Tech. Doc, No. 43

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ANNUAL REPORT

[1st April, 1993 To 31st March, 1994]

PROJECT DIRECTORATE OF BIOLOGICAL CONTROL
Post Bag No. 2491, H. A. Farm Post
Hebbal, Bellary Road
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Date 26.9.94

CHAPTER I

1. PROJECT PROGRESS REPORT

1.1. SALIENT FEATURES OF THE WORK DONE/MAJOR ACHIEVEMENTS DURING THE YEAR

1.1.1. BENEFICIAL INSECT INTRODUCTION, QUARANTINE HANDLING AND BASIC RESEARCH

During the period under report a total of 65 shipments of different insects were sent to various organizations and co-ordinating centres. The shipments included 48 natural enemies and 17 host insects maintained at the Project Directorate.

Screening of various *Bacillus thuringiensis* products against *Trichogramma chilonis* and neonate larvae of *Helicoverpa armigera* revealed that Bitoxibacillin, Lepidocide and Dipel caused 60.7, 63.1 and 36.4% mortality of *T. chilonis* adults after 24 hours of constant exposure. However, none of the compounds caused any hinderance to parasitism, which ranged from 93.4 - 98.2%. Emergence of parasitoids from all treatments was normal and at par. Studies therefore suggest that both *B. t.* products and *T. chilonis* are compatible and can be released/sprayed together for effective biosuppression.

Screening of neonate larvae of *H. armigera* against *B.t.* products revealed that Lepidocide, Thuricide and Delfin caused 93.6, 83.8 and 78.04 % mortality of larvae within 3 days of hatching while BTK-I and II and Dipel caused 59.5, 50.7 and 50.2% mortality, respectively. BTK-I, II, Tow arrow, Dipel and Asthur also caused mortality between 6.8 - 11.5 % 4-7 days after hatching. Results generally revealed quick action of these compounds. In Bitoxibacillin 18.4 % larvae pupated which was significantly less than control where 38.0 % larvae pupated. In other products very few larvae could pupate. On observation it was revealed that in various products number of larvae either did not pupate or were half pupated (deformed) but were not killed even after 30 days of treatment. This could be perhaps due to ingestion of sublethal dosages. In products like BTT, Asthur, Dendrobacillin and BTK-II 17.8, 17.0, 16.6 and 11.2 % of such larvae were observed. In Tow arrow, BTK-I, Bitoxibacillin, Lepidocide and Dipel, percentage of such larvae were 4.6, 3.8, 3.4, 1.8 and 1.3 %.

Screening of trichogrammatids against *Opisina arenosella* eggs indicated that *T. embryophagum* parasitized 82.05 % eggs followed by *T. pretiosum* (27.3 %), *T. bactrae* (15.1 %) *Trichogramma* sp. (12.45 %), *T. chilonis* (10.96 %), *T. brasiliensis* 8.96 % and *T. evanescens* (6.25 %) while other species failed to parasitise *O. arenosella* eggs laid in the frass. High egg hatching was also observed in most of the species indicating that trichogrammatids were unable to parasitise eggs inside the frass except *T. embryophagum* where only 15.38 % eggs hatched, thus suggesting that this species can be further tried for making field releases.

Effect of UV treatment on freshly parasitised eggs of *Corcyra cephalonica* by *Trichogramma chilonis* showed that exposure of 0 - 3 day old eggs to UV rays from 45 to 90 minutes does not affect the developing *Trichogramma* larvae inside the host. However, when *T. chilonis* reaches the late larval instars UV rays kill them inside the host egg. Thus 0 to 3 days old *T. chilonis* tissue can be utilised for cell live culture as the host gets killed but not *T. chilonis*.

Evaluation of endosulfan resistant/tolerant strain of *Trichogramma chilonis* was continued and the results revealed that after 131 generations when shifted to 0.035 % concentration, 100 % mortality occurred within 6 hours and parasitism was 70.0 %. However after rearing for another 30 generation at the same concentration level, mortality pattern after 6 and 24 hours in F 162 generation was 50.0 and 80.0 % and parasitism was 100.0 %. It was decided after obtaining 100.0% parasitism for about 25 generations continuously to shift parasitoids to next higher concentration i.e., 1.25 ml/liter (0.044 %) in F 164 generation. Parasitoids again showed higher susceptibility to this dosage and low parasitism of 65.0 % was obtained.

Studies on the effect of different egg number of *Helicoverpa armigera* on parasitism and adult recovery of *Trichogramma brasiliensis* revealed that per cent parasitism was high (60 - 80 %) at low host density (5 to 20 eggs/female parasitoid) and at a host density of 30 to 100 eggs parasitism ranged from 31.2 to 46.6 %. Number of adults obtained per egg was highest when 5 eggs were exposed to a single female (2.5 adults/egg) followed by 2.0 adults/egg in 10 eggs/parasitoid and 1.27 in 20 eggs/parasitoid treatment. From 30 to 100 eggs/parasitoid treatment, adults obtained ranged from 1.00 to 1.14 per/egg. Thus *T. brasiliensis* exhibited superparasitism tendency in lower egg density, and it could be concluded that egg - female parasitoid ratio of 40:1 is ideal to avoid super parasitism.

Results of exposure of *Trichogramma* spp. reared from *C. cephalonica* to the same eggs showed that fecundity of *T. pretiosum* was highest (41.5) followed by *T. dendrolimi* (39.8), *Tr. bactrae* (28.9), *T. brasiliensis* (28.3), *T. chilonis* (22.4), *Tr. armigera* (13.3) and *T. achaeae* (11.0). When adults obtained from *C. cephalonica* eggs were exposed to *H. armigera* eggs fecundity of *Tr. armigera* increased significantly and that of *T. chilonis* and *T. achaeae* marginally. Though fecundity in others declined, number of adults obtained per egg was significantly more. Number of adults per egg ranged from 1.64 to1.89 in comparison to 1.01 to 1.09 in C. cephalonica eggs. In a third set where adults obtained from H. armigera eggs after rearing for 20 generations on this host were exposed to C. cephalonica eggs, fecundity of all species increased significantly. Exposure of trichogrammatids to H. armigera eggs increased fecundity significantly in Tr. armigera (122.5%), Tr. bactrae (12.8%), T. pretiosum (22.8%), T. chilonis (289.2%), T. achaeae (225.4%) and T. brasiliensis (112.3%). In T. dendrolimi it remained almost same. It is therefore clear that if above species are reared on H. armigera eggs an increase in its fecundity can be achieved. Rearing on any host did not effect developmental period, emergence of parasitoids or longevity. There was more recovery of adults/egg from H. armigera compared to C. cephalonica, (increase of 60.7 - 61.5 %).

A study on the effect of different egg density of Helicoverpa armigera and parasitoids numbers on intensity of parasitism on cotton by Trichogramma chilonis indicated that in 1 female/plant parasitism was very low with a maximum of 19.5 % at a density of 15 eggs/plant. In 2 females/plant treatment, host parasitism with egg density at 20 eggs/plant was highest (45.8 %). In 4 and 6 females/plant treatment, host parasitism increased upto 15 and 10 eggs/plant and declined thereafter. T. chilonis showed some density dependence as parasitism was generally low in the level of 2 and 5 eggs/plant. Effective suppression of H. armigera, therefore, can be achieved by regulating dosages as per egg density.

An experiment carried out to find out the competitive interaction between Cheilomenes sexmaculata and Chrysoperla carnea in the presence and absence of Aphis gossypii revealed that in presence of aphids there was no interaction between 1st instar grubs of each species and they consumed 74 % of aphids provided within 24 hours. During 2nd instar C. carnea killed 66.0 % larvae of C. sexmaculata and all aphids provided were consumed in 24 hours. During 3rd instar C. carnea killed 66.0 % of C. sexmaculata and C. sexmaculata killed 33.0 % of C.carnea. However, in latter case both larvae were found entangled with each other and on separation both died within 24 hours. In the absence of aphids such attack was more pronounced. C. carnea killed 91.0, 100 and 100 % C. sexmaculata larvae during 1st, 2nd and 3rd instars and C. sexmaculata killed 10.0, 33.0, and 0.0 % in 1st, 2nd and 3rd instars, respectively.

Performance of Cheilomenes sexmaculata in different temperatures and humidity ranges indicated that in general C. sexmaculata was able to bring down high aphid population at 18°C when it predated on 72.3 and 76.8 % aphids at 40 % and 70 % R.H., respectively. A. gossypii increase was less at this temperature suggesting it was not optimum for its reproduction. At 22°C, *C. sexmaculata* reduced *A. gossypii* population by 86.4 % at 40 % R.H. and 97.4 % at 70 % R.H. In control, aphids multiplied 11.6 times at 70 % R.H. compared to 3.2 times at lower humidity of 40 %. At 26°C, population reduction of 80.9 and 99.6 % was obtained at lower and higher humidity, respectively. At this temperature aphids multiplied 9.6 and 10.8 times within 5.0 days. Thus *C. sexmaculata* performs better at 22-26°C temperature and 70% humidity.

The economics of production of *H. armigera* was worked out. Including the cost of the diet ingredients, labour, electricity charges, etc., the cost of production of one set of diet vials (containing 96 vials) with 1 larva in each was calculated to be Rs. 49.72. Considering 50 % mortality from the time of inoculation into the diet till pupation, the cost of producing one *H. armigera* pupa was found to be one rupee.

The experiment on developing a pesticide tolerant strain of *Telenomus remus* was initiated by using endosulfan at 0.1 ml concentration. Now the experiment is in progress at 0.3 ml concentration. Here, though high mortality has been recorded, over generations, a parasitism of 50 % has been obtained.

Studies on the storage of *Carcelia illota*, a tachinid parasitoid of *H. armigera*, has shown that storage of the puparia of this parasitoid at 10°C results in 40 %, 22.5 %, 17.5 % and 0 % emergence at 10, 20, 30 and 40 days of storage respectively in comparison to the puparia retained at room temperature where 100 % emergence could be obtained.

A survey conducted for the presence of *Diadegma semiclausum* at Nilgiris on cabbage has shown a parasitism of 30 % in the mature cabbage fields by this parasitoid. There were no differences in the biological parameters of the Nilgiris strain in comparison with the exotic Taiwan strain.

Maternal age and host deprivation had no effect on the longevity of *Bracon kirkpatricki*. Maximum number of cocoons were formed and cocoon production occurred for 38 days when hosts were provided for a day old mated females. Significant reduction in cocoon production occurred when hosts were not provided for more than 6 days. The parasitoid produced cocoons for a range of 18 - 21 days when the host was exposed to 3 to 9 day old females. Beyond 9 days, the number of days of effective cocoon production was drastically reduced.

The results of the comparative studies using the indigenous and Indonesian strains of *Cotesia flavipes* and testing them for their parasitising ability, progeny production and sex ratio amongst progeny at parasitoid host ratios of 1:2, 1:1 and 2:1 revealed the superiority of the indigenous strain in producing more adults per host larva parasitised and a greater proportion of females in the progeny. The ratio of 2:1 gave best results among the ratios tested.

Tomato, cotton, pigeon pea and chick pea plants were tested using *H. armigera* eggs on the leaves for the parasitising ability of *Chelonus blackburni* reared from *P. operculella* and *C. cephalonica* (laboratory hosts). The results indicated that there was no parasitism in chickpea while tomato had the greatest parasitism of about 17 %. The parasitism of *H. armigera* was not very different amongst the three host plants whether the adults were reared from *P. operculella* or *C. cephalonica* and the adult emergence was also low irrespective of the host plant.

Egg clusters of *Chilo partellus* with varying egg numbers were used to study the performance of *Trichogramma chilonis* for their parasitising ability, adult emergence and proportion of females in the progeny. The results indicated a 92.33 % parasitism in egg clusters having 26-30 eggs and an overall parasitism percentage of around 70 % in egg clusters having 16-55 eggs. The proportion of females in the progeny was around 2.5 to 3.8 in the egg clusters numbering from 16-55 eggs. The number of adults were also around 35 in these egg clusters.

The relationship between larval period and pupal weight of *Chilo partellus*, *Corcyra cephalonica*, *Phthorimaea operculella*, *Plutella xylostella*, *Helicoverpa armigera* and *Spodoptera litura* revealed a negative correlation between the two and in general a shorter larval period and lesser weight of pupae of males than females in the species studied.

1.1.2. BIOLOGICAL SUPPRESSION OF SUGARCANE PESTS

Experiments were laid out at Punjab Agricultural University, Ludhiana to evaluate the effectiveness of *Trichogramma chilonis* for the control of *Chilo auricilius*. The releases of 6 day old parasitized host eggs were made from July to October at 10 day interval @ 50,000/ha. The incidence varied from 6.9-7.4 per cent in the parasitoid released plots as compared with 17.9 per cent in the control.

An attempt to field evaluate *T. chilonis* against *C. auricilius* and *C. s. indicus* at Indian Institute of Sugarcane Research, Lucknow revealed that the borer incidence and intensity at harvest in released and control blocks were 40.7 and 2.7 per cent and 39.3 and 3.1 percent, respectively. While for internode borer it varied from 50.2

to 59.0 per cent in released plot as compared to 51.2 to 61.71 per cent in unreleased plots. At harvest the internode borer incidence and intensity in released plot were 57.71 and 5.4 per cent which was significantly less than 64.32 and 6.7 per cent in control plots. Augmentative releases of indigenous and Indonesian populations did not reduce the level of internode borer incidence at Coimbatore.

Per cent parasitisation by C.flavipes of stalk borer larvae at Lucknow in different plots ranged from 8.60 to 31.31 (mean 19.45). Difference between released and unreleased plots in parasitization percentages were not discernible. Cotesia flavipes adults @ 650/ha were released at fifteen days intervals in block trial. The progress of infestation of stalk and internode borer was at low pace in the Cotesia released plot as compared to control plot.

An experiment was laid out in Punjab to compare the field efficacy of two strains of Cotesia flavipes. viz. indigenous strain and Indonesian strain. The releases of parasitoiids were made @ 800 adults/ha at 10 day intervals from last week of April to end of October. It was found that the indigenous strain of C. flavipes was better as compared to the Indonesian strain to control three species of sugarcane borers, viz. Chilo auricilius, C. infuscatellus and Acigona steniellus.

The effect of releases of cocoons of Epiricania melanoleuca for the control of Pyrilla perpusilla was studied by collecting the parasitoid cocoons and releasing them in areas where these were almost absent in Ludhiana. The releases were made once @ 5,000/ha. It was found that with in a month the population of pyrilla was very low where cocoons were released as compared with the control plot.

Four species, viz. Cotesia flavipes, Glyptomorpha nicevillei, Campyloneurus mutator and Sturmiopsis inferens were recorded from Chilo auricilius, S. inferens was recorded for the first time from Punjab. Only Cotesia flavipes and G. nicevillei were recovered from Acigona steniellus. Five parasitoid species, viz. Telenomus dignoides, Rhaconotus scirpophagae, Isotima javensis, G. nicevillei and an unidentified tachinid were recovered from eggs and larvae of Scirpophaga excerptalis.

Three formulations of B. t. viz. Delfin, Dipel 8L and Centari were tested against C. auricilius and it was found that after 72 hrs all treatments proved better than control. Higher dosages of Delfin and Dipel 8L proved significantly better than the lower dosages.

At Sugarcane Breeding Institute, Coimbatore natural parasitism by C. flavipes was highest on sorghum borer followed by internode borer. On shoot borer, the parasitoid showed no activity throughout the year. A survey conducted for natural enemies of internode borer at Coimbatore and sugar mill areas in Tamil Nadu revealed the absence of larval parasitoids except for C. flavipes as also viral as against fungal infections.

In laboratory parasitization studies, indigenous population showed higher levels of parasitization on sorghum borer than on internode borer. Indonesian population behaved erratically in laboratory cultures which could not be maintained continuously. Host acceptance time of females of Indonesian population on C. partellus was slightly less than that of indigenous population. Nine insecticides tested against adults of C. flavipes by residual film exposure showed them to be toxic.

Four species of ground beetles collected from sugarcane ecosystem were identified. The activity of carabids was almost equal in cropped area and fallow land. Field collected carabids fed on sugarcane borers and sucking insects in the laboratory.

Cryptolaemus montrouzieri showed feeding and development on sugarcane pink mealy bug. However, ants appeared to interfere with its activity.

The commercial formulation of B. thuringiensis - Dipel was found to be effective against internode borer in laboratory bioassay.

Laboratory investigations were carried out at Lucknow on the biology of exotic strain of C. flavipes on the larvae of C. auricilius. The longevity of male and female wasp was 8.69 $\pm$ 3.32 and 5.4 $\pm$ 2.25 days, respectively. On an average a female paralysed 2 $\pm$ 1.43 host larvae during its total life period. Each female wasp produces 37.17 $\pm$ 27.85 adults. Emergence of adults from cocoons was 94.89 per cent. Sex ratio of the emerging progeny was 1: 0.33 (Male : Female) in single pair experiments while in group rearing when 10 males and 10 females were released for parasitisation the sex ratio in the progeny improved (1:0.85). Mean production of wasps from each parasitised larvae of stalk borer was 21.85.

Parasitization of top borer, Scirpophaga excerptalis by Isotima javensis predominated the parasitisation in 4th brood (9.2 percent) while the parasitisation by other natural enemies were at a low key at Sardar Nagar. A total of 2,850 males and 4,500 females of Elasmus sp. released in the earmarked field resulted in increased parasitization to an extent of 4.4 per cent against 2.5 per cent parasitization observed in nature.The top borer infestation at Shakar Nagar was negligible and egg parasitization to an extent of 14.19 per cent by *Telenomus* sp. was recorded

Parasitisation by *Cotesia flavipes* and *Campyloneurus mutator* to the extent of 2.5 % and 3.5 %, respectively, was recorded on stalk borer, *C. auricilius* in Sardar Nagar.

1.1.3. BIOLOGICAL SUPPRESSION OF COTTON PESTS

The studies made at Hyderabad revealed that it is possible to obtain Rs.31,700 / ha by spending about Rs.5050/ha through IPM strategies on cotton (1: 6.27 cost : benefit ratio), whereas the intensive insecticidal usage may give Rs. 54,000/ha (1:3.46, cost benefit ratio) on 30 rounds of spray for Rs.15,569 spent. The latter also proved detrimental for the development of beneficial fauna.

Research-cum-demonstration trials were laid out at three locations in Punjab (Mansa, Sandhwan and Barriwala) with four treatments, viz. bio-agents (*Trichogramma chilonis* & *Chrysoperla carnea*), PAU recommended spray schedule, farmer's spray schedule and cotrol. The releases of *T chilonis* were made @ 1,50,000/ha and that of *C. carnea* @ 1,00,000/ha. It was observed that bollworm complex incidence in four treatments, viz. bio-agents, PAU spray schedule, farmer spray schedule and the control were 77.9%, 27.8% 37.6% and 80.7% respectively at Sandhwan, 64.6%, 54.1% 67.4% and 82.1% at Mansa and 15.03%, 22.06%, 17.73%, and 62.53% at Barriwala.The results indicate that the releases of *Trichogramma* could lead to a reduced level of the pest, possibly by combining with the insecticidal spray.

The IPM module consisting of blanket application of methyl demeton (0.03%) three releases of *Chrysopa scelestes* @ 50,000/ha/week and releases of *Trichogramma chilonis* @ 1,50,000/ha/week and one spray each of endosulfan (0.07%) and monocrotophos 0.04% proved effective against cotton bollworm *Earias vittella* and sucking pests *Aphis gossypii*, jassid and whitefly at Anand.

In the trial conducted at the farmers field at Alandurai by TNAU, Coimbatore on development of biocontrol based IPM for cotton pests, the results indicated that the set of treatment with biocontrol agents (*Chrysoperla carnea*, *Trichogramma chilonis* and Ha NPV) and need based application of insecticides, neem oil as envisaged in the AICRP programme, treatments on ETL based on recommendation by TNAU, were on par with each other in reducing the population of sucking pests, the incidence of bollworms and recording higher yield but superior to the farmers method with more number of insecticides, applied at frequent intervals.

The results of the trial using *C. carnea* for the control of aphids, thrips and white flies and comparing it with plant protection schedule in Pune (Maharashtra) indicated that the jassid and whitefly population was minimum in biocontrol treatment plots. There was no significant difference in thrip incidence in all the treatments. In case of bollworm control the chemical treatment was found superior in reducing bollworm damage as evidenced by the boll and locule damage of 46.08 and 26.64 % in insecticidal treated plots as against 68.66 and 39.27 % in biocontrol treated plots. The insecticide treated plots gave higher yields of seed cotton (1121.37 kg/ha) than biocontrol treated plots (888.11kg/ha).

Laboratory studies were made to study the effect of two different formulations and dosages of *Bacillus thuringiensis* on the larvae of *Earias* sp. It was found that higher dosages of Delfin (2kg/ha) and Dipel 8L(2 lit./ha) resulted in higher mortality as compared with their lower dosages (1 kg/ha).

1.1.4. BIOLOGICAL SUPPRESSION OF TOBACCO PESTS

In a survey for tobacco aphid natural enemies at Rajahmundry, it was found that syrphids appeared first followed by coccinellids which kept the population at check.

