and Mr.R.Asokan attended the Fourth Biocontrol workers Group Meeting at Bangalore from 18-10-94 to 19-10-94 at Project Directorate of Biological Control, Bangalore

Dr.K.P.Jayanth participated in the Fifth International Conference on Aerobiology at Hotel Ashok, Bangalore from 10- 08-94 to 15-08-94 and also attended the third meeting of the ICAR Fact Finding Committee on parthenium at the Project Directorate of Biological control, Bangalore on 05-09-94 to 06-09-94 .

Project Directorate of Biological Control, Bangalore

Dr.S.P.Singh, Dr.K.Narayanan, Dr.N.S.Rao, Mr.S.R.Biswas, Mr.B.S.Bhumannavar, Dr.N.Bakthavatsalam, Mr.S.Ramani, and Dr.(Mrs.)N.Pushpalatha attended the Fourth Workshop of Biocontrol Workers Group meeting at Project Directorate of Biological Control, Bangalore from 17-10-94 to 18-10-94

Dr.S.P.Singh Singh participated in International Symposium on Pulses Research New Delhi from 02-04-94 to 04-04-94; National Seminar on Cotton Production - Challenges in 21st Century at Haryana Agricultural University. Hissar from 18-04-94 to 20-04-94; Training Programme for the Management of Sugarcane Supply and Development held at Bangalore from 19-06-94 to 23-06-94; Trainers Training Programme on Sustainable Pest Control Methods - Mass Production of Natural Enemies - Organized in collaboration with Members of Consumers Forum, New Delhi at Project Directorate of Biological Control, Bangalore from 26-10-94 to 28-10-94; National Symposium on Agriculture in Relation to Environment, Indian Agricultural Research Institute, New Delhi, from 16-01-95 to 18-01-95; Farmers Rally on Biological Control organized by MPAU, Rahauri at village Peth, Pune District on 22-02-95 and Challenges to the Consumer Movement Local and Global, organized by Indian Institute of Consumer Studies, Bangalore from 05-03-95 to 17-03-95;

Dr.K.Narayanan participated and presented paper in the Summer Institute "Advances in Agricultural Microbiology with special reference to Mycorrhizal Symbiosis and their Role in Crop Productivity" at Department of Agricultural Microbiology, UAS, Bangalore, from 22-10-94 to 22-10-94; The National Symposium on 'Emerging Trends in Pest Managements"held at Dr. Y.S. Parmar University of Horticulture and Forestry, Solan from 28-6-94 to 30-06-94 and Second National Conference of Applied Zoologists Research Associations on Recent Trends in Plant, Animal and Human Pests Management; Impact on Environment at Christian College Madras, from 27- 12-94 to 29-12-94.

Dr.Y.S.Parmar University of Horticulture & Forestry, Solan

Dr.P.R.Gupta attended the Workshop on Biological Control held at Bangalore during 18-10-94 to 19-10-94

Indian Agricultural Research Institute, New Delhi

Dr.K.L.Srivatsava attended the Workshop on Biological Control held at Bangalore during 17-10-94 to 19-10-94

Mahatma Phule Krishi Vidyapeeth, Pune

Dr.B.G.Awate attended the Workshop on Biological Control held at Bangalore during 17-10-94 to 19-10-94

Post Graduate Studies/Training

Andhra Pradesh Agricultural University, Hyderabad

Mr.A.Ganeswara Rao trained seven batches of B.Sc. (Ag.) and one batch each of M.Sc.(Ag.) and Ph.D students of College of Agriculture, Rajendranagar on multiplication of different parasitoids / predators of different crop pests.

Assam Agricultural University, Jorhat

Dr.A.Basit taught a course on advanced biological control of crop pests to P.G. students and also acted as a major adviser to post graduate students in their research work.

Central Plantation Crops Research Institute, Kayangulam

Dr. S.Sathiamma trained twentyone (officials from the Department of Agriculture, Coconut Research Stations and Coconut Development Board from Andhra Pradesh, Bihar, Karnataka, Kerala, Pondicherry and Tamil Nadu) on 'Biological suppression of insect pests of coconut' for four days. Six technical officers from Coconut Development Board, Kochi underwent training for one day on pest management in coconut. Visited coconut gardens at Kappil, Shertala and Vaikom (Kerala) on request from the farmers and appropriate technology was given to farmers. Participated in organizing exhibitions in different occasions i.e. at the Prem Nazir Memorial Mahamela at Attingal, Thiruvananthapuram from 22- 08-94 to 03-10-94; State level Agricultural Fair at Kanakakkunnu palace, Thiruvananthapuram from 13-12-94 to 18- 12-94 and at Rajiv Gandhi Memorial All India Exhibition at Kollam, Kerala from 15-12-94 to 13-3-94.