Six chrysopid larvae per tobacco plant released at the begining of aphid infestation in tobacco field crop effectively reduced the build up of aphid population and was on par with phorate 10 G @ 2g/plant and both these were superior to the control plot where the aphid population increased continuously. All the *B. t.* treatments and endosulfan (1 ml/lit) were superior to control in reducing capsule damage by *H. armigera* in tobacco. Delfin, Dipel and Bactospeine were significantly superior to endosulfan. Among *B.t.* formulations , Delfin and Dipel were superior to Bactospeine and thus can be used effectively against *H. armigera*. The *B.t.* treatments Dipel and Delfin were on par and significantly superior to all other treatments in reducing the seedling damage by *S. litura*.

A. africanus could locate *S. litura* and parasitize effectively in both caged and uncaged tobacco nursery beds and significantly reduced the number of seedlings damaged over control.

In a biocontrol based IPM demonstration trial in an area of 0.5 ha nursery at Morampudi commercial tobacco nursery belt, integration of parasitoids,predators,insect pathogens, antifeedant (NSKS) and ovipositional trap crop castor against *S. litura* was demonstrated. The CB ratio for IPM was 1:2.74 whereas for conventional chemical control it was 1:1.52. It was also observed that with the use of biocontrol agents the damage to tobacco nurseries was significantly reduced over chemical control and the trap crop of castor lured heavy population of S. litura away from nurseries and encouraged the biocontrol, agents both released and indigenous ones.

1.1.5. BIOLOGICAL SUPPRESSION OF PESTS OF PULSES

Trials with T. chilonis and HaNPV on H. armigera were conducted in Hyderabad and Coimbatore. Application of HaNPV @ 125 LE/ha, 250 LE/ha and 125 LE/ha in combination with the release of Trichogramma chilonis registered 87, 73 and 47 % larval mortality. In Coimbatore spraying of endosulfan 0.07% (thrice), Ha NPV 250 LE/ha thrice, release of T. chilonis @ 1 lakh/ha five times, as well as spraying of NPV 125 LE/ha + T. chilonis 50,000/ha thrice were quite effective in reducing the larval population and damage by H. armigera and also recorded higher grain yield.

Evaluation of B.t. formulations viz., Dipel, Delfin, Biobit, BARC strain, BTK-I, BTK-II, B.T.T, and Agree at 0.5 kg/ha at Hyderabad and Coimbatore revealed that the lowest damage (26.83%) was in Biobit followed by Endosulfan 0.07 % (27.16 %) as against 57.84% damage in untreated control at Hyderabad. Highest larval mortality (53.33%) was also recorded in Biobit followed by Dipel and Delfin (40%). The trial in Coimbatore revealed that Dipel, Delfin and BTK I were on par but superior to BTT, BTK II, BARC strain, Biobit and endosulfan. All B. t. formulations were however superior to untreated check, and the grain yield data among the treatments were not significantly different.

The effectiveness of NPV against H. armigera in chickpea was estimated at Hyderabad and Coimbatore. Spray application @ 250 LE/ha reduced the larval population significantly (83.3%) followed by 125 LE/ha (75.0 %) and and 125 LE /ha + endosulfan 0.035 % (63.9 %). The results at Hyderabad indicated that HaNPV @ 250 LE/ha was effective in reducing H. armigera on chickpea. In Coimbatore the damage was significantly less in endosulfan 0.07 % treatment followed by HaNPV 125 LE + jaggery 0.5 % + endosulfan 0.035 %, HaNPV 250 LE; HaNPV 250 LE + jaggery 0.5 %; HaNPV 125 LE+ endosulfan 0.035 %. With regard to yield, the HaNPV 250 LE was superior to other treatments in recording higher yield followed by HaNPV 125 LE + jaggery 0.5 % + endosulfan 0.035 %, endosulfan 0.07 % and HaNPV 125 LE + endosulfan 0.035 % which also shows that the HaNPV @ 250 LE / ha was good.

Two peaks of moth emergence once in 2nd week of September and the second in 4th week of September were recorded while monitoring H. armigera population through pheromone trap catches at Hyderabad.. Two weeks after noticing the peak moth population, egg population of H. armigera was observed synchronising with the peak flowering period of pigeonpea. This could greatly help in synchronizing field release of *Trichogramma* and spray of NPV depending on the peak moth emergence noticed in pheromone traps.

1.1.6. BIOLOGICAL SUPPRESSION OF RICE PESTS

In the trial conducted during kharif, 1993 at TNAU, Coimbatore release of *Trichogramma japonicum* @ 5 cc/ha (5 times) was on par with release of parasitoid (4 times) followed by spraying of phosphamidon 300 ml/ha once as well as spraying of phosphamidon 300 ml/ha on 30 and 37 DAT in reducing the stemborer dead hearts upto 44 DAT. However, on 51 DAT, ETL based application of phosphamidon (twice) was superior to the above treatments. With regard to white ears, release of parasitoid followed by spraying of phosphamidon was on par with spraying of phosphamidon (twice) alone in recording less white ears damage. Higher yield could be recorded from the plots treated with spraying of phosphamidon (twice) as well as release of *T. japonicum* (4 times) and spraying phosphamidon once. In rabi, 1993 the results indicated that release of *T. japonicum* @ 5 cc/ha thrice followed by spraying of phosphamidon 300 ml/ha once was on par with need based spraying of phosphamidon 300 ml/ha twice in reducing the stemborer DH and white ears and recording higher yield than release of parasitoids *T. japonicum* and *T. chilonis* alone, each four times.

Field experiment on the evaluation of *Trichogramma japonicum* to control *Scirpophaga incertulas* on rice in Ludhiana showed that the releases of *T. japonicum* @ 50,000/ha at 10 days interval, during August and September were effective, and the parasitoid was also recovered from the colonized plot. Similarly *T. chilonis* was tried against *Cnaphalocrosis medinalis* @ 50,000/ha, at 10 days interval and it was found that the number of leaves damaged by the pest were almost half in the released plot as compared with the control plot.

Release of *T. japonicum* @ 50,000 adults/ha at Pune was found to be the most effective and significantly superior to chemical control i.e. two sprays of endosulfan (0.07 %) and control. The parasitoid suppressed the pest to an extent of 43.89 % as against 13.74 % in endosulfan.

At Coimbatore release of miridbug, *Cyrtorhinus lividipennis* @ 70 nymphs/m2 thrice on 45, 55 and 65 DAT was on par with application of carbofuran 3 G @ 33 kg/ha on 44 DAT in reducing the population of brown planthopper, *Nilaparvata lugens*. The population of wolf spider, *Lycosa pseudoannulata* was uniform in all the treatments indicating the safety of carbofuran 3 G to the wolf spider.

In the studies made on the assessment of population dynamics of pests of rice and their natural enemies at Coimbatore need based application of phosphamidon 300 ml/ha recorded less incidence of stemborer dead hearts and white ears and was safer to the wolf spider L. pseudoannulata and web spider, Tetragnatha javana.

Three egg parasitoids viz., Tetrastichus schoenobi, Telenomus rowani and Trichogramma japonicum were recorded at Coimbatore parasitizing eggs of rice stem borer, to an extent of 28.1, 25.9 and 5.2 per cent respectively. The activity of T. schoenobii was high during June (61.9 %), July (35.7 %) and September (36.7 %) and the extent of parasitism by T. rowani ranged from 30.1 to 52.1 per cent and by T. japonicum the parasitism ranged from 6.5 to 10.6 per cent. On egg mass basis, the total parasitism by the three parasitoids was higher during December (83.6 %), March (76.9 %), November (71.1 %), October (69.3 %), January (63.3 %), and September (61.0 %). The larval parasitoids of rice leaf folders, Cnaphalocrocis medinalis and Marasmia patnalis viz., Trichomma cnaphalocrocis, Temelucha philippinensis, Xanthopimpla flavolineata, Brachymeria sp., Charops brachypterum, Elasmus sp., and Apanteles flavipes effected their maximum parasitism to the extent of 7.0, 8.1, 11.3, 11.9. 1.4, 1.4, 4.6 and 11.5 per cent, respectively.

Successful establishment of the parasitoid Allorhogas pyralophagus has been achieved with the recovery of this exotic parasitoid from the yellow stem borer larvae collected from the parasitoid released rice field of Assam.

Seasonal incidence of key natural enemies of rice hispa Dicladispa armigera in the hispa endemic areas of Disangmukh, (Sibsagar) and Kakajan revealed the activity of egg -larval parasitiod Chrysonotomyia sp.,larval parasitoid Bracon hispae and egg parasitoids Trichogramma spp., Oligosita sp. Out of these natural enemies Bracon hispae and Chrysonotomyia sp. were dominant both during the Rabi and Kharif, 1993. Efforts have been made to develop laboratory rearing techniques for these indigenous parasitoids.

Studies in Coimbatore revealed that spraying of monocrotophos 100ml/ha (thrice), Bacillus thuringiensis 2.5 lit/ha (thrice), buprofezin (4 times) 1.6 kg/ha, NSKE 5% (4/5 times) as need based either alone or in alternation viz., monocrotophos-buprofezin B. t, Bup-B.t-NSKE; as well as B. t. - NSKE-mono were found to reduce the leaf folder damage and increased the grain yield significantly. The safety of treatments in conserving the population of predators and extent of larval parasitism was in the order of NSKE > B. thuringiensis > buprofezin > monocrotophos either alone or in alternation.

1.1.7. BIOLOGICAL SUPPRESSION OF OIL SEED PESTS

Only one parasitoid, *Diaeretiella rapae* was recovered from mustard aphid, *Lipaphis erysimi* whereas coccinellid, *Coccinella septempunctata* and syrphids, *Episyrphus alternans*, *E. balteatus*, *Metasyrphus confractor*, *Scaeva latemaculata* and *Spaeroporia indiana* were the predators recorded at Ludhiana

A field experiment was laid out in Ludhiana to study the efficacy of *C. septempunctata* and *Cheilomenes sexmaculata*. The second instar larvae of these beetles were released @ 1000/ha and it was found that *C. septempunctata* was better to control the mustard aphid as compared with *C. sexmaculata*. The feeding capacity of the larvae of these two species studied in the laboratory showed that the larvae of *C. septempunctata* consumed 380.40 ± 42.3 and *C. sexmaculata* 304.3 ± 35.8 aphids during their development period.

The laboratory studies conducted at Hyderabad on infectivity of *Metarhizium anisopliae* and *Bacillus popilliae* indicated that neither of them were effective against white grub of groundnut which was also evident from the field study where no difference in crop stand or yield was obtained from all the plots.

Spray application of Dipel at 0.5 and 0.75 kg/ha was highly effective and significantly reduced the population of *Achaea janata* followed by Dipel at 0.25 kg/ha in castor at Hyderabad. Spray application of AJNPV at 250LE/ha, 125 LE/ha and at 125 LE + endosulfan 0.03% also significantly reduced the larval population and was on par with endosulfan (0.07%). Application of either Dipel or AjNPV has not affected the activity of *Microplitis maculipennis*.

1.1.8. BIOLOGICAL SUPPRESSION OF COCONUT PESTS

In an attempt to standardise the laboratory multiplication technique for the endoparasitoid *Apanteles taragamae* at Kayangulam it was found that the second instar caterpillars of *Opisina arenosella* were best suited to multiply the same in large numbers. Laboratory reared bethylid, elasmid and chalcid parasitoids brought about a significant reduction of *O. arenosella* when field releases were made of the same. Variation of protein, both qualitative and quantitative could be noticed in diseaed and healthy grubs of *Rhynchophorus ferrugineus* when infected with a rod shaped nuclear virus.

Stethoconus praefectus was found to be the dominant predator of *Stephanitis typicus* at Mannuthy and Vyttilla but their population was very low and failed to effect any check on *Stephanitis* population.

1.1.9. BIOLOGICAL SUPPRESSION OF FRUIT PESTS

At IIHR, Bangalore several parasitoids and predators of the insect pests infesting mango, ber, citrus, guava, etc., were collected and identified. The record of Aphidius sp., Aphelinus sp., and Signiphora sp., appeared to be new on pomegranate aphid, Aphis punicae.

The coccinellid predator Cyrptolaemus montrouzieri consumed about 360 eggs or 500 nymphs of the mango mealybug Rastrococcus iceryoides. The development of the predator was prolonged when it was fed with the mealybug eggs. In the field the predators were able to bring down the mealybug infestation. A total of 7360 C. montrouzieri, 12,600 Coccidoxenoides peregrinus and 1250 Leptomastix dactylopii were released to suppress the mealy bug populations on pomegranate.

Four demonstration trials were conducted at Bangalore on guava and grape mealybugs and the efficacy of the natural enemies proved in the farmers field.

A study on response of the ber scale insect parasitoid Anicetus celonensis revealed that dimethoate (0.05%), dichlorvos (0.1 %) and phosalone were relatively less toxic to the parasitoid while the fungicides were safe.

The releases of Aphytis proclia and Encarsia perniciosi in Kashmir on apple each made @ 2000 per tree during third week of July and second week of June showed that the infestation by San Jose scale was reduced to the extent of 0.3 to 5.6% (A. proclia) and 0.3 to 2.4% (E. perniciosi). Similarly the predator,(Chilocorus bijugus) when released @ 20/ tree indicated that scale density was reduced from 1.9 to 8.6 (less than last year) suggesting that the rate of predator should be increased.

Single release of Chilocorus bijugus larvae @ 50 neonate grubs per tree at Solan brought about a reduction in mean population from 9.9 to 8.2/cm^2 bark area within a month, thus grub stage appears to be suitable for suppression of the San Jose scale in apple orchards.

Aphelinus mali which was introduced at Nauni in 1991 has uniformly spread in the apple orchard and is providing satisfactory control of the woolly apple aphid, as compared with the pest situation before the release of the parasitoid.

As many as 2,72,000 parasitoids (1,24,000 A. proclia and 1,48,000 E. perniciosi) and 3207 C. bijugus were reared in the laboratory and were released in the various orchards in Kashmir. The predators C.bijugus were released and consequently recovered from Jawahar Nagar and Zakura (Kashmir).

Entomopathogenic nematode *Heterorhabditis bacteriophora* was multiplied in the laboratory at Solan and it was found that from one late instar *Corcyra* larva, 4500 juveniles could be obtained and the population at harvest varied from 61-89% (3500 alive infective juveniles/host larva). The survival under refrigeration was upto 1.5 months. When applied @ 100 infective juveniles per cm^2 surface area (10^{12}/ha), against white grubs of *Brahmina coriacea* (III instar), it was found that four months after application the per cent live grubs was less in treated plot (40 - 53.3%) than control plot (66.7 - 80%)

1.1.10. BIOLOGICAL SUPPRESSION OF VEGETABLE PESTS

Natural enemies of insect pests affecting brinjal, cabbage, chillies, okra, peas, tomato, etc., were collected and identified at Bangalore. *Burmoides suturalies*, a coccinellid predator was often encountered preying on aphids of peas and chillies.

Trichogramma pretiosum recorded a mean of 45.05% parasitism of tomato fruit borer *Helicoverpa armigera* eggs under open field conditions during January-April' 94, when a release was made at the rate of 5 lakh adults/ha.

Chrysoperla carnea was found to control the aphids on chillies when releases were made at the rate of 5 larvae per plant compared to chemical insecticides.

Natural parasitisation of *Helicoverpa armigera* eggs by *Trichogramma* (58.3 - 100%) provided satisfactory control of the fruit borer on tomato crop and no need was felt for release of *T. pretiosum* at Solan.

In cauliflower and cabbage fields at Solan *Pieris brassicae* larvae were heavily parasitized by the solitary ichneumonid endoparasitoid *Hypersota ebeninus*. Parasitization by *Cotesia glomeratus* was evident after March and it varied from 2-11.9%. No necessity was felt for application of any insecticide against *P .brassicae*.

The eggs of cabbage butterfly *Pieris brassicae* in Kashmir were parasitized to the extent of 25% by some unidentified hymenopterans during second week of September and aphids were predated upon by coccinellids while no other natural enemy was recorded on cutworm, diamondback moth and white grubs.

Screening of diseased larvae at IIHR, Bangalore of *P. xylostella* and *C. binotalis* yielded bacterial pathogen, *Serratia macrcesens* and microsporidian, *Nosema* and *Vairimorpha* sp.. On farm trails in tomato using HaNPV on *H. armigera* in various locations in Karnataka gave encouraging results.

Application of five rounds of fungus *Nomuraea rileyi* @ $3.2x10^8$ conidia/ml+ Triton x-d100 (0.01%) at weekly intervals during evening hours significantly brought down the larval population of *H. armigera* in tomato to 0.4 as compared to 2.3 in control.

A trial carried out to determine the field efficacy of Dipel 8L and Centari in controlling *P. xylostella* in Bangalore with six weekly sprays of Dipel 8L and Centari and four spays of endosulfan at 10 day interval indicated that application of Dipel and Centari significantly reduced the larval population to 0.84 per plant as compared to 2.60 in endosulfan and 5.08 in control plots. The maximum yield of 39.1 tonnes / ha was recorded in Dipel treated plot which was significantly more than endosulfan treated plot (31.2 t/ha) and control (24.4 t/ha. The yield from Centari treated plot (34.2 t/ha) was on par with Dipel and endosulfan treated plots.

1.1.11. BIOLOGICAL SUPPRESSION OF POTATO PESTS

The releases of *C. koehleri* and *C. blackburni* were found to be superior to *T. chilonis* and recommended insecticide endosulfan (0.05 %) at Pune. The parasitoids suppressed the pest to 59.41 and 58.65 % respectively as against 47.22 and 37.40 per cent in *T.chilonis* and endosulfan treatments.

The parasitoid, *Trichogramma chilonis* was able to search for the host up to a distance of 7 metre from point of release. Also it was observed that the percentage of parasitization was higher at short distance i.e. 62.5 to 75 % up to 3 metres and it goes on decreasing to 50 % upto 6 m and reduced further to 25 % at 7 m distance.

1.1.12. BIOLOGICAL SUPPRESSION OF WEEDS PESTS

Laboratory studies at Bangalore indicated that repeated mating in *Zygogramma bicolorata* reduced the viability of eggs laid by females and also their longevity. Studies on diapause showed that the beetle is capable of diapausing throughout the breeding season, with an increase in percentage with the approach of the dry season. A tachinid egg larval parasitoid *Chaetexorista* sp. was recorded for the first time from *Z bicolorata* in Bangalore. It was found to parasitise up to 22.9% of the larvae collected from the field during September, 1993.

The leaf feeding chrysomelid *Haltica* sp. and the pod boring curculionid *Nanophyes* sp. were found to cause heavy damage to the aquatic weed *Ludwigia* sp. preventing an increase in the density of the weed. *Scirtothrips dorsalis* was also observed feeding on the leaves of this weed in Bangalore.

Successful control of water hyacinth has been acheived by the field release of Neochetina eichhorniae and N. bruchi in Alengmara (Lakhaibill) and the Tocklai river, Jorhat as about 90 % water surface has been cleared 21 months after release in AAU and 80 % cleared in about 30 months in Alengmara.

Neochetina spp. have established on water hyacith and its damage was also observed but there was no impact on the weed in Ludhiana. The mite, Orthogalumna terebrantis was not observed after its release in the pond.

Studies on biological control of water hyacinth through Neochetina weevils gave encouraging results in Anand.

About 29,300 caterpillars of Pareuchaetes pseudoinsulata were released for the control of Chromolaena odorata at different locations in Kerala but no sign of establishment was seen.

1.2. Proposed programme for 1994-95

1. BASIC RESEARCH

Basic research on parasitoids and predators at Project Directorate of Biological Control, Bangalore

1.1. Maintenance of species and strains of egg parasitoids for various hosts

1.2. Quality control by rearing on 'target host' and comparing with 'laboratory reared host' and to findout for how many generations higher fecundity is retained

1.3. Electrophoresis of various strains/species to differentiate the variation

1.4. Evaluation of all above strains/species obtained from various experiments in comparison to reared on laboratory on crops like cotton, tomato, maize, sugarcane etc.

1.5. Maintaining cultures of certain predators

1.6. Attempts will be made to synthesise artificial diet for chrysopids and coccinellids

1.7. Sex ratio alteration will be attempted in chrysopids and coccinellids by antibiotics and temperature treatments

1.8. Evaluation of already available diets defined for D. arenosella and S. litura 1.9. Selection of pesticide tolerant strains of Telenomus remus

1.9. Studies and survey of Nilgiris strain of <u>Diadegma semiclausum</u>

1.10. Studies on the parasite of <u>Plutella xylostella</u>, <u>Cotesia flavipes</u>

1.11. Performance of <u>Tridiogramma chilonis</u> on <u>Chilo partellus</u> egg clusters with varying egg numbers.

1.12. Comparative studies on some artificial diets for <u>Chilo partellus</u>

1.13. Influence of larval weight of <u>Chilo partellus</u> on parasitism by <u>Cotesia flavipes</u>

1.14. Fabrication of wind tunnel olfactometer/ multiple choice activity chambers etc.

1.15. Studies on the habitat selection, host selection and host preference by larva and adults of chrysopids and coccinellids.

1.16. Identification of chemical cues (Kairomones/synomones) that evokes a behavioral response on chrysopids and coccinellids in terms of the ovipositional preference and feeding preference by wind tunnel olfactometer multiple choice methods.

Basic research on entomopathogens

1.17. Basic studies and mass multiplication of NPV of <u>Helicoverpa armigera</u> and <u>Spodoptera litura</u> in vivo and invitro (PDBC)

1.18. Screening of mango and guava flavinoids and some phenolic acids as UV-protectants for NPV of <u>Spodoptera litura</u> (IIHR)

1.19. Screening of field collected <u>Plutella xylostella</u> and <u>Crocidolomia binotalis</u> for baculoviruses (IIHR)

1.20. Comparative efficacy of various Bt formulations like Dipel 8L, Centari and Bioasp in controlling <u>Plutella xylostella</u> in cabbage (IIHR)

1.21. Field efficacy of <u>Nomureae rileyi</u> against <u>Spodoptera litura</u> (IIHR)

1.22. Maintenance of varieties of <u>Bacillus thuringienis</u> (IARI)

2. BIOLOGICAL SUPPRESSION OF SUGARCANE PESTS

2.1. Survey of natural enemies of internode borer in factory areas as well as Coimbatore (SBI)

2.2. Adaptive trials to prove effectiveness of *Trichogramma chilonis* against *Chilo auricilius* (PAU & IISR)

2.3. Comparative studies of Indonesian and indigenous strains of *Cotesia flavipes* against sugarcanr borers (PAU, SBI & IISR)

2.4. Colonization and redistribution of *Epiricania melanoleuca* against *Pyrilla* (PAU & IISR)

2.5. Studies on indigenous parasitoids and entomopathogens of sugarcane pests with particular reference to their seasonal availabity and parasitism/ predatism with a view to utilize them (PAU & IISR)

2.6. Studies on kairomones of *C. partellus* frass and their bioassay on *C. flavipes* (SBI)

2.7. Laboratory multiplication of *Rhaconotus* sp.and *Telenomus* sp. (SBI)

2.8. Species complexity and seasonal fluctuations of carabids in sugarcane ecosystem (SBI)

2.9. Studies on *C ontrouzieri* and *Brumus sturmiopsis* against mealy bugs and whitefly, respectively (SBI)

2.10. Survey for pathogens of internode borer (SBI)

2.11. Studies on soil persistence of GV and synergistic effect of adjuvants on the virus (SBI)

2.12. Comparative field evaluation of GV and *B huringiensis* against shoot borer (SBI)

2.13. Pathogenicity of *B. thuringiensis* to internode borer (SBI)

2.14. Pathoigenicity of *Hirsutella* sp. to internode borer and pyrilla (SBI)

2.15. Field evaluation of *T. chilonis* against *Sacchariphagus indicus* (IISR)

2.16. Field evaluation of *Beauveria bassiana* for control of sugarcane borers (IISR)

2.17. Field evaluation of *Metarhizium anisopliae* for control of *Pyilla perpusilla* (IISR)

3. BIOLOGICAL SUPPRESSION OF COTTON PESTS

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

3.2. Isolation and identification of pathogens of sucking pests (PAU)

4. BIOLOGICAL SUPPRESSION OF TOBACCO PESTS

4.1. Studies on natural enemies of tobacco pink aphid. *Myzus nicotianae* Blackman (CTRI & Nipani)

4.2. Evaluation of different formulations of *Bacillus thuringiensis* against *Helicoverpa armigera* on tobacco.(CTRI, GAU & Nipani)

4.3 Evaluation of *Apatochrysa* sp. and *Chrysoperla carnea* for the control of tobacco aphid (CTRI & Nipani)

4.4 Evaluation of dosage of *Apanteles africanus* against *Spodoptera litura* in tobacco nurseries (CTRI)

4.5. Integrated management of *Spodopteera litura* in tobacco nurseries (CTRI)

5. BIOLOGICAL SUPPRESSION OF INSECT PESTS OF PULSE CROPS

5.1. Effectiveness of *Trichogramma chilonis* and NPV against *Helicoverpa armigera* on pigeonpea intercropped with sorghum (APAU)

5.2. Evaluation of *Bacillus thuringiensis* formulations against *Helicoverpa armigera* on pigeonpea (APAU & TNAU)

5.3. Effectiveness of NPV against *Helicoverpa armigera* on chickpea (APAU & TNAU)

5.4. Effectiveness of *Trichogramma chilonis* and HaNPV against *Helicoverpoa armigera* on pigeonpea (PAU & TNAU)

5.5. Effectiveness of HaNPV against *Helicoverpa armigera* on chickpea (PAU)

6. BIOLOGICAL SUPPRESSION OF OILSEED CROP PESTS

6.1. Testing of *Metarhizium anisopliae* and *Bacillus popilliae* against white grub on groundnut (GAU & APAU)

6.2. Seasonal abundance of natural enemies of groundnut leaf miner and Aphids (APAU)

6.3. Seasonal abundance of natural enemies of rape seed mustard aphid Lipaphis erysimi (PAU)

6.4. Testing of Metarhizium anisopliae and Bacillus popilliae against white grub on groundnut (GAU)

7. BIOLOGICAL SUPPRESSION OF PADDY PESTS

7.1. Studies on T. japonicum and T. chilonis (KAU, TNAU, PAU, MPAU & AAU)

7.2. Field trials using the various formulations of Bacillus thuringiensis for the control of paddy pests (KAU)

7.3. Evaluation of Trichogramma japonicum against rice stem borer, T. chilonis against leaf folder (PAU, Ludhiana)

7.4. Evaluation of the efficiency of miridbug, Cyrtorhinus lividipennis against brown planthopper, Nilaparvata lugens stal (TNAU)

7.5. Survey of different rice growing tracts for obtaining seasonal calender of natural eenemy complex of rice pests (TNAU)

7.6. Management of leaf folders with different Bacillus thuringeiensis formulations (TNAU)

7.7. Seasonal incidence of key natural enemies with a view to utilise them for suppression of rice hispa, Dicladispa armigera (AAU)

7.8. Evaluation of Allorhogas pyralophagus against yellow stem borer of rice (AAU, TNAU & KAU)

8. BIOLOGICAL SUPPRESSION OF COCONUT PESTS

8.1. Screening, evaluation and re-release of baculovirus of Oryctes rhinoceros (TNAU, AAU, CPCRI & APAU)

8.2. Studies on biological suppression of the lace bug Stephanitis typica (CPCRI & KAU)

8.3. Mass multiplication of Apanteles taragamae (CPCRI)

8.4. Field evaluation of the performance of lab reared larval, prepupal & pupal parasitoids of Opisina arenosella (CPCRI)

8.5. Studies on natural enemies of eggs of Opisina arenosella (CPCRI)

8.6. Strain improvement of Metarhizium anisopliae with a view to utilize it against Oryctes rhinoceros (CPCRI)

8.7. Characterization & pathogenicity trials with viral & bacterial pathogens and cross infection with Bacillus thuringiensis & Bacillus popilliae and other pathogens (CPCRI)

8.8. Survey of natural enemies ofRhynchophorus ferrugineus (CPCRI)

8.9. Laboratory multiplication & evaluation of Campsomeriella collaris against Leucopholis coneophora (CPCRI)

8.10. Natural pathogens and cross infection trials with Bacillus popilliae & other pathogens of L.oneophora (CPCRI)

8.11. Studies on predaceous mites & coccinellid predators of Raoiella indica (CPCRI)

9. BIOLOGICAL SUPPRESSION OF TROPICAL FRUIT CROP PESTS

9.1. Collection and identification of natural enemies of fruit crop pests (IIHR)

9.2. Feeding potential of Cryptolaemus montrouzieri on the mango mealybug Rastrococcus iceryoides (IIHR)

9.3. Demonstration trial on the effect of C. montrouzieri in the control of mangoo mealybug (IIHR).

9.4. Performance of C. montrouzieri in the control of grape mealybug (IIHR, APAU & MPAU)

9.5. Susceptibility of per scale insect parasitoids Anicetus ceylonensis and to different pesticides (IIHR)

9.6. Field evaluation of natural enemies against pomegranate mealybug (IIHR)

10. BIOLOGICAL SUPPRESSION OF TEMPERATE FRUIT CROP PESTS

10.1. Relative effectiveness of parasitoids & npredators against San Jose scale (Dr. YSPUH & F and SKUAS & T)

10.2. Seasonal incidence of San Jose Scale & wolly aphid in relation to natural enemies at different attitudes (YSPUH & F and SKUAS & T)

10.3. Performance of *Aphelinus mali* and chyrsopids against wolly apple aphid (YSPUH & F and SKUAS & T)

10.4. Dosage standardisation of locally available entomophilic nematodes against *Brahmina coriacia* (Dr.YSPUH & F)

11. BIOLOGICAL SUPPRESSION OF VEGETABLE CROP PESTS

11.1. Collection and identification of natural enemies of vegetable crop pests (IIHR, YSPUH & F. and SKUAS & T)

11.2. Studies on the parasites of tomato leif miner *Liriomyza trifolii* (IIHR)

11.3. Evaluation of *Trichogramma pretiosum* against tomato fruit borer (IIHR, MPAU, GAU, YSPUH & F and SKUAS & T)

11.4. Field evaluation of exotic parasitoidsof *Plutella xylostella* (IIHR)

11.5. Studies on the natural enemies of aphids and pod borer on chillies and peas respectively (IIHR)

11.6. Field efficacy of *Nomuraea rileyi* against *H. armigera* in tomato against *S. litura* in beet-root & against *H. armigera*, *S. litura* & *T. ni* in cabbage (IIHR)

11.7. Evaluation of natural enemies already identified against *Pieris* spp. on cabbage (SKUAS & T and Dr YSPUH & F).

12. BIOLOGICAL SUPPRESSION OF POTATO PESTS

12.1. Efficacy of parasitoids & microbiasl agents (alone & in combination) in comparision with recommended insecticide for the control of *Phthorimaea operculella* zeller (MPAU)

12.2. Efficacy of biotic agents against potato tuber moth in Arni (Country store) (MPAU)

12.3. Survey the natural enemies of potato tuber moth in different season (MPAU).

13. BIOLOGICAL SUPPRESSION OF WEEDS

13.1. Laboratory studies on the behaviour of *Zygogramma bicolorata*. Evaluation of biological control of Parthenium (IIHR)

13.2. Surveys in farmers field in and around Bangalore for feeding by *Z. bicolorata* on sunflower (IIHR)

13.3. Studies on factors responsible for low egg hatching of Z. bicolorata (IIHR)

13.4. Studies on diapause in Z. bicolorata (IIHR)

13.5. Studies on the natural enemy complex of Ludwigia sp. (IIHR)

13.6. Supply of natural enemies of weeds to different centres in the country (IIHR)

13.7. Biological control of water hyacinth using Neochetina spp. and Orthogalumna terebrantis (KAU, AAU, GAU, MPAU & PAU)

13.8. Biological control of Salvinia molesta by Cyrtobagous salviniae (KAU)

13.9. Biological suppression of Chromolaena odorata by the release of Pareuchaetes pseudoinsulata (KAU & AAU)

13.10. Biological control of Mikama scandens using exotic natural enemy (KAU)

13.11. Survey of indigenous natural enemies of Mikama, Pista and Limnocharis etc. (KAU)

1.3. EXPERIMENTAL RESULTS

1.3.1. Beneficial insects introduction, quarantine handling and basic research

1.3.1.1. Shipments received

During 1993-94, no exotic natural enemy was obtained.

1.3.1.2. Shipments sent

During the period under report, 65 shipments of 48 natural enemies and 17 shipments of host insects were sent from the Project Directorate to various co-ordinating and other centres (Table 1).

Table 1. Shipments sent

Natural enemy/ Host insect (1)	Centre (2)	No.of ship-ments (3)	Stage (4)	Numbers (5)
Spodoptera litura	Wockhardt Ltd. Aurangabad	1	Eggs	1000
		1	pupae	25
	GKVK, Bangalore	3	Eggs	1600
	FIPPAT, Madras	1	Eggs	2000
Helicoverpa armigera	Wockhardt Ltd. Aurangabad	1	Eggs	25
	GKVK, Bangalore	4	Eggs	800
Phthorimaea operculella	Wockhardt Ltd. Aurangabad	1	Eggs	1000
	UAS, RRS,Mudigere	1	Eggs	200
	Univ.of Agril. Sciences, Mudigere & Bangalore.	2	Eggs	1200
Chilo partellus	SBI, Coimbatore	2	Eggs	700
	SBI, Coimbatore	2	Eggs	400
Chilocorus nigritus	Ph. D. student UAS, Bangalore	1	Adults	100

Table 1 contd. ...

(1)	(2)	(3)	(4)	(5)
<u>Cryptolaemus montrouzieri</u>	Farmers from M.P.	1	Adults	150
<u>Curinus coeruleus</u>	Farmers from M.P. & A.P.	2	Adults	8000
<u>Pharoscymnus horni</u>	Ph.D. student UAS, Bangalore	1	Adults	40
<u>Cotesia flavipes</u>	SBI, Coimbatore (Indonesian strain)	4	Cocoons	450
	PAU,Ludhiana	3	Cocoons	400
<u>Chelonus blackburni</u>	PAU, Ludhiana	8	Cocoons	1000
	SBI,Coimbatore	1	Parasi-tised eggs	400
	CAD, Nanta Farm Kota			
	Dept. of Agri-culture Kota	1	Parasi-tised eggs	
<u>Allorhoges pyralophagus</u>	AAU, Jorhat	1	Cocoons	200
<u>Trichogramma chilonis</u>	GAU, Anand	1	"	30000
	PAU, Ludhiana	1	"	4500
	Agri.College, Imphal	2	"	12000
	RAU, Udaipur	1	"	5000
	FRI, Jodhpur	1	"	5000
<u>T. dendrolimi</u>	IARI, New Delhi	1	"	5000
<u>T. embryophagum</u>	IARI, New Delhi	1	"	3000
	FRI, Jodhpur	1	"	3000
	FRI, Coimbatore	2	"	22000
<u>T. japonicum</u>	CIPM, Bangalore	1	"	3000
	PAU, Ludhiana	1	"	4500
	Agri. College,Pune	1	"	6000
	Agri. College Imphal	2	"	13000
<u>T. pretiosum</u>	Agri. College,Pune	2		10000
	IARI, New Delhi	1	"	2000
	GAU, Anand	1	"	12500
<u>Trichogrammatoidea armigera</u>	IARI, New Delhi	1	"	3000

1.3.1.3. Maintenance of host insects and natural enemies

At the headquarters of the Project Directorate, the following host cultures were maintained

Aonidiella aurantii, Aspidiotus destructor, Hemiberlesia lataniae, Maconellicoccus hirsutus, Planococcus citri, Spodoptera litura, Helicoverpa armigera, Plutella xylostella, Corcyra cephalonica, Chilo partellus, and Phthorimaea Operculella.

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

Allorhogas pyralophagus, Chelonus blackburni, Cotesia flavipes, Copidosoma koehleri, Chilocorus nigritus, Pharoscymnus horni, Cryptolaemus montrouzieri, Cheilomenes sexmaculata, Telenomus remus, and Bracon kirkpatricki were multiplied for conducting basic studies and for the supply to the centres. Also some of the indigenous parasitoids of H.armigera and P. xylostella like Campoletis chlorideae, tachinid parasitoids and Diadegma semiclausum were collected from the field as and when required.

1.3.1.3.1 The details of trichogrammatid species and strains of T. chilonis maintained are provided in Table 2.

Table 2. Trichogrammatids in culture

Species	No.of egg cards prepared	No.of adults obtained	No.of generations obtained during92-93
Trichogramma achaeae	40	40000	36
T. brasiliensis	40	40000	36
T. chilonis (12 strains)	480	480000	432
T. dendrolimi	40	40000	36
T. embryophagum	40	40000	36
T. evanescens	40	40000	36
T. japonicum	40	40000	36
T. pretiosum	40	40000	36
Trichogramma sp. (Italian)	40	40000	36
Trichogrammatoidea armigera	40	40000	36
Tr. bactrae	40	40000	36

1.3.1.4. Comparative studies on the Indonesian and indigenous strain of Cotesia flavipes on Chilo partellus

As evident from the studies conducted in 1992-93 there were no drastic differences amongst the Ludhiana, Coimbatore and Bangalore strains of Cotesia flavipes in their progeny production, percent larvae parasitized or proportion of females in the progeny and hence the Bangalore strain itself was utilized as the standard indigenous strain to compare with the imported Indonesian strain for some parasitoid host ratios and their effect on number of larvae producing cocoons and sex ratio of the progeny.

Adult parasitoids which were 24h old were aspirated into a container and parasitoid - host ratios of 1:2, 1:1 and 2:1 were maintained for both the strains. The host larvae of Chilo partellus were exposed on a patch of artificial diet and the larvae removed after 24h and reared on the diet till cocoon formation. The number of host larvae producing parasitoid cocoons, number of adult parasitoids emerged per host larva and proportion of females in the progeny were recorded and the trial replicated 3 times for the various parasitoid :host ratios. The results are represented in Fig.1.

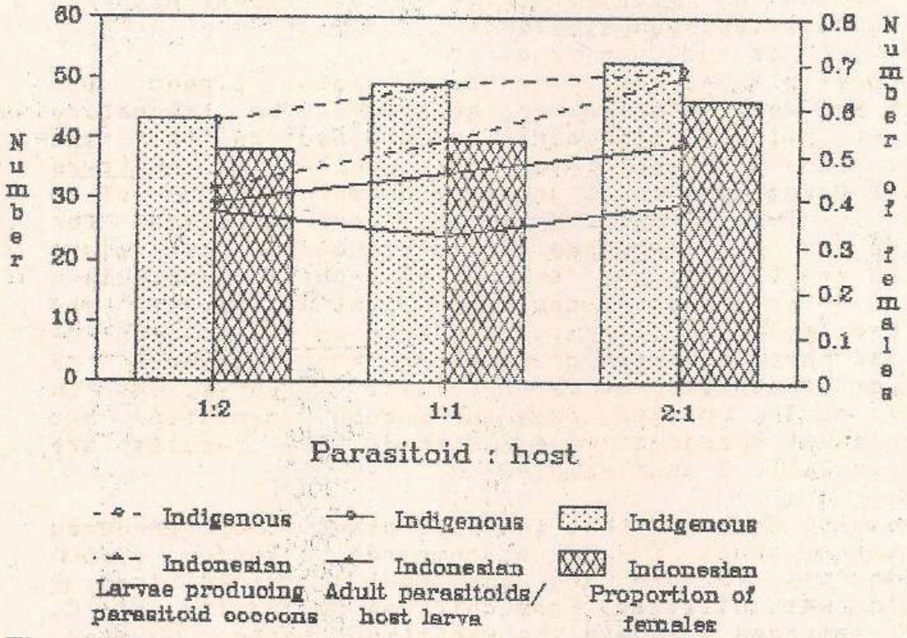


Fig. 1: Comparison of different strains of *Cotesia flavipes* using *Chilo partellus* as host larva

As can be seen from Fig.1 the indigenous strain was better than the Indonesian strain in progeny production as well as the number of larva producing cacoons in all the ratios tested. The ratio of 2:1 gave the best results with the indigenous strain resulting in highest proportion of larvae producing cocoons (0.685), greater adult parasitoids (52.7) and best female ratio of 0.52 proportion of females among the progeny. So a parasitoid: host ratio of 2:1 is considered best for *Cotesia flavipes* and the indigenous strain was found possessing superior traits than the Indonesian strain. It is quite probable that the imported strain has lost its capacity to parasitize due to continuous laboratory rearing while the indigenous strain because of its adaptability in the field and to our conditions is faring better. It would be advisable to use the indigenous strain itself in future studies against *Chilo partellus*.

1.3.1.5. Studies on the parasitizing ability of *Chelonus blackburni* on *Helicoverpa armigera* eggs when reared on *P. operculella* and *C. cephalonica* on some selected host plants

Four host plants, namely, cotton, tomato, pigeon pea and chick pea were selected for the study. The laboratory culture of *Chelonus blackburni* maintained on the two factitious hosts, *Phthorimaea operculella* and *Corcyra cephalonica* for more than 10 generations were made use of in the study. Two parasitoid adults were utilized for replication and 50 *H. armigera* eggs stuck on the host plant leaves with a wet brush and this exposed to the adults in a container. After 24h of exposure the plant was removed and the hatched larvae of *H. armigera* reared on cut pieces of bhendi till cocoons were discovered. The emergence of adults from these cocoons was recorded. Observations on number of adults emerged, days for cocoon formation and days for adult emergence were recorded. The results are presented in Table 3 and Table 4.

The results indicate that the host plant tomato produced more number of adults (4.25) as compared to cotton (3.50) and pigeon pea (0.75) when the adults reared from *P operculella* was utilized. From chickpea no adults of *C. blackburni* emerged for both the factitious hosts. However, the adults reared from *C. cephalonica* produced 4.00, 3,75 and 3.25 adults on tomato, cotton and pigeon pea respectively and they were significantly different.