Gujarat Agricultural University, Anand

Dr.D.N.Yadav acted as a committee member in Task Force for Biological Control constituted by Department of Biotechnology, Government of India, New Delhi.Also acted as a Member in Biopesticides Recommendation Committee constituted by Director of Agriculture, Gujarat State Department of Agriculture.

Kerala Agricultural University, Trichur

Dr.P.J.Joy served as resource personal for TV, Insecticide Selection Committee, Member of the Board of Studies and Member, Faculty Research Committee, Kerala Agricultural University. Acting as the Head of the Department of Agricultural Entomology, College of Horticulture, Vellanikkara, Trichur. Participated in the State Agricultural Fair and Exhibition at Trivandrum, from 14-12- 94 to 18-12-1994.

Punjab Agricultural University, Ludhiana

Scientists working on the biological control imparted training to Officers of sugar mills and to Department of Agriculture, Punjab on various aspects like identification and multiplication of natural enemies.
In a State level Seminar on Popularization of Biological Control at Nawanshahr a Memento was presented to Punjab Agricultural University, Ludhiana by Hon'ble Minister of Agriculture and Forestry, Punjab for popularizing the biological control of sugarcane pests in Punjab.

Indian Institute of Horticultural Research, Bangalore

Dr. M.Mani imparted training on biological suppression of fruit crop pests to various trainees on the following aspects on 05-12-94, 14-02-95, 01-04-94 to 28-06-94 and 15- 11-94 to 17-11-94

Dr.K.P.Jayanth participated in a TV programme on biological control of water hyacinth on the Science programme " Turning Point " by Doordarshan on 26-11-94; conducted Viva- Voce Examination of Entomology Honours Programme students of St.Joseph's College, Bangalore and distributed prizes and certificates to them at their Convocation on 09-03-95 and received the " Jawaharlal Nehru Award " for outstanding Post-graduate Agricultural Research for 1994 for his Ph.D. thesis entitled "Bioecological and physiological studies on the insect *Zygogramma bicolorata* and evaluation of its potential in controlling the weed *Parthenium hysterophorus*." on 11-03-95

Sugarcane Breeding Institute, Coimbatore

Dr.S.Easwaramoorthy has been nominated as Associate Editor for the Journal of Biological control.

Project Directorate of Biological Control, Bangalore

Dr.S.P.Singh is nominated as a Member (i) ICAR Scientific Panel of Division of Crop Sciences; ICAR Entomology Project Screening Committee; Task Force on Biological Control, Department of Biotechnology, Government of India, New Delhi; Department of Biotechnology Mission Mode Project on Biological Pest Control; Research Advisory of World Bank - NARP Basic Research Sub-Project on Integrated Pest Management; Panelist for Kisan Goshties at International Exhibition 'AGRI EXPO' on 10-03-95; For evaluating the need for equipments and manpower for Central Coffee Board Research, Chickmangalur (Karnataka); President, Biocontrol Society of India; Resource person for TV, AIR. Dr. Singh is guiding two Ph.D. students. He is a member of research advisory committee of several students working on biological control for their Ph. D. degree. He has evaluated Ph. D thesis from other universities.

Dr. S. P. Singh and Dr.K.Narayanan acted as resource persons on the plenary discussion on F.A.O. sponsored training on " Microbial control of vegetable crop pests" by the invitation of Plant protection Advisor, Plant protection Directorate and Storage, Faridabad, Govt. of India. Dr. Narayanan also acted as a referee for evaluating the various Ph.D. thesis for Jawaharlal Nehru Award.

ACRONYMS

AAU	: Assam Agricultural University
APAU	: Andhra Pradesh Agricultural University
CICR	: Central Institute of Cotton Research
CPCRI	: Central Plantation Crops Research Institute
CTRI	: Central Tobacco Research Institute
GAU	: Gujarat Agricultural University
GBUAS &T	: Gobind Vallabh Pant University of Agricultural Sciences & Technology
IARI	: Indian Agricultural Research Institute
ICAR	: Indian Council of Agricultural Research
IIHR	: Indian Horticultural Research Institute
IISR	: Indian Institute of Sugarcane Research
KAU	: Kerala Agricultural University
MPKV	: Mahatma Phule Krishi Vidyapeeth
NCIPM	: National Centre for Integrated Pest Management
PAU	: Punjab Agricultural University
PDBC	: Project Directorate of Biological Control
SBI	: Sugarcane Breeding Institute
SKUAS &T	: Sher-e-Kashmir University of Agricultural Science & Technology
TNAU	: Tamil Nadu Agricultural University
UAS	: University of Agricultural Sciences
YSPUH &F	: Dr.Y.S.Parmar University of Horticultural & Forestry