Table 3. *Chelonus blackburni* adult emergence from *H. armigera* placed on various host plants (25 eggs/adult) (Mean of 4 replications)

Host plant	Adults reared from	
	P. operculella	*C. cephalonica*
Cotton	3.05 ± 0.06 (2.02)	3.75 ± 0.14 (2.06)
Tomato	4.25 ± 0.12 (2.16)	4.00 ± 0.24 (2.14)
Pigeon pea	0.75 ± 0.21 (1.12)	3.25 ± 0.13 (1.95)
Chick pea	0 (0.71)	0 (0.71)
CD (P= 0.05%)	0.121	0.118

Figures in parenthesis are √x+0.5 transformed values

Table 4. Days to adult emergence and percent larvae producing adults for the various host plants tested

Host plant	*P. operculella*		*C. cephalonica*	
	Days to adult emergence	% larvae into adult parasitoids	Days to adult emergence	% larvae into adult parasitoids
Cotton	37.21 ± 1.62	7.00	36.42 ± 0.93	7.50
Tomato	29.42 ± 2.86	17.00	30.14 ± 0.82	16.00
Pigeon pea	28.64 ± 3.12	3.00	27.14 ± 0.62	13.00
Chick pea	-	-	-	-

The results presented in table 4 indicate that generally the number of adults as indicated by the percent larvae producing parasitoid adults was generally low with the maximum being in tomato whether the adults were reared from *C. cephalonica* or *P. operculella*. The days to adult emergence was ranging from 27.14 to 37.21 in various host plants and the two factitious hosts.

The results indicate that generally percent parasitism of *H. armigera* was very low whether the adults of *C. blackburni* reared from *P. operculella* or *C. cephalonica* were used. However, amongst the host plants tomato produced more adults than other host plants when adults reared from *P. operculella* were used. The parasitoids failed to parasitize *H. armigera* eggs placed on chick pea plants in the case of adults from both factitious hosts.

1.3.1.6. Performance of *Trichogramma chilonis* on egg clusters of *Chilo partellus* with varying egg numbers.

In order to test the performance of *Trichogramma chilonis* on egg clusters of *C. partellus* consisting of varying number of eggs, an experiment was laid out using individual fertilized females exposed to individual egg clusters. The number of eggs in each cluster was counted and then exposed to a single fertilized female of *T. chilonis* for 24 h. The egg cluster was removed and later observed for percent eggs parasitized, number of adults emerging, days for adult emergence and proportion of female progeny. The egg clusters were then grouped into class intervals and the results are presented in Table 5.

The egg clusters of *C. partellus* varied in number from 1 to more than 57 eggs per cluster. *T. chilonis* parasitized eggs of *C. partellus* irrespective of the number. However, the percent parasitism was maximum (92.33%) in the eggs clusters with 26-30 eggs while it was least for egg clusters with 1-5 eggs possibly indicating that a single female can parasitize effectively about 28 eggs of *C. partellus*. However, the per cent parasitism ranged from 76.80 to 92.33 in egg clusters from 16 to 45. However, the number of adults varied only from 34.00 to 38.50 from egg clusters containing eggs from 26-55, showing that about 35 adults can be produced from the eggs of *C. partellus* containing about 26-55 eggs by a single female of *T. chilonis*. The sex ratio was around 3 (proportion of female progeny) from the egg clusters containing 26-55 eggs. The sex ratio was however very less from egg clusters containing lesser egg numbers as also the number of adults emerged. The least adult emergence was seen from 1-5 eggs cluster while the maximum of 38.50 was recorded from 51-55 eggs cluster. The days for adult emergence did not vary much and was around 11 days in all cases.

Table 5. Per cent parasitism, number of adults, sex ratio and days for adult emergence of *T. chilonis* exposed on *C. partellus* egg clusters

No.of eggs in the clusters	n	% eggs parasitized	No. of adults emerged	Propo-tion	Days for adult emergence
1 - 5	12	19.44 ± 13.06	1.08 ± 2.22	0.24	13.33
6 - 10	12	75.84 ± 28.63	9.27 ± 6.88	2.07	11.10
11 - 15	16	57.45 ± 42.56	10.53 ±10.41	1.13	11.20
16 - 20	12	76.80 ± 22.04	26.36 ±15.01	3.87	11.20
21 - 25	9	78.68 ± 28.39	28.11 ±10.44	2.21	11.29
26 - 30	8	92.33 ± 9.14	35.88 ±12.83	2.92	11.29
31 - 35	4	88.92 ± 7.45	37.00 ±12.04	3.14	11.00
36 - 40	2	73.95 ± 25.06	34.50 ± 6.50	3.02	11.50
41 - 45	2	79.28 ± 0.715	36.00 ±14.00	2.65	11.00
46 - 50	2	66.10 ± 2.10	34.00 ±11.00	2.35	11.50
51 - 55	2	62.66 ± 20.35	38.50 ±13.50	1.89	11.00

The results indicate that a single female can produce about 35 adults from egg numbers varying from 26-55 even if the percent parasitism of eggs were variable for these egg numbers.

1.3.1.7. Relationship between larval period and pupal weight of some lepidopteran insects.

The larval period of both the sexes and the pupal weights were studied for <u>Chilo partellus</u>, <u>Corcyra cephalonica</u>, <u>Helicoverpa armigera</u>, <u>Spodoptera litura</u> and <u>Opisina arenosella</u>. The larval periods of individual insects were recorded and their pupal weights recorded for the male and female pupae separately. The relationship between the two was worked out for all the above lepidopteran insects. The results are presented in Table 6.

Table 6. Relationship between larval period and pupal weights in some lepidopteran insects

Insect	Sex	Mean larval period (days)	Mean pupal weight (mg)	Correlation co-effi-cient (r)
<u>Chilo partellus</u>	Male	34.95	46.62	- 0.543**
	Female	39.08	125.80	- 0.640**
<u>Corcyra cephalonica</u>	Male	37.81	34.16	- 0.721**
	Female	41.16	46.18	- 0.620**
<u>Helicoverpa armigera</u>	Male	30.55	314.43	- 0.562**
	Female	31.16	393.40	- 0.622**
<u>Spodoptera litura</u>	Male	18.24	344.75	- 0.642**
	Female	18.36	350.33	- 0.581**
<u>Plutella xylostella</u>	Male	14.07	4.32	- 0.528**
	Female	14.23	5.24	- 0.679**
<u>Opisina arenosella</u>	Male	49.28	22.11	- 0.728**
	Female	52.28	34.10	- 0.841**

** - Highly significant at $P \leq 0.01$.

A perusal of table 7 reveals that in all the insects studied the male larval period was less than the female larval period. In addition in all the insects studied the female pupal weight was also more than the male pupal weight. A negative correlation was observed between the larval period and pupal weight in the case of males and females in all the insects studied indicating greater weight of pupal as the larval period was shorter.

1.3.1.8. Interaction between grubs of Cheilomenes sexmaculata and Chrysoperla carnea with and without food

An experiment was carried out for studying interaction between I, II and III instar larvae of both C. sexmaculata and C. carnea with aphids and without aphids in order to ascertain which species will displace the other if they are present together. In this study, aphids A. gossypii were provided @ 50, 75 and 100 per replication for both predators and there were 10 replications each for I, II and III instars. Larvae of both predatory species were taken from laboratory reared material. Both larvae were released in glass vial (7.5 x 2.5 cm) along with aphids and were secured by cotton plug. Observations were recorded after 24 hours on surviving species and number of aphids fed. In a second experiment both larvae were released without any aphid in glass vial (7.5 x 2.5cm) and were plugged with cotton wool. In this experiment also observations were recorded after 24 hours on surviving individual. Each experiment (larval instar wise) was replicated 10 times. Results of the experiment are presented in Fig.2.

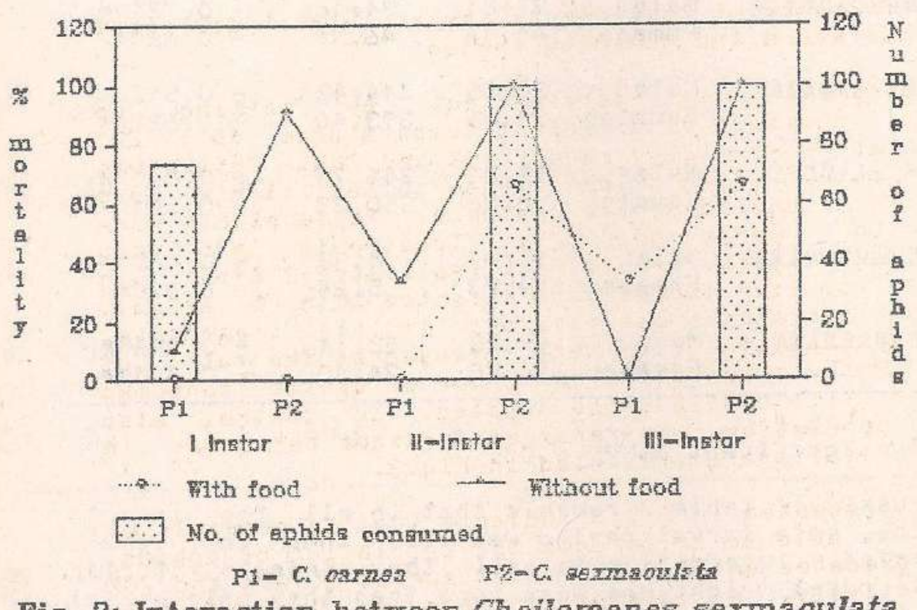


Fig. 2: Interaction between *Cheilomenes sexmaculata* and *Chrysoperla carnea* with aphid *Aphis gossypii* as prey

Results presented in Fig.2 indicate that during 1st instar in presence of aphid population no interaction was observed. Perhaps in presence of food neither species attacked each other. Both species together fed on 74.0% aphid that were provided. However during 2nd instar C.carnea larvae after consuming all aphids provided for food killed 66.0% C. sexmaculata larvae, as dead C. sexmaculata larvae were seen after 24 hours. In third instar also C. carnea killed 66.0% C. sexmaculata larvae and in 33.0% case both larvae were seen killed . They were found entangled with each other, suggesting attack on each other for survival.

Results in Fig.2 indicate that such attack was more pronounced in absence of food and it was survival of one of the species. During I instar only 10.0% of C.carnea were killed whereas C. sexmaculata was killed to the tune of 91.0% in competitive interaction. During second and third instars C. carnea larvae were killed to the tune of 33.0 and 0.0% in comparison to 100.0% in C. sexmaculata. The study indicated that C. carnea is superior as it displaces C. sexmaculata larvae in all competitive interaction and the two predators should be released separately especially in case of low food availability.

1.3.1.9. Performance of Cheilomenes sexmaculata at different temperature and humidity ranges

An experiment was carried out by setting up environmental chambers at different temperatures 18°, 22° and 26°C and at two humidity ranges 40% and 70%. Cotton was planted in pots. After 30 days these potted plants were transferred in to environmental chambers. These plants were infested with Aphis gossypii. Treatments at each temperature and humidity ranges were replicated 3 times. In control the top five leaves were infested with 5 aphids. Initial count of aphids was recorded in all treatments. Cheilomenes sexmaculata grubs were released at the rates of 250 aphids. Daily observation on number of aphids consumed was recorded till beetle grubs pupated. In control also increase in population was recorded for same period as in treatments. Results are presented in Fig.3.

Results presented in Fig.3 indicate that in general C. sexmaculata was able to bring down the population of aphids. At 18°C, it predated on 72.3 and 76.8% aphids at 40% and 70% R.H., respectively. A. gossypii increase was less at this temperature suggesting that it was not optimum for its reproduction. Larval development period was 13.0 - 14.8 days. At 22°C, C. sexmaculata reduced A. gossypii population by 86.4% at 40% R.H. and 97.4% at 70% R.H. In control aphids multiplied 11.6 times at 70% R.H. in comparison to 3.2 times at lower humidity of 40%. Larval development was 8.5 - 9.0 days at this temperature. At

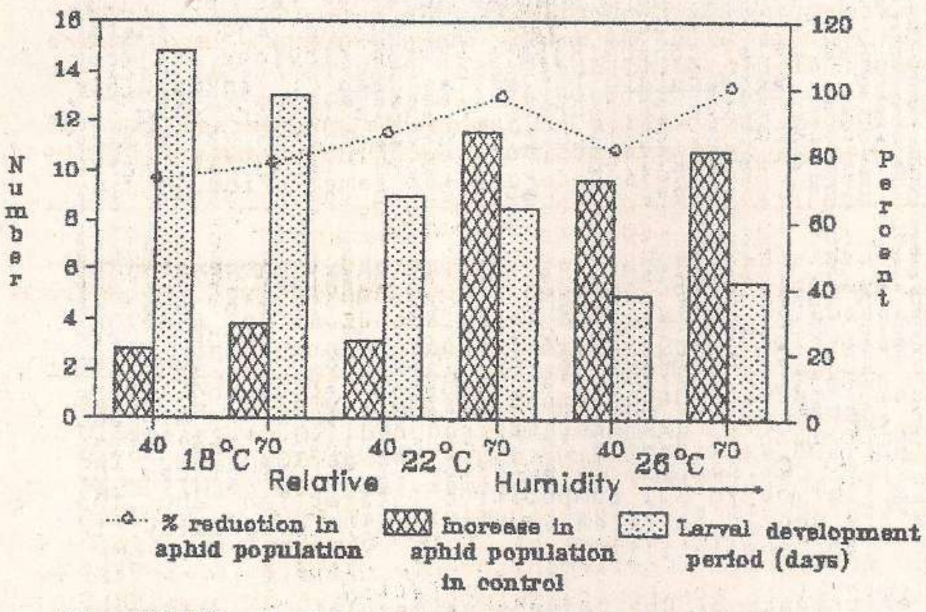


Fig. 3: Effect of temperature and humidity on predation by *C. sexmaculata* larvae

26°C, population reduction of 80.9 and 99.6 % was obtained at lower and higher humidity, respectively. At this temperature aphids multiplied 9.6 and 10.8 times within 3.0 days. Thus it is clear that C. sexmaculata performs better in temperature from 22-26°C and at higher humidity of 70%

1.3.1.10. Screening of various Bacillus thuringiensis products against Trichogramma chilonis and neonate larvae of Helicoverpa armigera

This experiment was carried out with 11 B. t. products viz. BTK-I, BTK-II, BTT, Dendrobacillin Asthur, Lepidocide, Bitoxibacillin, Delfin, Thuricide, Tow arrow, and Dipel. Solution of these products were sprayed @ 0.5 kg/ha. A clear plastic container was utilized as testing unit. A window was cut on all sides of container (5.5 x 5.5 x 2 cm size) and 100 wire mesh was heat sealed across it to provide aeration and to make the unit escape proof. Both container and egg card containing 300 eggs of Helicoverpa armigera were sprayed. After shade drying 50 adults of T. chilonis were released for 24 hours. After that time, observation on mortality was recorded and egg cards were observed for % parasitisation. In another experiment eggs which were about to hatch were sprayed with all above mentioned products and larvae on hatching were reared till pupation. Observations on mortality were recorded. Dead larvae were observed under microscope individually to ascertain whether mortality was due to B. t. or any other reasons. Results are presented in Tables 7 and 8.

Table 7. Effect of various B.t. products on parasitism of Helicoverpa armigera eggs by Trichogramma chilonis

B.T. PRODUCTS	Per cent		
	Mortality* of adult parasitoid	Parasitism	Emergence
Delfin	0.0	94.0	96.8
Thuricide	0.0	96.2	98.0
Tow arrow	0.0	98.0	97.2
Bitoxibacillin	60.7	93.4	95.4
Lepidocide	63.1	96.0	98.0
Dipel	36.4	94.4	96.0
BTK-I	0.0	96.8	97.0
BTK-II	0.0	94.5	98.0
BTT	0.0	97.2	98.6
Dendrobacillin	0.0	98.2	96.6
Asthur	0.0	95.5	94.8

* Corrected mortality after Abbot's formula

Results presented in table 7 reveals that bitoxibacillin, lepidocide and dipel caused 60.7, 63.1 and 36.4% mortality of T. chilonis adults after 24 hours of constant exposure. In all other treatments there was no mortality (corrected mortality). However, none of the compounds caused any hinderance to parasitism, which ranged from 93.4 - 98.2%. Emergence of parasitoids from all treatments was normal and at par. Studies therefore suggests that both B. t. products and T. chilonis are compatible and can be released/sprayed together for effective biosuppression.

Results presented in table 8 on screening of neonate larvae against B.t. products revealed variation in response to B. t. products. Lepidocide, Thuricide and Delfin caused 93.6, 83.8 and 78.04% mortality of larvae within 3 days of hatching. BTK-I & II and Dipel caused 59.5, 50.7 and 50.2% mortality, respectively. In other products it ranged from 15.8-36.5% for the same period. In addition BTK-I, II, Tow arrow, dipel and Asthur also caused mortality between 6.8-11.5% between 4-7 days after hatching. Results generally

Results of the experiment are presented in Table 9.

Table 9. Screening of trichogrammatids against *Opisina arenosella* eggs laid inside frass of larvae on coconut leaves

Species	% parasitism	% eggs hatched	% eggs desiccated
Trichogrammatoidea armigera	0.00	94.04	5.90
Tr. bactrae	15.10	82.16	2.70
Trichogramma achaeae	0.00	97.90	2.07
T. brasiliensis	8.96	88.20	2.75
T. chilonis	10.96	84.00	2.66
T. evanescens	6.25	85.40	6.25
T. embryophagum	82.05	15.38	2.56
T. dendrolimi	0.00	94.73	5.26
T. japonicum	0.00	100.00	0.00
T. pretiosum	27.30	71.42	2.19
T. sp. (Italian strain)	12.45	86.47	2.81

Results presented in Table 9 indicated that *T. embryophagum* parasitized 82.05% eggs followed by *T. pretiosum* 27.3%, *Tr. bactrae* 15.1%, *Trichogramma* sp. 12.45%, *T. chilonis* 10.96%, *T. brasiliensis* 8.96% and *T. evanescens* 6.25%, other species failed to parasitise *O. arenosella* eggs laid in the frass. High egg hatching was also observed in most of the species indicating that some trichogrammatids were unable to parasitise eggs inside the frass. In *T. embryophagum* treatment, only 15.38% of host eggs hatched, thus suggesting that this species can further be tried for making field release.

1.3.1.12. Evaluation of endosulfan resistant/tolerant strain of *Trichogramma chilonis*

The experiment was initiated during 1989-90 by exposing Bio C1 strain, which was selected for field trial to 0.12 ml/liter solution of endosulfan. Experiment was continued this year also by spraying 1 ml/liter solution and shifting test species to 1.25 ml/liter solution in F 164 generation. Glass tube (20 x 30.5 cm size) both end of which were open was used in the experiment. Required solution was sprayed inside the tube and was dried under the shade. Adult parasitoids obtained from previous test were released inside after covering both ends of tube with long cloth. Egg card was introduced after 15-30 minutes of adult release. Within this time susceptible ones were eliminated. Observation on percent mortality of adult was recorded after 6 and 24 hours of exposure and subsequently for parasitism. During 1989-90 parasitoids were shifted from 0.12ml/liter to 0.25 ml/l. after 13 generations, 0.25 to 0.50 ml/l. after 13 generation, 0.50 to 0.75 ml/l. after 14 generation 0.75 to 1.00 ml after 32 generations and 1.00 to 1.25 ml after 92 generations. At present experiment is at 1.25 ml/lit stage. Results are presented in Fig.4.

Results presented in Fig.4 revealed that after 131 generations when shifted to 0.035% concentration 100% mortality occurred within 6 hours and parasitism was 70.0%. However after rearing for another 30 generation at same concentration mortality pattern after 6 and 24 hours in F 162 generation was 50.0 and 80.0% and parasitism was 100.0%.

It was decided after obtaining 100.0% parasitism for about 25 generations to shift parasitoids to next higher concentration i.e., 1.25 ml/liter (0.044%) in F 164 generation. Parasitoids again showed higher susceptibility of this dosage and low parasitism of 65.0% was obtained. Experiment will continue for next year also.

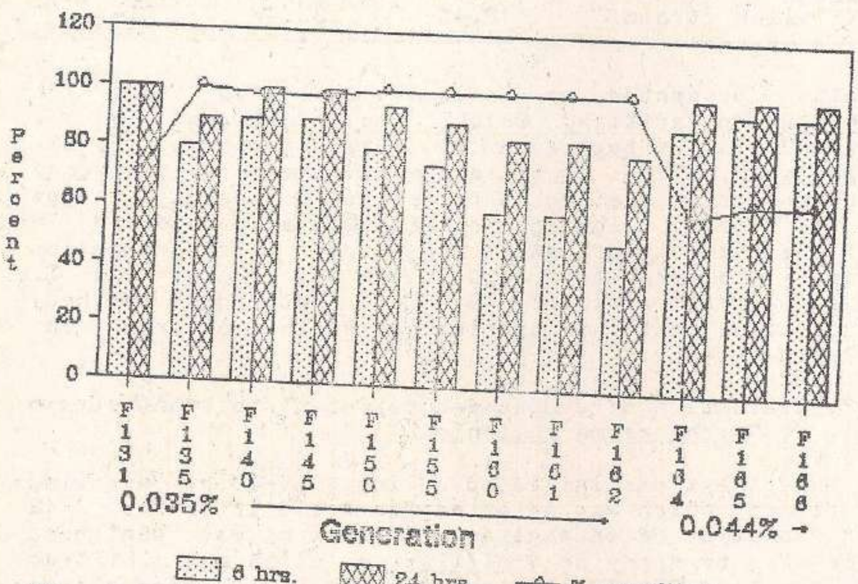


Fig. 4: Exposure of *Trichogramma chilonis* adults to endosulfan.

1.3.1.13. Effect of UV treatment on freshly parasitized eggs of Corcyra cephalonica by Trichogramma chilonis

The experiment was carried out by parasitizing fresh eggs of Corcyra cephalonica by T. chilonis and then exposing to UV light. Corcyra eggs parasitized by T. chilonis which were at different developmental stages viz. 0, 1, 2, 3, 4, 5, 6, 7 and 8 days after exposure were kept under UV (30 watt)light for different periods i.e. 45 minutes, one hour and one hour thirty minutes. After exposure to UV, cards were collected and observed for emergence of the parasitoids. The experiment was conducted in order to determine the effect of UV light on parasitized eggs as may happen in nature also and for future study of obtaining cell lines where only Trichogramma tissue is removed from host egg. Results are presented in Fig.5.

Results presented in Fig.5 indicate that irrespective of exposure time of UV rays from 45 minutes to 90 minutes T. chilonis egg and first two larval instars remained unaffected and parasitoids emerged normally. However from third larval instar onwards, UV rays killed all stages.

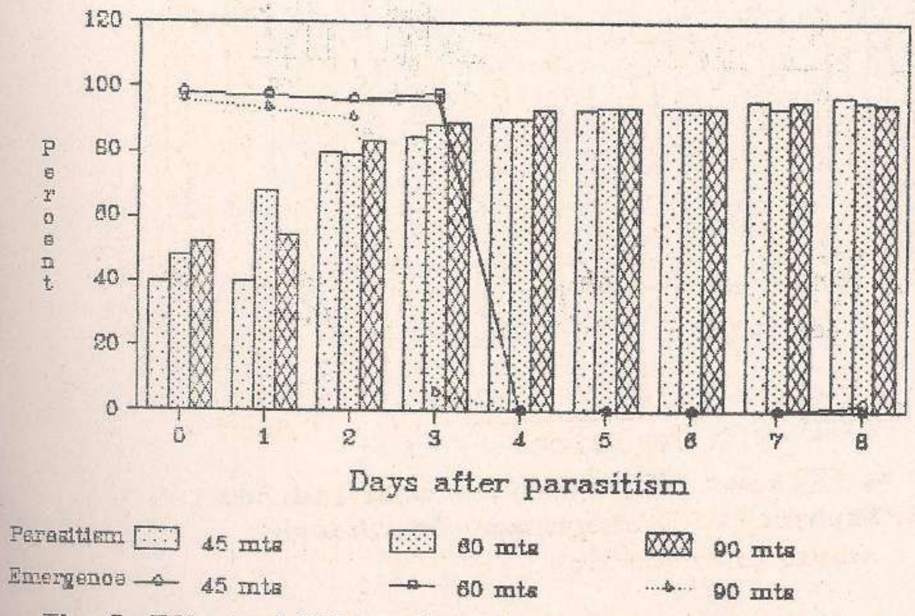


Fig. 5: Effect of UV treatment on parasitized eggs of *Corcyra cephalonica* by *Trichogramma chilonis*

Thus to obtain *T. chilonis* tissue, 0-3 days old exposed eggs can be utilized. Perhaps in later stage when only *Trichogramma* remains inside host eggs, it gets killed by UV exposure.

1.3.1.14. Effect of different egg numbers on parasitism and adult recovery of *Trichogramma brasiliensis*

An experiment was carried out by exposing *Helicoverpa armigera* eggs in different numbers viz 5, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 to *Trichogramma brasiliensis* for 24 hours in glass vial (15x25 cm). Each treatment (egg numbers) were replicated 4 times. Observation on % parasitism, no. of adults obtained and subsequently mean no. of adult parasitoids obtained per egg, % eggs hatched, % eggs desiccated and emergence from parasitized eggs were also recorded. Results are presented in Fig.6.

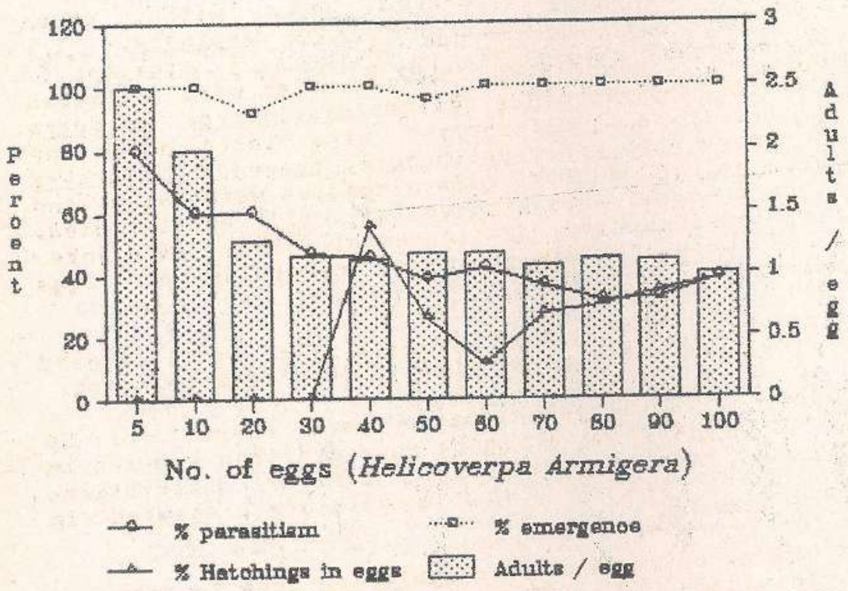


Fig. 6: Egg number effect on parasitism and adult recovery of *Trichogramma brasiliensis*

Results presented in Fig.6 reveals that % parasitism was high in lower density from 5 to 20 eggs/female parasitoid parasitism ranging from 60.0-80.0% and between 30 to 100 eggs, it remains between 31.2 to 46.6%. Number of adults obtained per egg was highest where 5 eggs were exposed to single female, adults obtained was 2.5/egg followed by 2.0 adults/egg in 10 eggs/parasitoid, 1.27 in 20 eggs/parasitoid treatment. From 30 to 100 eggs/parasitoid treatments, adults obtained ranged from 1.00 to 1.16 adults/egg. Thus T. brasiliensis exhibits superparasitism tendency in lower egg availability. It is thus clear that 40 H. armigera eggs: 1 female parasitoid ratio is ideal to avoid superparasitism. Also per cent eggs which desiccated was more in lower density level compared higher density level.

1.3.1.15. Effect of change of host on biological attributes of various trichogrammatids

The experiment was carried out with seven trichogrammatids viz. Trichogrammatoidea armigera, Tr. bactrae, Trichogramma pretiosum, T. chilonis, T. achaeae, T. brasiliensis and T. dendrolimi. These species were selected on basis of their performance against Helicoverpa armigera eggs. In first set, all species were taken from the laboratory where they were continuously reared on Corcyra cephalonica eggs. 50 adults of each species were taken and C. cephalonica eggs were exposed till all adults died. Observations on fecundity, developmental time, emergence, longevity of male and females and no. of adults per eggs were recorded.

In second set, Helicoverpa armigera eggs were exposed as in the first set and similar observations were recorded.

In third set, all seven species were reared for 20 generations on Helicoverpa armigera eggs and then exposed to C. cephalonica eggs as done above. Similar observations were recorded for this set also. Results are presented in Tables 10, 11 and 12.

Result of exposure from C. cephalonica eggs to same is presented in table 10. It showed that fecundity of T. pretiosum was highest (41.5) followed by T. dendrolimi (39.8), Tr. bactrae (28.9), T. brasiliensis (28.3), T. chilonis (22.4), Tr. armigera (13.3) and T. achaeae (11.0). There was no difference in developmental time, emergence and no. of adults obtained per egg. Longevity of T. brasiliensis and T. dendrolimi was more compared to other species. In exposure where adults obtained from C. cephalonica eggs were exposed to H. armigera eggs (Table 11), fecundity of Tr. armigera increased significantly and that of T. chilonis and T. achaeae marginally. Though fecundity in other species declined, number of adults

Table 10. Exposure of trichogrammatids from Corcyra to Corcyra eggs

Species	Fecundity	Development time (in days)	Emergence	Longevity Male	Longevity Female	No. of adults /egg
Trichogrammatoidea armigera	13.3	12.0	97.9	0.4	3.2	1.06
Tr. bactrae	28.9	12.0	100.0	1.8	3.5	1.08
Trichogramma pretiosum	41.5	11.0	98.7	2.0	4.0	1.08
T. chilonis	22.4	11.0	99.1	1.3	4.8	1.09
T. achaeae	11.0	11.0	98.4	2.8	4.8	1.03
T. brasiliensis	28.3	11.0	98.6	4.3	6.1	1.01
T. dendrolimi	39.8	11.0	98.9	2.5	5.1	1.09

obtained per egg was significantly more. Since egg of H. armigera is bigger and can sustain more developing larvae, in real sense fecundity remained more or less same. There was no difference in developmental time and emergence between species. Number of adults per egg ranged from 1.64 to 1.89 in comparison to 1.01 to 1.09 in C. cephalonica eggs.

In a third set, where adults obtained from H. armigera egg after rearing for 20 generation on this host were exposed to C. cephalonica eggs, fecundity of all species increased significantly.

Exposure of trichogrammatids to H. armigera eggs increased fecundity significantly in Tr. armigera by 122.5%, T. bactrae 12.8%, T. pretiosum 22.8%, T. chilonis 289.2%, T. achaeae 225.4% and T. brasiliensis 112.3%. In T. dendrolimi it remained almost same. It is therefore clear that if above species are reared on H. armigera eggs it increases its fecundity. Therefore, the same quality control can be achieved in the laboratory as found in field population. Rearing on any host did not effect developmental period or emergence of parasitoids. Longevity also remained same. There was more recovery of adults/egg from H. armigera compared to C. cephalonica, an increase of 60.7 - 61.5% was observed when reared on H. armigera eggs.

Table 11. Exposure of trichogrammatids from *Corcyra* to *Helicoverpa armigera* eggs.

Species	Fecundity	Development time (in days)	Emergence	Longevity Male	Longevity Female	No.of adults /egg
Trichogrammatoidea armigera	23.0	10.0	98.2	0.2	7.3	1.79
Tr. bactrae	26.2	11.0	98.8	4.5	5.7	1.89
Trichogramma pretiosum	28.6	11.0	98.3	4.5	10.3	1.64
T. chilonis	24.2	10.0	96.3	1.2	5.0	1.83
T. achaeae	15.1	9.0	95.8	1.3	6.7	1.84
T. brasiliensis	26.6	12.0	98.4	5.2	6.8	1.72
T. dendrolimi	20.7	10.5	97.7	4.0	7.5	1.88

Table 12. Exposure of trichogrammatids from *Helicoverpa armigera* to *Corcyra cephalonica* eggs

Species	Fecundity	Development time (in days)	Emergence	Longevity Male	Longevity Female	No.of adults /egg
Trichogrammatoidea armigera	29.6	13.0	98.4	3.6	4.0	1.09
Tr. bactrae	32.6	12.8	96.4	2.0	4.6	1.17
Trichogramma pretiosum	51.0	12.0	98.4	2.4	4.6	1.06
T. chilonis	87.2	12.0	98.6	4.4	6.3	1.03
T. achaeae	35.8	10.0	97.6	1.1	4.5	1.02
T. brasiliensis	60.1	13.0	98.6	4.8	6.6	1.09
T. dendrolimi	38.0	11.0	96.8	3.0	5.4	1.02

1.3.1.16. Different egg densities of Helicoverpa armigera and parasitoid numbers on the intensity of parasitism on cotton by Trichogramma chilonis

Experiment was carried out by raising cotton plants in pots. After 30 days of germination, cotton plants were covered with a cage (45 x 30 cm). Helicoverpa armigera eggs were inoculated in different densities viz. 2, 5, 10, 15 and 20 eggs/plant. Eggs were distributed in top five leaves of the plants. Trichogramma chilonis was released @ 1, 2, 4 and 6 females/plant inside the cage. Each experiment, egg density wise and parasitoid number wise was replicated 6 times. Exposure was done for 24 hours. After exposure period, eggs were collected back and were observed for parasitism. After each exposure, cages were thoroughly checked and parasitoids were removed before next exposure. Results are presented in Fig. 7.

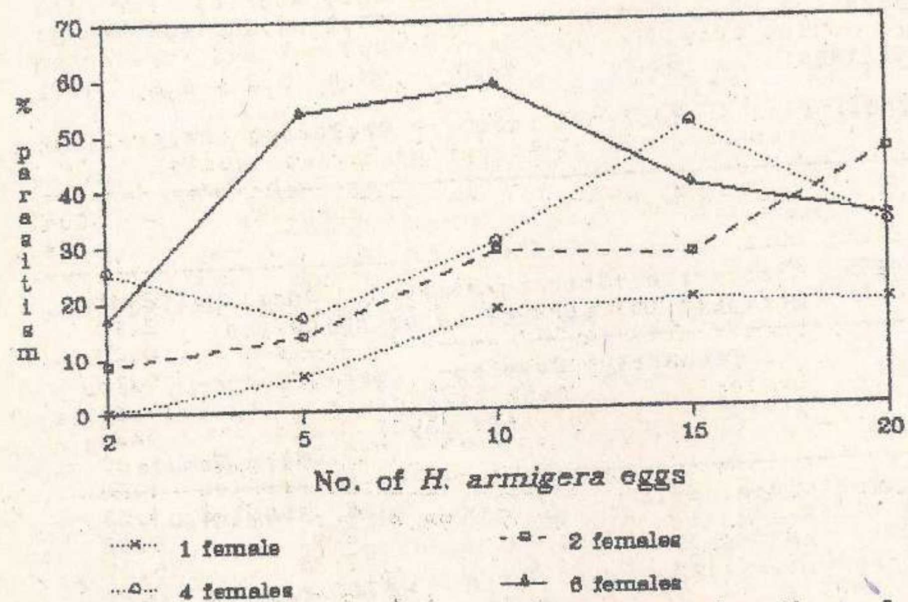


Fig. 7: Effect of *Helicoverpa armigera* egg density and *T. chilonis* numbers on intensity of parasitism

Results indicated that in 1 female/plant parasitism was very low with maximum of 19.5% in density of 15 eggs/plant. In 2 female/plant treatment, parasitism rose with egg density and at 20 eggs/plant it was highest 45.8%. In 4 and 6 females/plant treatment, parasitism rose in density upto 15 and 10 eggs/plant and declined thereafter. In general, more parasitism was recorded where more females were released. Results indicated that parasitism rose upto a certain density level and declined thereafter even if more eggs were present/plant. *T. chilonis* showed some density dependence as parasitism was generally low in level of 2 and 5 eggs/plant. Effective suppression of *H. armigera*, therefore, can be achieved by regulating dosages as per egg density.

1.3.1.17. Economics of production of *H. armigera*

The diet developed by Nagarkatti and Sathyaprakash (1974) has been in use in the laboratories for the multiplication of *H. armigera*. The cost of production of *H. armigera* using this diet has been worked out and presented in Table 13.

Table 13. Diet ingredients used for producing one set of diet and the different production costs

Sl.No.	Item/Ingredient	Quantity	Cost (Rs.)
(A) 1	Kabuligram flour	105g	2.15
2	Ascorbic acid	3.25g	3.90
3	Sorbic acid	1.00g	0.70
4	Methyl para hydroxy benzoate	2.00g	0.73
5	Streptomycin sulphate	0.25g	1.26
6	Yeast tablets	10.00g	1.60
7	Multivitaplex capsules	2 capsules	1.20
8	Viteoline	2 capsules	1.53
9	Formaline(10%)	2 ml	0.03
10	Agar agar	12.75	15.17
11	Distilled water	780 ml	0.85
(B)	Electricity charges		3.00
(C)	Labour charges		3.00
(D)	Miscellaneous expenses		2.00
	Cost of production of one set of diet (96 vials)		37.12
	Cost of one vial of diet		0.39

Cost of production of _H. armigera_ pupa

(E)	1	Egg collection cage	0.92
	2	Bhendi	1.50
	3	Sodium hypochlorite solution (10ml) for sterilization	0.38
(F)		Electricity charges for using the washing machine	3.00
(G)		Other labour charges	3.00
(H)		Miscellaneous expenses	2.00
		Total cost of production of 96 vials of diet with larvae in them(A+B+C+D+E+F+G+H)	47.22
		Considering 50% mortality in the larval stage, the cost of production of one _H. armigera_ pupa	1.00

1.3.1.18. Evolving a pesticide tolerant strain of _Telenomus remus_

This experiment was initiated at 0.1 ml concentration, where 100% parasitism was obtained. At 0.2 ml concentration, though mortality was recorded as 100% after 4 to 6 hours of exposure, parasitism could be increased from 54.5 to 80%. Now the experiment is in progress at 0.3 ml concentration. More than 50% mortality is being recorded, but 50% parasitism is being obtained.

1.3.1.19. Studies on the effect of storage of tachinid parasitoids of _H. armigera_

Carcelia illota were obtained from the field collected _H. armigera_ larvae. These were reared in the laboratory and the puparia were stored in BOD incubators maintained at 10±1°C and at 60±2% RH. The puparia were removed from the BOD at 10 day intervals. The date of emergence from the stored puparia was checked up and per cent emergence noted. As shown in the Fig. 8, storage for even 10 days at 10°C resulted in only 40% emergence in comparison to 100% emergence in the control batch. After 20 days of storage, 22.5% emergence occurred and after 30 days, 17.55%. Storage for 40 days resulted in zero emergence. The mean developmental period from the puparial stage to adult emergence was 10.8 days in the control batch. In the storage batches, the developmental period (including the storage period) was 19, 30 and 32 days in the case of 10, 20 and 30 days of storage respectively. The above study shows that _C. illota_ puparia can be stored for only about 10 days at 10°C and that the developmental period can be prolonged by storage at 10°C. It also shows that storage at 10°C did not cause any deformation of the adults emerging from the stored puparia.

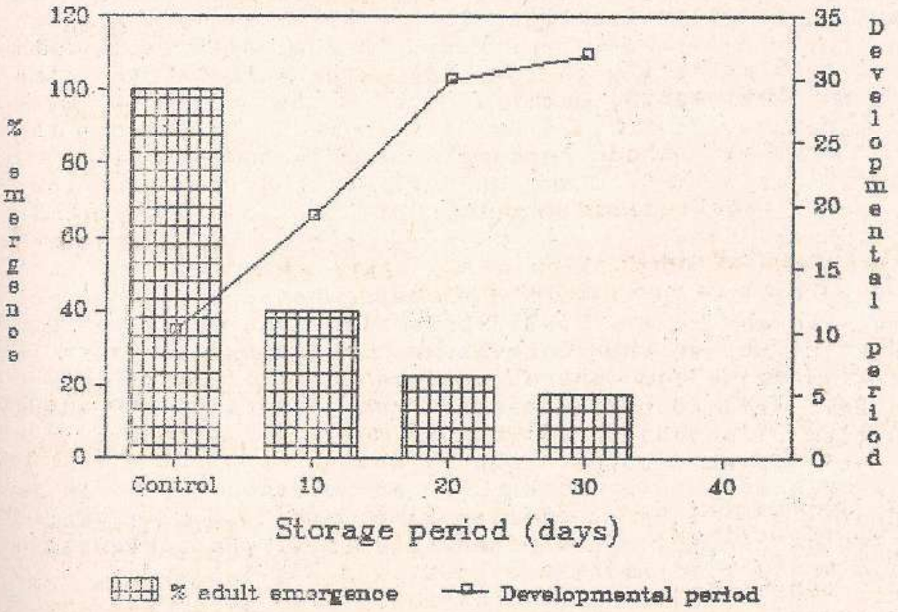


Fig. 8: Effect of storage on *Carcelia illota* puparia

1.3.1.20. Survey for the Nilgiris strain of _Diadegma semiclausum_

A survey was conducted to look for the presence of _D. semiclausum_ on _Plutella xylostella_ at Nilgiris. In September 1993, cabbage fields were surveyed at the following fields at Nilgiris - Wood house farm, Kappachi, Aravanadu and Nanjanadu. In mature cabbage fields, a mean parasitism of 30% by _D. semiclausum_ was observed. There was no difference in the biological parameters of the Nilgiris strain in comparison to the Taiwan strain obtained earlier. The mean developmental period from egg laying to cocoon formation was 10.5 days and from cocoon to adult about 5 days. Per cent adult emergence was about 60% and the sex ratio was highly male biased. Earlier observations on the lab reared _D. semiclausum_ had shown that the cocoons turned black just before emergence. In the field conditions at Nilgiris, it was observed that even freshly formed cocoons were dark in colour. This could due to the climatic conditions at the higher altitudes.

1.3.1.21. Effect of host deprivation and maternal age on the performance of Bracon kirkpatricki

Laboratory studies were conducted on the performance of B. kirkpatricki when they were deprived of hosts at different ages. After emergence the parasitoids were allowed to mate. Corcyra larvae were exposed to the parasitoids from day 1 after mating(T_1). In the other treatments the parasitoids were initially deprived of hosts and hosts were exposed from day 3, 5, 7, 9 and 13. In order to check the effect of host deprivation and maternal age on longevity, a control was maintained where no host was provided and this was compared with the longevity of the parasitoids in different treatments.

The parasitoids lived for 43 days when they were not provided with any hosts. Host deprivation from day 1 to day 13 had no effect on the longevity as longevity recorded in all the treatments and control were on par. In the different treatments, mean longevity ranged from 29 days to 42 days (Table 14).

Maximum number of cocoons (37) was obtained in T_1. In T_2 and T_3, 29.67 and 24.33 cocoons per female were obtained which were on par with T_1. There was a significant reduction in cocoon production in T_7 .

Table 14 shows that in T_1 cocoons were formed till the 38th day. However, in T_2, T_3, T_4 and T_5, cocoon production occurred till 20th, 18th, 21st and 18th day respectively, which were all significantly lesser than T_1. Cocoon production occurred for minimum number of days in T_6.

The above experiment shows that hosts should be provided for B. kirkpatricki a day after mating for good cocoon production and also for cocoon production to occur for more number of days. The parasitoid could perform moderately well till 8 days of host deprivation. But it is clear that if host deprivation occurred beyond that, it had a detrimental effect on the performance of the parasitoid.

Insect pathology

1.3.1.22. Mainteinance of host culture

Laboratory pathogen and maintenance of host culture of Helicoverpa armigera and Spodoptera litura was continued using natural food and / or artificial diets at PDBC, Bangalore.

Table 14. Effect of maternal age and host deprivation on performance of *B. kirkpatricki*

Treatments (Age of the mated females)	Mean longevity of female (Days)	No.of cocoons (per female)	Cocoon production (till...days)
T_0 (No host provided)	35.00	-	-
T_1 (1 day)	42.67	37.00[a]	38[a]
T_2 (3 days)	41.00	29.67[ab]	20[b]
T_3 (5 days)	33.33	24.33[ab]	18[b]
T_4 (7 days)	42.33	21.33[b]	21[b]
T_5 (9 days)	37.00	15.67[bc]	18[b]
T_6 (13 days)	29.33	4.67[c]	8[c]
CD (P=0.05%)	NS	14.20	5.11

NS : Not significant

1.3.1.22.1. Mass multiplication of nuclear polyhedrosis virus

Mass production of nuclear polyhedrosis virus of *H. armigera* and *S. litura* using their respective hosts was a continuous process. During the period under report, 13,800, 7000, 3160 and 2000 larvae of *H. armigera* were reared inoculated, virosed and harvested respectively at PDBC, Bangalore.

In case of *S. litura* 10,000 larvae were reared , 6000 were inoculated. Out of this 3000 were virosed and the larval equivalent and harvested were 1500.

1.3.1.22.2. Supply of nucleus culture

Supply of nucleus culture of *H. armigera* and *S. litura* nuclear polyhedrosis viruses to various Government and private organizations for use for mass propagation of the viruses was low. Distribution of virus suspension for field or various crops like cotton, chickpea, tomato etc. were also made from PDBC, Bangalore.

1.3.1.22.3. Enhancing the efficiency of in vitro production of insect virus

Subsequent to the exploration of live larval sexing for lepidopterans based on the external sex characters, multiplication of NPVs of *H. armigera* and *S. litura* was done on the female larvae. While sexes could be distinguished from third instar stage onwards to an accuracy of 93% in *S. litura* and *H. armigera*, selective utilization of female larvae of S. litura for NPV production gave more virus.

Yield (10,516 x 10^6 polyhedral inclusion bodies (PIBs), almost ten times more than that was obtained with male larvae (1875 x 10^6 PIBs). Further studies are in progress to find effective exploration of insect biomass vis-a-vis increased virus yield.

1.3.1.22.4. Integrated use of NPVs with entomopathogenous nematodes

Survey for the identification of native entomopathogenic nematodes was done using white trap method of extension further, steps have been taken to set the strains from elsewhere so as to test for their efficacy singly or in combination with NPVs.

Preliminary study reavealed the susceptibility of P. xylostella and Crocidolomia binotalis and Maruca testulatis to the entomophilic nematodes which paved the way for future integrated pest management strategy for the control of major pest complex occurring on cruciferous and redgram crop ecosystem using entomopathogens alone.

1.3.1.22.5. Insect tissue culture

For stabilizing primary and permanent haemocyte cell culture of H. armigera, attempts were made to characterize the different types of haemocytes. The above studies revealed the identification of prohaemocytes, plasmatocytes, vermiform and spindle shaped cells etc. Addition of 16 mm Alcl3 to the serum (Faetal bovine serum FBS) containing medium for S. litura (SF-9), increased the infection rate by a heterologous, multiple, embedded nuclear polyhedrosis virus of S. litura when inoculated with filtered supernatent medium from infected primary haemocyte culture of S. litura.

1.3.1.23. To study the efficacy of various concentrations of HaNPV sprayed at varying time-schedule in protecting tomato against H. armigera.

NPV trials in tomato was laid out in 540 m2 area, in order to confirm the results of the earlier trials on the NPV optimum dose and spray schedule for tomato fruit borer control. The trials consisted of five main treatments viz.,

i) NPV @ 100 LE/ha
ii) NPV @250 LE/ha,
iii) NPV @ 300 LE/ha,
iv) Endosulfan .07% and
v) Control check with three sub-treatments of various spray schedules viz.,

a) Seven sprays @ 5 days intervals,
b) Five sprays of three sprays at 5 days interval and 2 sprays at 8 days interval
and
c) Four sprays at 8 days interval.

Each subtreatments has been further replicated thrice. Regular sprays of NPV along with jaggery (1%) + Triton -X-100(0.01%) and endosulfan have been carried out. Observations on egg and larvae count have been taken. Further observations on percent borer damage and harvest yield will be taken as the trial is still in progress.

1.3.1.24. Screening of field collected P. xylostella and C. binotalis for baculoviruses.

Regular screening of field collected larvae of P. xylostella and C. binotalis were made in the laboratory. The diseased larvae showed the presence of bacterial pathogen, Serratia marcescens and Microspordians, Nosema and Vairimorpha.

1.3.1.25. NPV on farm trials

NPV on farm trials in tomato has been carried out through extension guides, UAS, Bangalore. For the Kharif the trials were carried out in four locations namely: Channapatna, Nelamangala, Magadi and Chikkaballapura. Encouraging results were obtained in all the locations except in Chikkaballapura where the results were vitiated due to low pest incidence. From the rabi season the trials were being carried in six locations in Karnataka, Bangalore North (2 locations), Doddaballapura,Kolar, Magadi and Nelamangala. The trials are still in progress.

1.3.1.26. Field efficacy of Dipel 8L and Centari against P. xylostella in cabbage.

The trial has been carried out to determine the field efficacy of Dipel 8L and Centari in controlling P. xylostella in 336 sq. m. area with four treatments of five replications each. Six weekly sprays of Dipel 8L and Centari and four sprays of Endosulfan at 10 days interval were given. Weekly observations on larval count and final harvest yield were made.

Results indicated that application of Dipel and Centari significantly reduced the larval population to 0.84 per plant as compared to 2.60 in endosulfan and 5.08 in control plots. Significant increase in yield of 39.1 tons/ha was recorded in Dipel treated plot, which is on par with 34.2 tons/ha in Centari treated plot, as compared to lowest yield of 24.4 tons/ha in control plot. However, endosulfan treated plot recorded 31.2 tons/ha which is on par with Centari treated plot.

1.3.1.27. Field efficacy of N. rileyi against H.armigera in tomato (large scale field trial)

The trial has been carried out on an isolated area of 400m2 each for fungal treatment and for control check. Each treatment consisted of 20 plots of 20m2 each. Five weekly sprays of N. rileyi @ 3.2 x 10 conidia/ml along with triton x-100 (.01%) were given during evening hours. Regular weekly observations on larval count were made in both the treated and untreated plots. Results showed that there was significant reduction in fruit borer population in treated plot(0.4) as compared to untreated plot (2.3). Observations on fruit borer damage percentage and on harvest yield could not be made due to heavy rain during the cropping season which lead to severe phytophthora fruit rotting.

1.3.1.28. Field efficacy of N. rileyi against S. litura in Beet root

The trial on beet-root has been laid out on 400m2 area in order to evaluate the field efficacy of N. rileyi against S. litura. Four treatments of five replications each were imposed including control. The weekly sprays of fungus and one fortnightly spray of endosulfan were given. Further spraying of fungus and endosulfan could not be continued because of low incidence of pest. The trial will be repeated in the next year.

1.3.2. BISUPPRESSION OF SUGARCANE PESTS

1.3.2.1. Shoot borer, Chilo infuscatellus Snellen

At Sardar Nagar, the shoot borer infestation in pre-monsoon remained low, 4.7 to 5.6 percent on dead heart basis. The shoot borer complex in the area comprises larvae of Chilo infuscatellus and green borer, Raphimetopus ablutellus and the root borer, Emmalocera depressella and the pink borer, Sesamia inferens. Of the different borers, occurrence of C. infuscatellus predominated except in May, when the root borer larvae, Emmalocera depressella dominated over the rest of the borers.

Natural parasitism of the shoot borers was appreciably low in April, May and June. By the end of theseason i.e in July few larvae of shoot borer parasitised by Cotesia flavipes were collected under the natural conditions.

At Shakarnagar, the shoot borer, Chilo infuscatellus occurs right from shoot stage to the cane stage of the crop. In November-December planted crop, the attack of shoot borer ranged from nil to 28.58 per cent and the peak infestation was reached in the month of June. In June, July and August the attack of shoot borer was also noticed damaging the cane stalks, the damage in terms of joint infestation during this period ranged between 0.57 to 12.8 percent. Maximum population (larvae + pupae) of shoot borer in the region was recorded in the month of June (13.33 thousand/ha) and the lowest in August (Fig.9).

During November through February 94, shoot borer prevalence was noticed in October planted crop (New crop). In this crop the infestation of shoot borer ranged between 2.55 and 5.18 percent with larval + pupal population / ha ranging between 493 and 2345.

In general, the shoot borer attack at Shakarnagar during the year was higher as compared to the previous year. The natural parasitisation by Cotesia flavipes and Stenobracon sp. was recorded to an extent of 5.82 per cent and 2.58 per cent, respectively.

At Pravaranagar, the shoot borer infestation ranged from 3.4-13.0 per cent during different months, the maximum being in May and minimum in November. Prevalence of low level of parasitisation by Cotesia flavipes was observed in April, August, Sept., Feb. and March and by Sturmiopsis inferens in April, May, July, August to November (Table 15).

Table 15. Percent shoot borer infestation and its natur[al] enemies during the year 1992-93 at Pravaranagar

Month (1993-94)	Shoot borer incidence (%)	Parasitoids *Cotesia flavipes*	Parasitoids *Sturmiopsis inferens*
April	8.2	2	1
May	12.7	-	1
June	9.4	-	-
July	8.10	-	1
August	4.8	1	1
September	6.10	1	3
October	4.0	-	1
November	3.85	-	1
December	4.5	-	1
January	4.3	-	-
February	3.8	3	-
March	5.80	3	-

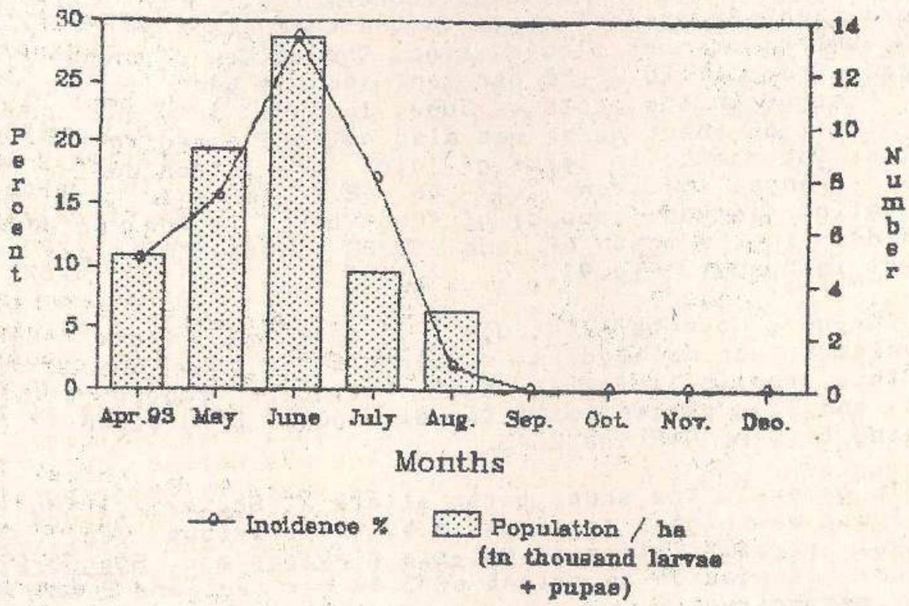


Fig. 9: Sugarcane shoot borer infestation during 1993 at Shakarnagar

Exotic parasitoids, *Trichogrammatoidea eldanae* was mass multiplied and supplied to farmers for its release against the shoot borer, *Chilo infuscatellus*. A total of 1, 61, 60,000 adults were supplied to 370 farmers for release of the parasitoid in an area of 1010 acres around the Pravaranagar.

Field evaluation of *T. eldanae*:

Two plots, a release and a control plot were earmarked for the trial. The parasite was released at weekly intervals from 18.2.94 to 25.3.94 (Total 6 releases). The released plot recorded less incidence of shoot borer 1.19 percent as against 5.7 percent in the unreleased plot.

1.3.2.2. Field evaluation of *Trichogramma chilonis* for the control of *Chilo auricilius*

The field experiments to evaluate the effectiveness of *Trichogramma chilonis* for the control of sugarcane stalk borer, *Chilo auricilius* were laid out near the Village Cheema (Dist. Jalandhar). Three fields of CoJ 64 variety of sugarcane, each measuring one ha, of the same age were selected at a distance of 1 km from one another for this purpose. The *T. chilonis* (6 day old parasitised host eggs) were released in two fields while the 3rd field without release was kept as control; The releases of parasitoid were started on 7th July, 1993 and continued upto 27th October, 1993 @ 50, 000/ha at 10 days interval. The dates of releases and observations on the incidence of borer are given in Table 3. The mean incidence of borer varied from 0.8% to 6.9% during the period of observation in one treated plot while the corresponding figures for the second plot were 0.9% and 7.4%. The mean incidence observed in the control plot varied from 1.3% to 17.9% on 27th october, 1993. In all the three treatments incidence of pest was negligible at the start of experiment ,i.e on 7.7.93 . Incidence of borer is based on five clumps and the average was worked out. The observations on the incidence was observed by removing the trash and leaves of each cane . In general the incidence of the borer remained low in control plot and parasitoid release plots during July and August, 1993 (Table 16).

1.3.2.3. Field evaluation of *Trichogramma chilonis* against *Chilo auricilius* and *Chilo sacchariphagus indicus*.

This experiment was conducted at IISR, Lucknow farm in autumn planted field of 1 ha planted with COLK 8001. The whole field was divided in two halves having one half for the release of the egg parasitiod and the other half was kept as a check (control plot). These two blocks were separated with buffer area of 55 x 40 m.

Table 16. Field evaluation of Trichogramma chilonis for the control of Chilo auricilius

Month Year (1993)	Dates of release & observation	* Mean incidence of C. auricilius during different Month(%)		
		Trichogramma chilonis plots		Control plot
		Expt. No. 1	Expt. No. 2	
July	7, 09,30	0.8	0.9	1.3
August	7, 17,27	1.3	1.7	2.3
September	7, 17,28	3.8	4.1	11.8
October	12, 27	6.9	7.4	17.9

* Av. of 5 units, each consisted of 5 clumps
-Pre- release incidence on 7.7.93 was negligible in all plots
-Plot size under each treatment was 1 ha.
-T. chilonis was released @ 50,000/ha

The egg parasitiod, Trichogramma chilonis received from Project Directorate (BC), Bangalore was released as per the programme except in July, August as the parasitoids were not received in good condition and also in October due to non receipt of the parasitoid consignment.

Progressive borer infestations of stalk borer and internode borer were recorded in August, September and October from the five clumps selected randomly at five locations in the two blocks. At harvest (December) the total canes from the ear-marked sample unit were split open and borer incidence was recorded.

As is evident in table 17 the stalk borer incidence in released and control blocks ranged between 13.6 to 44.6 and 11.2 to 39.2 per cent respectively upto October and also at harvest the incidence remained at the same level. The borer incidence and intensity at harvest in released and control blocks were 40.7 and 2.7 percent and 39.3 and 3.1 percent, respectively. With regard to internode borer infestation, it varied from 50.2 to 59.0 percent in released plot as compared to 51.2 to 61.71, percent in control plots during August to October. At harvest the internode borer incidence and intensity in released plot were 57.71 and 5.4 percent, respectively as against 64.32 and 6.7 percent in control plots (Table 17). At harvest there was significantly low infestation of internode borer in the plot where T. chilonis was released as compared to control plot.

Table 17. Efficacy of <u>Trichogramma chilonis</u> against sugarcane stalk and internode borer

Period of Observation	Percent incidence of two borers Stalk borer		Internode borer	
	Release plot	Control plot	Release plot	Control plot
Prerelease (August)	16.8	17.3	50.2	51.2
September	13.6	11.2	56.8	54.8
October	44.6	39.2	59.0	61.71
At harvest (December)	40.7	39.3	57.71	64.32

Observations were recorded from 5 clumps selected at five places at random in released and control plots.

* Harvest data subjected to 't' test. Difference between 1 and 2 significant at 1%. Other data not significant.

Note: As the releases could not be made as per schedule, the data remained inconclusive.

1.3.2.4. Natural parasitism of borers by <u>C. flavipes</u>

Natural parasitism of borers by <u>C. flavipes</u> was monitored from April 1993 to March 1994 (Fig.10).

The mean monthly parasitism was higher in shoot borer than in internode borer throughout the year. On shoot borer, the highest percentage was noticed in September. On internode borer the parasitoid was observed in some months whereas on shoot borer it was absent throughout the year.

1.3.2.5. Comparative efficacy of indigenous and Indonesian strains of <u>Cotesia flavipes</u> for the control of sugarcane borers

The effect of two strains of <u>Cotesia flavipes</u> viz. indigenous and Indonesian was studied in the fields for the control of <u>Chilo infuscatellus</u>, <u>Chilo auricilius</u> and <u>Acigona steniellus</u>. Three fields of the sugarcane plant crops of var. Coj 64, each measuring 1 ha were selected near village Cheema (Dist. Jalandhar) in the 3rd week of April, 1993. The first observation on the incidence was taken on 25.4.1993 by observing 5 units of canes from each field and each unit

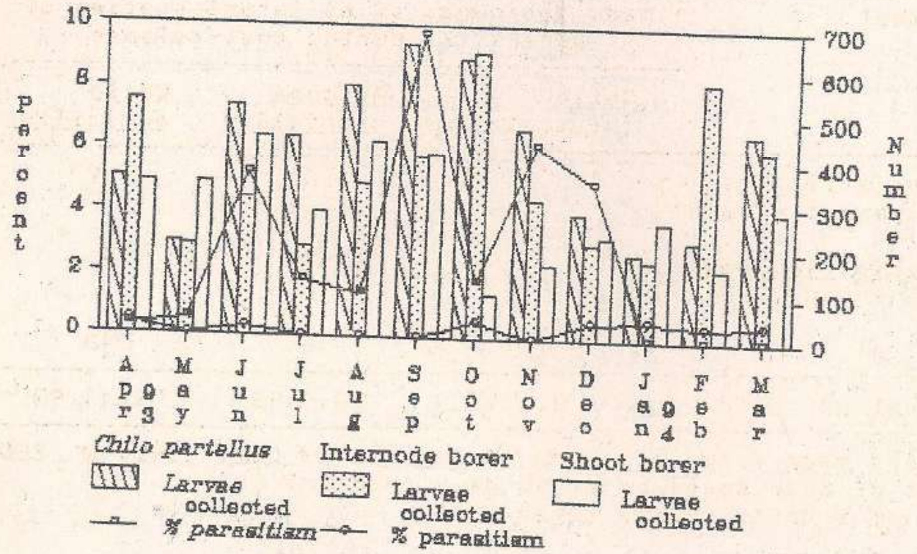


Fig. 10: Natural parasitism of sugarcane borer by *Cotesia flavipes*

consisted of 100 canes. The data are presented in table 18. The releases of parasitoid were started in the end of April and continued till October, 1993. The incidence in case of C. infuscatellus was observed on 5.6.93. The incidence was 6% and 15% in case of indigenous and Indonesian strains respectively while in control the incidence was 17% (Table 18). The incidence of A. steniellus was observed on 28 September. The incidence in plots of indigenous and Indonesian strains of C. flavipes and control was 8%, 13% and 16%, respectively. The corresponding figures of incidence of C. auricilius in the three treatments were 9%, 15% and 18% on 9 November. There was no difference of incidence between control and the Indonesian strain plots while the indigenous strain of C. flavipes contributed for the control of all the three species of borers. It is concluded that the indigenous strain is superior as compared with the Indonesian strain of C. flavipes for the control of these borers (Table 18).

Table 18. Comparative efficiency of two strains of *Cotesia flavipes* for the control of sugarcane borers

Treatment	* Mean incidence of different species of borers (%) during post-release		
	Chilo infuscatellus	*Acigona steniellus*	*Chilo auricilius*
1. *Cotesia flavipes* (indigenous strain)	6	8	9
2. *Cotesia flavipes* (Indonesian strain)	15	13	15
3. Control	17	16	18
Observation date	5.6.93	28.9.93	9.11.93

Releases made from last week of Apr. to 31 Oct. 1993. @ 800 adults of both sexes/ha at 10 days interval
* Av. of 5 units of 100 canes each.

1.3.2.6. Incidence of *Chilo auricilius* in nature

The incidence of *Chilo auricilus* in nature was observed by examining canes on 3.2.94 at crushing site of Doaba Cooperative Sugar Mills Ltd., Nawanshar (Dist. Jalandhar). Canes of the sugarcane variety Coj 64 brought for crushing from 12 different villages by the farmers of the respective village were examined at the crushing site of the sugar mill. From each trolley randomly selected 200 canes were examined for recording the percentage incidence of the *Chilo auricilius*. For recording the percentage of internode damaged, the damaged canes out of 100 canes were dissected and number of damaged internodes were counted. The data are presented in Table 19. As revealed from the incidence of borer varied from 8% to 50% and percentage of internode damaged in the infested canes varied from 10.7% to 26.7% and the mean incidence of *C. auricilius* was 16.1 per cent, mean number of internode damaged canes was 19.7%.

1.3.2.7. Studies of indigenous parasitoids of sugarcane borers, their seasonal availability and parasitism in nature

Studies were carried out to survey the indigenous parasitoids of sugarcane borers, viz. *Chilo infuscatellus*, *Chilo auricilius* *Acigona steniellus* and *Scirpophaga excerptalis*. The seasonal availability and parasitism in nature by different parasitoids were also recorded. The life stages of the borers were collected from the fields and reared in the laboratory till the emergence of

Table 19. Incidence of Chilo auricilius in nature

Farmer's name	Village	*Cane damaged (%)	Internode damaged (in damaged canes(%))
Sh. Pal Singh	Salem pur	12	15.6(12)
Sh. Nanbir Singh	Mukand pur	10	16.9(10)
Sh. Pritam Singh	Jadla	12	21.9(12)
Kesar Singh	Balthan	20	15.7(20)
Sh. Moti Ram	Padi sura Singh	10	10.7(10)
Sh. Naginder Singh	Jadli	18	18.2(18)
Sh. Asa Singh	Sadhu	8	15.8(8)
Sh. Choor Singh	Garcha	50	21.3(50)
Sh. Piara Singh	Jadla	8	25.0(8)
Sh. Magar Singh	Salem pur	18	20.7(18)
Sh. Tota Singh	Jadli	9	21.2(9)
Sh. Madan Lal	Garcha	18	26.7(18)
Mean		16.1	19.7

- Sugarcane variety examined .. Coj 64
* Based on 20 canes
No. of damaged canes examined given in parenthese

parasitoid/host range stage. The parasitoid emerged were identified and their parasitism recorded. The data are presented in tables 8,9, & 10. In case of Chilo infuscatellus, 567 larvae, 5 pupae and 18 egg clusters were collected and reared during April to June, 1993 but no parasitoid was recovered from any immature stage of this borer.

In the case of Chilo auricilius, 1203 larvae and 122 pupae were collected and reared in the laboratory from September, 1993 to February, 1994 (Fig.11). Only one pupal parasitoid was recovered once but it escaped and it was not possible to identify. Four species of larval parasitoids, viz. Cotesia flavipes, Glyptomorpha nicevillei, Campyloneurus mutator and a tachinid (? Sturmiopsis inferens) were recovered and their parasitism varied from 2.6-7.7%, 0.3%, 1.3% and 0.3-9.0% respectively. The tachnid was recorded for the first time from Punjab and its parasitism was highest during February, 1994.

In the case of Acigona steniellus, 757 larvae and 77 pupae were collected and reared in the laboratory from July, 1993 to February, 1994 (Fig. 12). Only two parasitoid species, viz. C. flavipes and G. nicevillei were recovered from larvae and their parasitism varied from 10%-14% and 2% respectively.

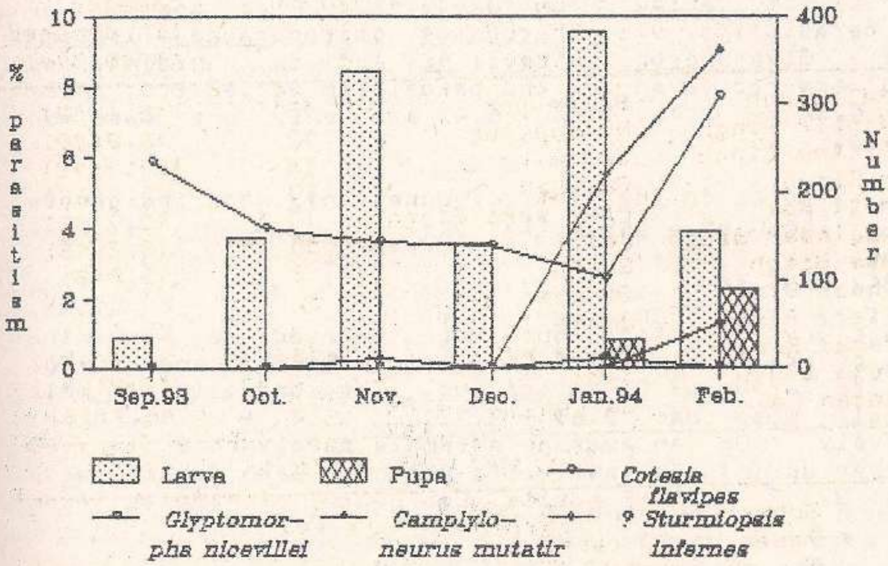


Fig. 11: Parasitoids of *Chilo auricillus*

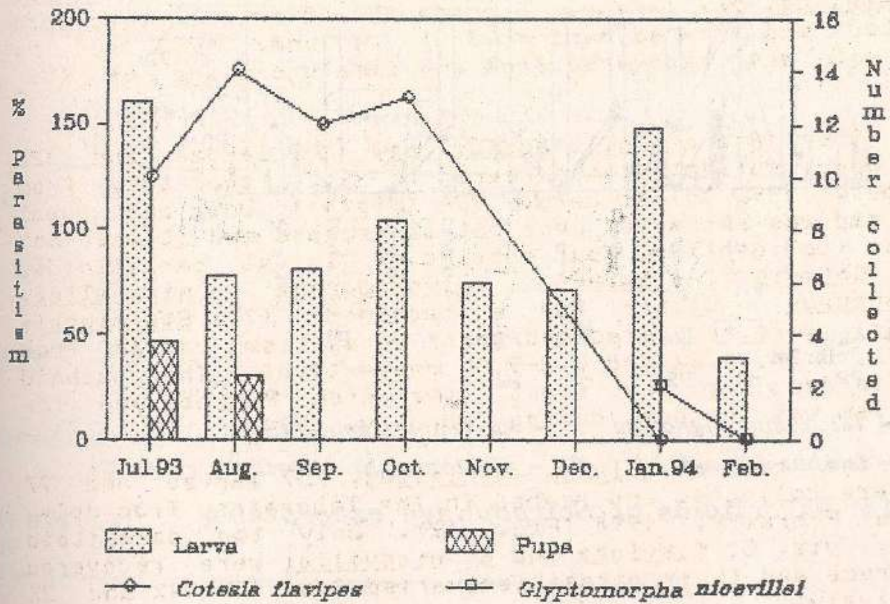


Fig. 12: Parasitoids of *Acigona steniellus*

In the case of Scirpophaga excerptalis 162 egg clusters, 637 larvae and 48 pupae were collected and reared from April, 1993 to March, 1994 (Fig. 13). Only one species of egg parasitoid, i.e. Telenomus dignoides was recorded and its parasitism varied from 10%-18.1% . Five species of larval parasitoids, viz. Rhaconotus scirpophagae, Isotima javensis, Glyptomorpha nicevillei and an unidentified tachinid were recovered and the parasitism varied from 4.8% -13.5%, 4.3% - 7.7%, 4.8% - 6.4% and only one specimen respectively.

1.3.2.8. Studies on the exotic(Indonesian) and indigenous strain of Cotesia flavipes.

Laboratory studies

Laboratory investigations were carried out on the biology of exotic strain of C. flavipes 21-25°C and 50-70% R.H. on the larvae of C. auricilius. The longevity of male and female wasp was 8.69 ± 3.32 and 5.4 ± 2.25 days, respectively. On an average a female paralysed 2 ± 1.43 host larvae during its total life period. Each female wasp produces 37.17 ± 27.85 adults. Emergence of adults from

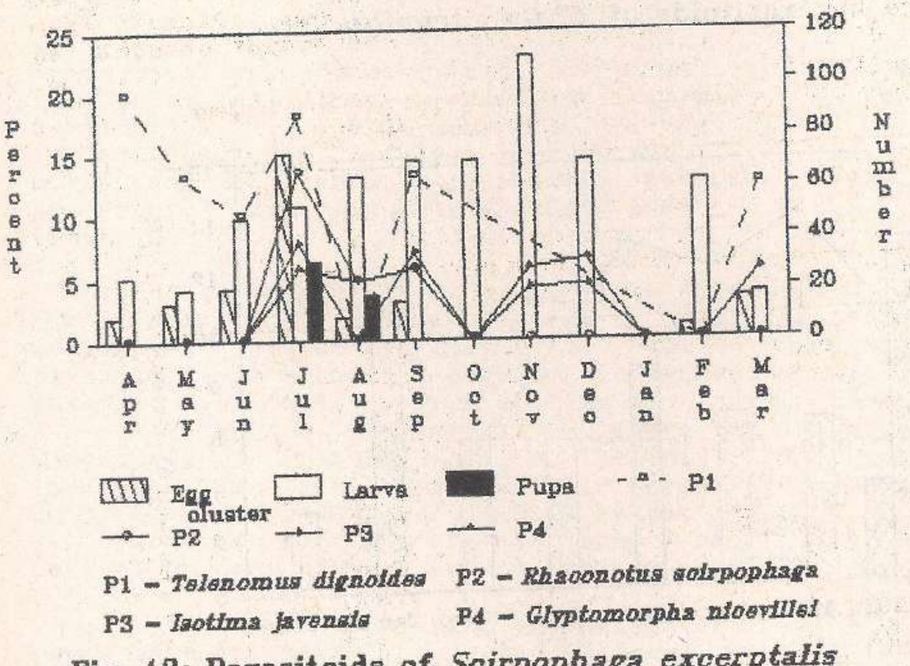


Fig. 13: Parasitoids of *Scirpophaga excerptalis*

cocoons was 94.89 per cent. Sex ratio of the emerging progeny was 1: 0.33 (Male : Female) in single pair experiments. However, in group rearing, when 10 males and 10 females were released for parasitisation the sex ratio in the progeny improved (1:0.85 - Male:Female). The group rearing ensured proper mating and also resulted in desired sex ratio. Mean production of wasps from each parasitised larvae of stalk borer was 21.85.

Field studies

a) A field trial was conducted on field releases of *C. flavipes* (Indonesian strain) from July to November in RBD with three treatments i.e @ 400, 800, 1200 adults/ha and a check with five replications against stalk borer and internode borer in crop planted with CoLK 8102. The observations on the infestation of stalk borer and internode borer were recorded in August and November, 1993 and February, 1994 (at harvest). The infestation of stalk borer and internode borer ranged from 38.96 to 47.79 and 32.04 to 44.87 per cent, respectively in February. Per cent parasitisation of stalk borer larvae in different plots ranged from 8.60 to 31.31 (Table 20). The data on borer infestation were statistically analysed and were found non-significant. The mean parasitisation of stalk borer larvae in different plots was 19.45 percent. It is evident from the above results that the release of wasp brought an

Table 20. Effect of *Cotesia flavipes* on stalk and internode borer incidence, parasitisation of stalk borer larvae and cane yield (t/h)

Treatment	Incidence of stalk borer (%)		Incidence of internodal borer		Percent parasitisation of stalk borer larvae by *C.flavipes*	No.of millable cane/h	Yield (ha)
	Stalk basis	Internode basis	Stalk basis	Internode basis			
@ 400	42.45 (40.62)	4.71 (12.47)	35.13 (36.26)	2.85 (7.69)	18.43	95.7	64.4
@ 800	38.96 (38.09)	3.91 (11.17)	44.87 (41.91)	3.65 (9.81)	8.60	110.8	77.4
@ 1200	45.38 (42,31)	4.51 (12.14)	40.81 (39.54)	3.02 (9.81)	31.31	93.9	75.2
Control	47.79 (43.72)	4.72 (12.51)	32.04 (34.36)	2.21 (8.48)	25.55	87.9	81.7
CD at 5%	NS	NS	NS	NS	18.48		
SE	2.42	0.73	3.37	0.09	5.99		

overall increase in the parasitisation of the larvae but because of the great mobility of wasp from one plot to another the differences are not discernible.

b) A block trial was conducted in an acre of ratoon crop of CoLK 8001 at IISR farm. Cotesia flavipes adults @ 650/ha were released at fifteen days intervals in 1/2 acre from August to November, 93. Percent stalk borer and internode borer infestation was recorded from the released and unreleased area in September, October and January. The progressive incidence and intensity values of stalk and internode borer are presented in Fig. 1 and 2 respectively. As is evident in Fig. 1 and 2 the progress of infestation of stalk and internode borer was at low pace in the Cotesia released plot as compared to control plot.

At harvest, stalk borer incidence and intensity in the parasitiod released plot was 29.4 and 2.9 percent, respectively as compared to 34.4 and 4.3 percent, respectively in the control plots. Similarly the internode borer incidence and intensity in the released plot was 41.0 and 3.6 percent respectively as compared to 57.3 and 4.4 percent in the control plot. The data was subjected to 't' test. Internode borer incidence and intensity in the released plot were significantly lower as compared to control plot (Table 21).

Table 21. Efficacy of Cotesia flavipes against sugarcane stalk and internode borer

Treatment	Percent stalk borer infestation		Percent internode borer infestation	
	Stalk basis	Internode basis	Stalk basis	Internode basis
Released	29.4	2.9	41.0	3.6
Control	34.4	4.3	57.3	4.4
't'	NS	NS	Significant at 5%	Significant at 5%

1.3.2.9. Top borer, Scirpophaga excerptalis

At Sardar Nagar, the top borer incidence in different broods ranged from 2.3 to 18.4 percent (Table 22).

Of the different varieties grown in the area Co 1148 and CoLk 8001 recorded highest incidence in all the broods as against lowest incidence in CoS 8315 (Table 23).

Table 22. Percent incidence of top borer and parasitisation by different natural enemies at Sardar Nagar in 1992-93

Brood	Total parasitisation in brood	Parasitised by a	b	c	d	e	f
1st	7.34%	3.8	2.53	1.00	-	-	-
2nd	4.56%	1.4	3.15	0.5	-	-	-
3rd	11.8	0.4	7.00	2.37	0.44	1.63	0.22
4th	18.41	-	9.2	2.36	2.51	4.30	-
5th	2.3	-	1.3	-	-	1.0	-

a : *Temelucha* sp.; b : *Isotima javensis*; c : *Stenobracon* sp.
d : *Elasmus* sp.; e : *Rhaconotus* sp.; f : *Spathius* sp.

Table 23 Infestation of *S. excerptalis* in different varieties of sugarcane in different broods during 1993-94

Variety	Per cent incidence of top borer (No.brood) 1st	2nd	3rd	4th	5th
CoLK 8001	14.9	11.32	13.00	21.2	18.6
Co 1148	11.1	12.42	13.00	22.8	20.0
BO 91	11.0	9.2	10.6	12.00	14.46
CoS 8403	5.4	9.1	11.00	9.7	5.3
CoS 8315	6.16	7.6	7.2	7.0	5.0

Parasitization by *Isotima javensis* predominated the parasitisation in 4th brood (9.2 percent) while the parasitisation by other natural enemies were a at low key. An attempt was also made to breed *Elasmus* sp. under the laboratory conditions for its field release against the top borer in the area. A total of 2,850 males and 4,500 females released in the earmarked field resulted in increased parasitization to an extent of 4.4 per cent against 2.5 per cent parasitization observed in nature.

The top borer at Shakar Nagar was negligible. Egg parasitisation by *Telenomus* sp. was recorded to an extent of 14.19 percent.

1.3.2.10. Seasonal occurrence on internode borer at Coimbatore

Seasonal occurrence of internode borer parasitoids was monitored from April '93 to March '94 by sampling the borer larvae at fortnightly intervals (Fig. 14.) C. flavipes was the only parasite recovered from the borer. The parasitoid activity was greater in January-February '94 than in the remaining months.

1.3.1.11. Survey of natural enemies of internode borer in factory areas

Natural enemies of internode borer were surveyed in the five sugar factory areas of Tamil Nadu at harvest time (Table 24).

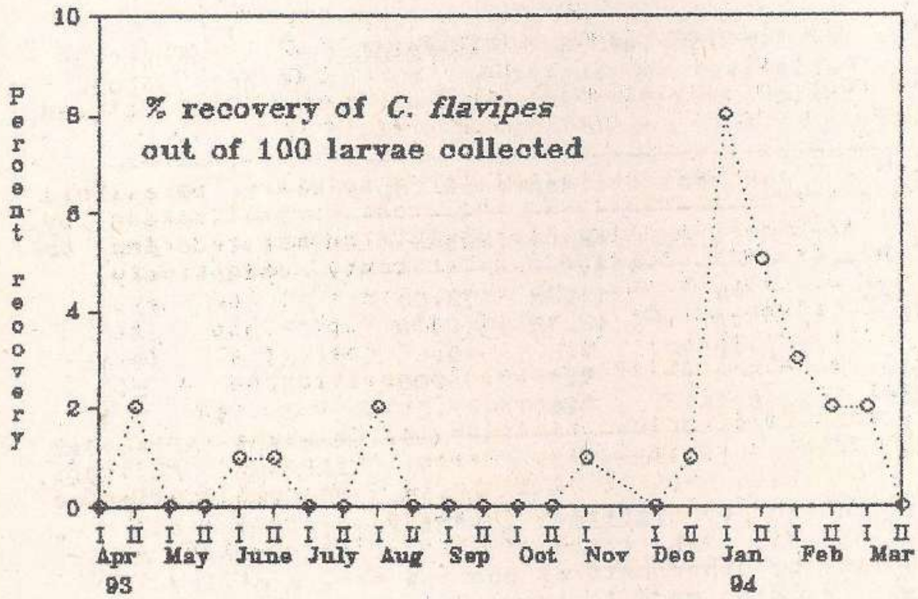


Fig. 14: Seasonal occurence of *Cotesia flavipes* on internode borer at Coimbatore

In the sugar factory areas too, *C. flavipes* alone was observed to be active. The highest incidence of the parasitoid (3.2%) was seen in Arignar Anna Sugar Mills whereas there was no activity of the parasitoid in Salem Co-op. Sugar Mills Ltd.

1.3.2.12. Field evaluation against internode borer

In a field trial conducted to evaluate the efficacy of indigenous and Indonesian populations of the parasitoid, weekly releases of the parasitoid were made @ 800 females/ha from August to December '93. The incidence of internode borer, which increased progressively, did not differ between release and control plots. No recovery of the parasitoid could be made (Fig. 15) even from the parasitoid released plots.

1.3.2.13. Stalk borer, *Chilo auricilius*

At Sardar Nagar, activity of stalk borer was noticed from August to harvest stage of the crop.

Presence of *Campyloneurus mutator* a solitary parasitoid is being observed regularly in the area. Parasitisation by *Cotesia flavipes* and *Campyloneurus mutator* was recorded to an extent of 2.5 per cent and 3.5 per cent, respectively.

1.3.2.14. Predators

1.3.2.14.1. Ground beetles species composition

Four species of ground beetles *viz.*, *Calosoma orientale* Hope, *Pheropsophus nigricolis* Arrow, *Planetes ruficeps* Schaum, *Scaraites* sp. affn. *mahratta* Andrews collected from sugarcane ecosystem were identified.

1.3.2.14.2. Trap catch studies

Pitfall trap catches of carabids monitored from June to December 1993, showed equal activity of beetles in cropped area and fallow land (Table 25).

1.3.2.14.3. Feeding studies

The host range of carabids caught in pitfall traps was examined in the laboratory. The beetles fed on shoot borer, internode borer, top borer, sorghum borer as well as mealy bugs, scale insect and white flies.

1.3.2.14.4. Predatory coccinellids

Preliminary studies on *Cryptolaemus montrouzieri* showed feeding on the pink mealy bug cultured on sugarcane setts. Pupae of the predators were recovered from setts on which

Table 24. Incidence of natural enemies of INB in sugar mill areas of Tamil Nadu

Sugar mill	No.of larvae collected	% parasitism	
		C. flavipes	Others
Arignar Anna Sugar Mills, Kurungulam	721	3.2	0.0
Thiru Arooran Sugars Ltd, Vadapathimangalam	757	0.4	0.0
Perambalur Sugar Mills, Eraiyur	88	1.1	0.0
Vellore Co-op. Sugar Mills Vellore	256	2.3	0.0
Salem Co-op. Sugar Mills Mohanur	108	0.0	0.0

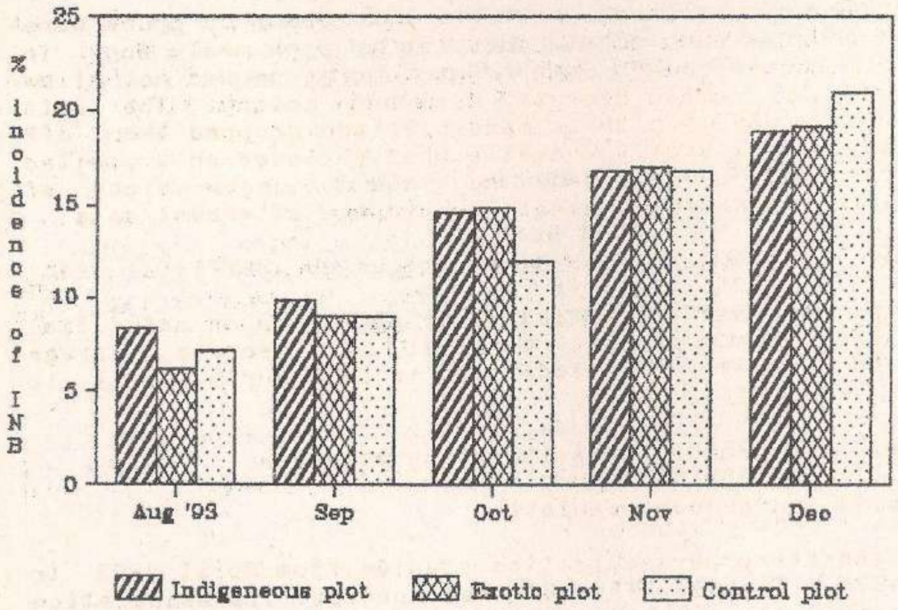


Fig. 15: Field evaluation of *Cotesia flavipes* against internode borer

Table 25. Pitfall trap catches of carabids and spiders in sugarcane ecosystem

Month (1993)	Cropped field		Fallow land	
	Carabids	Spider	Carabids	Spiders
June	7	10	9	7
July	16	12	17	15
August	11	8	11	6
September	9	19	10	9
October	10	9	7	6
November	9	11	4	5
December	7	8	5	6

[The traps also caught some spiders whose numbers too did not differ between cropped field and fallow land.]

young grubs were released. However, when grown up grubs were released on sugarcane plants infested by pink mealy bugs in microplots the attendant *Camponotus compressus* did not allow the grubs to remain near the mealybug colony. The ants lifted the grubs with their mandibles and dropped them off the plant. Adults of the beetle when enclosed on a potted plant infested by leaf mealy bugs did not show signs of feeding or oviposition probably due to the attendant ants.

1.3.2.15. Mass culture of *C. partellus* on artificial diet

During mass multiplication of *C. partellus* on artificial diet, the mean percent survival of neonate larvae inoculated on diet varied from 11.5 to 58.9 during April to February 1994 (Table 26)

1.3.2.16. Laboratory parasitization studies

1.3.2.16.1. Indigenous population

In laboratory parasitization studies from April 1993 to March 1994 (Fig.16). The highest percent parasitization observed on *Chilo partellus* was 20.6 in June '93 whereas the lowest was 4.2 in October 1993. In the three months during which it was multiplied on internode borer, the highest level of parasitization was 5.0% in the month of November 1993.

Table 26. Laboratory multiplication of C. partellus on artificial diet

Month/ Year (1993-94)	Moths released for oviposition		No.of eggs/ neonate larvae released on diet	Survival percentage
	Male	Female		
April	500	511	1475	58.9
May	456	542	1300	29.9
June	158	191	3325	15.0
July	211	242	2833	11.5
August	206	192	2316	25.7
September	236	231	3275	20.7
October	139	105	1735	12.9
November	100	81	4295	29.7
December	42	38	2062	22.1
January	452	423	9075	27.2
February	199	78	400	34.0

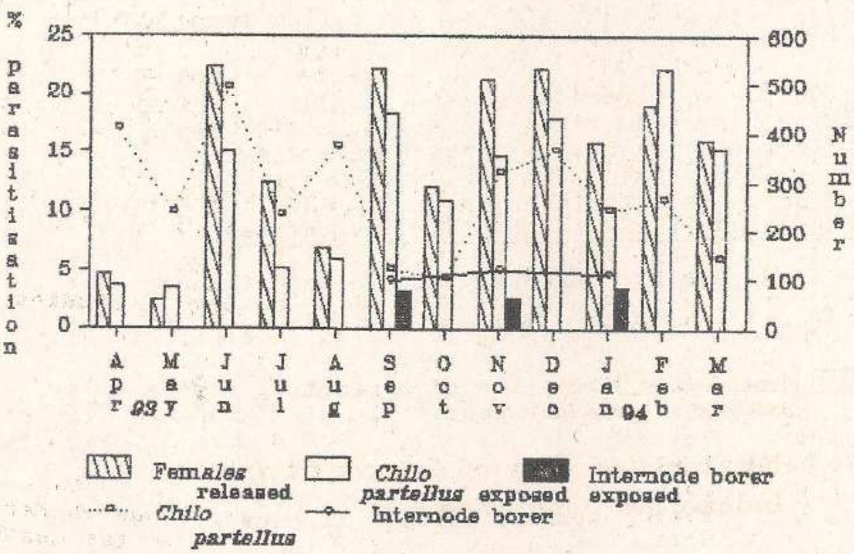


Fig. 16: Laboratory breeding of *Cotesia flavipes* (indigenous population)

1.3.2.16.2. Indonesian population

Indonesian population was maintained on laboratory reared C. partellus from April '93 to November '93. The parasitoid showed the highest level of parasitization (18.9%) in July '93 whereas the least was observed in November 1993 (Fig.17). The culture declined drastically thereafter and it could not be maintained in the laboratory.

1.3.2.16.3. Host acceptance time

When individual female of the parasitoid was allowed to parasitize single larva of C. partellus the mean time taken for oviposition by Indian population was 22.4 sec. whereas it was 15.9 sec. in Indonesian population (Table 27).

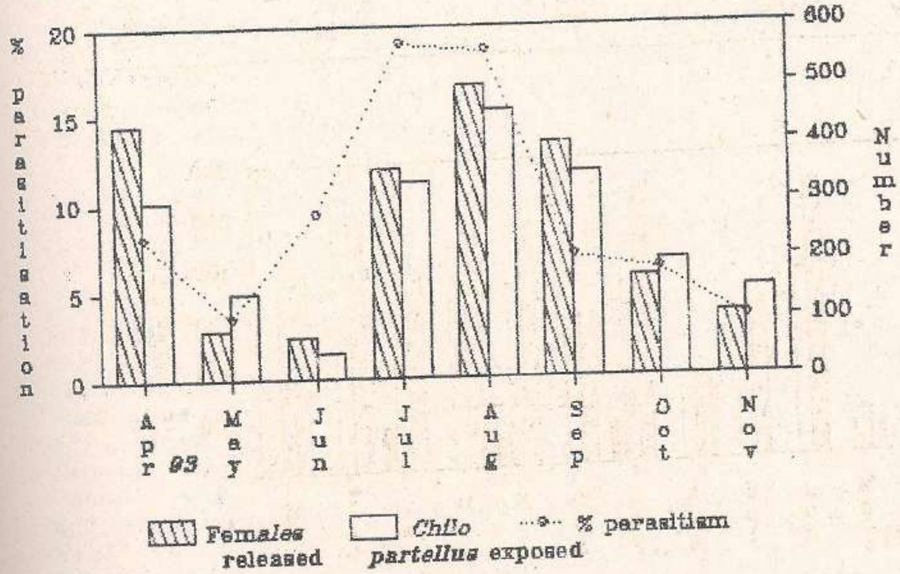


Fig. 17: Laboratory breeding of *Cotesia flavipes* (Indonesian population)

Table 27. Host acceptance time of *C. flavipes* on lab reared *C. partellus*

	Indian population	Indonesian population
n	13	26
Meantime (sec)	22.4	15.9
S.D.	32.0	34.7
Range	1.0 - 90.0	1.0 - 41.3

However, there was great variation in the host acceptance time of each population.

1.3.2.16.4. Toxicity of insecticides to adults

When nine insecticides viz., (endosulfan (0.1), malathion (0.1), quinalphos (0.05), dimethoate (0.1), monocrotophos (0.05), phosalone (0.1), deltamethrin (0.0014), cypermethrin (0.01), fenvalerate, (0.01)) were bioassayed against adults of *C. flavipes* by exposing them to residual films on leaf bits, all the insecticides proved to be highly toxic to the adults at the end of 6h exposure period

1.3.2.17. Laboratory studies on the comparative efficacy of different *Bacillus thuringiensis* formulations for the control of *Chilo auricilius*

The comparative efficacy of biopesticide *Bacillus thuringiensis* formulations, viz. Delfin, Dipel 8L and CenTari was studied for the control of *Chilo auricilius*. Two dosages (Table 28) of formulation were tried. The sugarcane setts having cavities for feeding by larvae of *C. auricilius* were dipped in spray fluid of these formulations for 6 hr. Thereafter the spray fluid was allowed to dry under laboratory conditions. There were four replications. The control was treated with tap water. On drying of spray fluid the larvae were placed singly in each cavity of the sugarcane sett. These were kept at room temperature for feeding. The mortality data was observed after 24hr, 48hr and 72 hr. The data presented in table 29 revealed that after 24 hr all the insecticides were on par with the control. After 48 hr except Centari 1.5 kg all other formulations gave higher mortality than the control. But above 70% mortality was observed in Delfin 2 kg. After 72 hrs, all treatments proved better than the control. Reasonable mortality was obtained only in Delfin and Dipel 8L. The higher dosages of both these formulations proved significantly better than the lower dosages.

Table 28. Laboratory studies on the effect of Bacillus thuringiensis formulations on the larvae of Chilo auricilius

Treatment	Dosage/ha	*Mean mortality at various intervals(%)		
		24 hr	48 hr	72 hr
Delfin	1.5 kg	5.7(13.83)	68.8(56.03)	88.4(70.08)
Delfin	2.0 kg	2.6(9.22)	88.4(70.08)	100.0(90.00)
Dipel 8L	1.5 lit.	3.8(11.25)	52.5(46.44)	87.8(69.53)
Dipel 8L	2.0 lit	5.7(13.83)	65.1(53.78)	100.0(90.00)
Centari	1.5 kg	0.0(0.00)	16.7(24.16)	47.5(43.55)
Centari	2.0 kg	0.0(0.00)	42.5(40.67)	72.9(58.61)
Control	-	0.6(4.61)	7.5(15.86)	14.6(22.50)
CD(p=0.05)		13.33	12.98	8.89

* Av. of 4 replications
Figures in parentheses are/S
Delfin = Biopesticide based on Bacillus thuringiensis Berlinin var. Kurstaki
Dipel 8L= Biopesticide based on B. thuringiensis Berlinin var.Kurstaki (14500 IU/mg)
Centari = Biopesticides based on B. thuringiensis Berlinin var. Kurstaki (15000 IU/mg)

1.3.2.18. Field evaluation of microbial insecticides against shoot borer

Four formulations of Bacillus thuringiensis viz,, Dipel, Biobit, Delfin and Centari, in comparison with GV were evaluated against shoot borer in a replicated field trial. However, no meaningful conclusions could be drawn due to the low incidence of the pest, particularly in the post-treatment period (Fig. 18)

1.3.2.19. Survey for pathogens of internode borer

Seasonal incidence at Coimbatore

Fortnightly collections of larvae at Coimbatore from April 93 to March 94 showed higher levels of virus incidence. Although virus was present throughout the year, its activity appeared to be higher from January to April (Fig. 19).

1.3.2.20. Incidence in sugar factory areas

In a survey conducted for pathogens of the borer in five sugar mill areas in Tamil Nadu, virus was predominant, exhibiting infection levels as high as 45.3% in Vellore Co-op. Sugar Mills (Table 29).

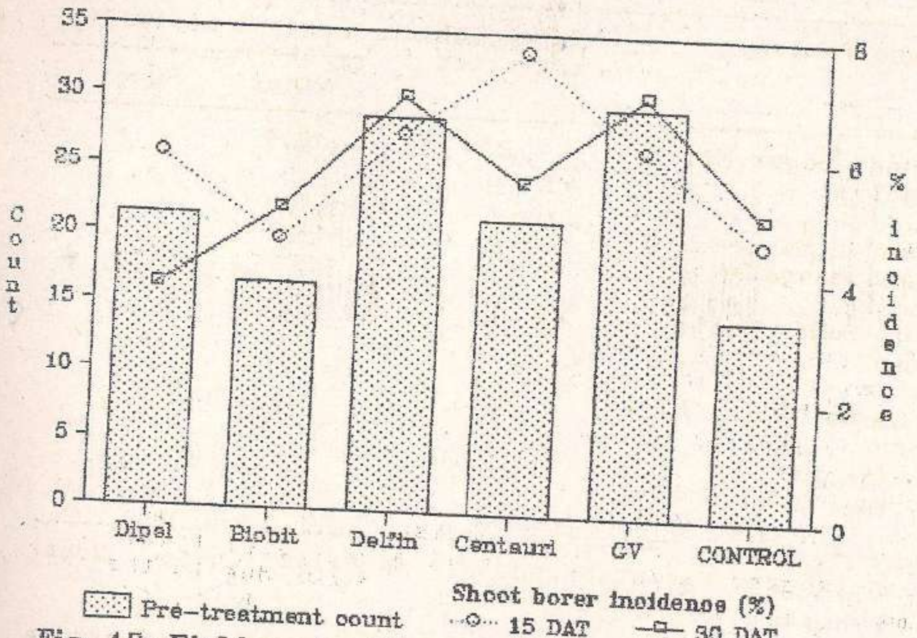


Fig. 18: Field evaluation of microbial insecticides against shoot borer

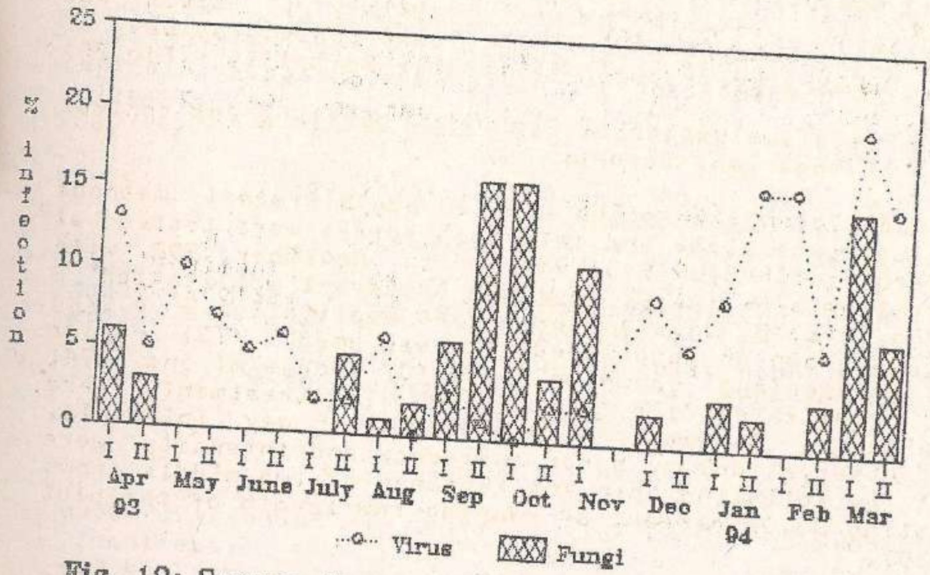


Fig. 19: Seasonal occurence of pathogens of internode borer at Coimbatore

Table 29. Incidence of pathogens of internode borer in sugar factory areas of Tamil Nadu

Name of the factory	Total larvae collected	Percent mortality	
		Virus	Fungi
Arignar Anna Sugar Mills Kurungulam	721	10.9	-
Thiru Arooren Sugars Ltd Vadapathimangalam	757	25.2	-
Perambalur Sugar Mills Eraiyur	88	11.4	-
Vellore Co-op. Sugar Mills, Vellore	256	45.3	-
Salem Co-op. Sugar Mills	108	9.3	2.8

Fungal incidence was observed only in Salem Co-op. Sugar mills.

1.3.2.21. Laboratory evaluation of Dipel against internode borer

Dipel, a commercial formulation of *B. thuringiensis*, was bioassayed against internode borer at concentration ranging from 0.003 to 0.1%. The highest mortality of 83.3% was noticed at 0.1% concentration. The lower concentrations of 0.05 and 0.75% also produced comparable mortality (Fig.20)

1.3.2.22. Field evaluation of *Beauveria bassiana* for control of sugarcane borers.

Efficacy of *B. bassiana* applied by different methods against sugarcane stalk and internode borers were tested at IISR. farm with CoLK 8102 variety in November,1992 with four treatments - (T1) *B. bassiana* broadcast application @ 2.0 kg/ha, (T2) *B. bassiana* broadcast application @ 4.0/kg (*B. bassiana* grown on autoclaved rice was used), (T3) Foliar spray of *B. bassiana* grown on PDA.@ 107 spores/ml and (T4) control, replicated five times in RBD. The treatments were taken up during September to November at 15 day intervals. Harvest observations on borer incidence and intensity were recorded by splitting open entire canes of two middle rows representing 33.0% percent of running row length of the plot (Table 30).

As evident from table 30, the borer incidence in the different treatments did not vary much. However, borers with *B. bassiana* infection in foliar spray and broadcasting @ 4.0

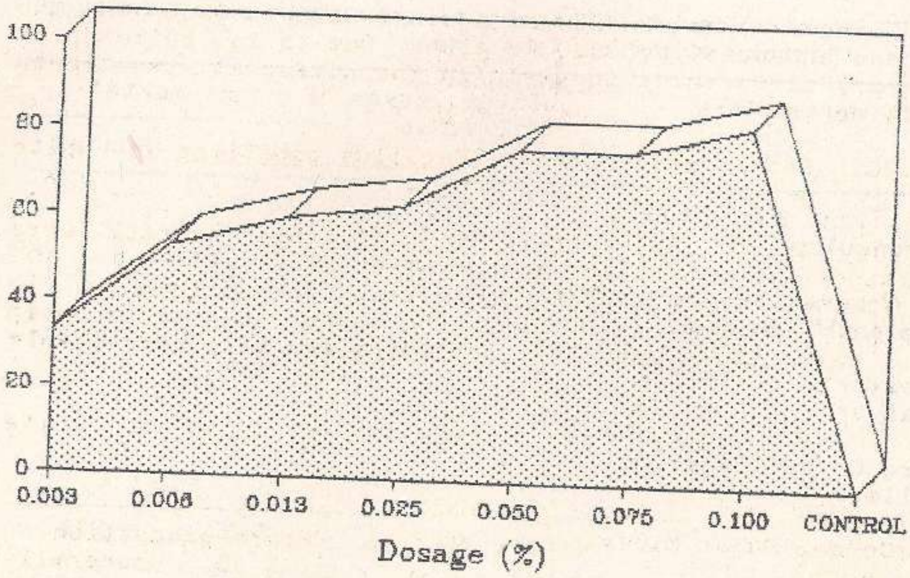


Fig. 20: Laboratory evaluation of Dipel 8L against internode borer

Table 30. Efficacy of different methods of <u>B. bassiana</u> application against sugarcane stalk and internode borer

Treatment	Stalk borer infestation		Internode borer infestation		Stalk borer incidence (%)	Cane yield (t/h)
	Incidence (%)	Intensity (%)	Incidence (%)	Intensity (%)		
<u>B. bassiana</u> Spraying @ 107 Spores/ml	43.48	4.37	29.38	1.78	43.0*	75.590
<u>B. bassiana</u> Broadcasting @ 2.0kg/ha	44.89	4.23	35.80	2.76	32.0	73.330
<u>B. bassiana</u> Broadcasting @ 4.0 kg/ha	34.48	3.81	39.11	2.77	45.0*	71.850
	49.15	4.59	39.29	2.60	22.0	72.770
'F' test	NS	NS	NS	NS		NS

* Two internode borer larvae were found infected with <u>B. bassiana</u>
NS : Not significant

kg/ha ranged from 43-45%, as against 22.0 to 32.0 in the check and broadcasting @2.0 kg ai/ha. Due to low build up of the borer, differences in yield in the different treatments was not marked.

1.3.2.23. Spores production of Bacillus popilliae in white grub

When third instar grubs of Holotrichia serrata were inoculated with a spore concentration range of 10^3 - 10^6 spores/ml, the spore production in grubs ranged from 3.1 to 5.5 x 10^{10} spores/ml. However, there was no relationship between the initial and final concentration of spores (Table 31).

Table 31. Spore production of Bacillus popilliae in white grub

Concentration inoculated	weight of grub (g)	Spore production (X 10^{10} spore/ml)
10^3	2.979	5.5
10^4	2.919	3.4
10^5	3.039	3.1
10^5	2.159	5.4
10^6	3.012	3.8

1.3.2.24. Sugarcane leaf hopper, Pyrilla perpusilla

The pyrilla infestation at Sardar Nagar was low during the year. At Shakar Nagar, pyrilla attack was noticed from July to December. The infestation was at its peak in October. Pyrilla eggs and nymphs were observed to be parasitized by Tetrastichus pyrillae and Recharsdrypus pyrillae to an extent of 73.3 and 9.6% respectively. Epiricania cocoons were not recorded in the area.

At Pravaranagar, the incidence of Pyrilla was mild. Occurrence of Epiricania was noticed in the area where the parasitoid was released earlier. The population of the parasitoid could control the Pyrilla build up in the area.

1.3.2.25. Colonization and redistribution of Epiricania melanoleuca

At Dadh Farm in Pravaranagar, build up of Epiricania melanoleuca was monitored, where the ectoparasitoid had established earlier. The activity of Epiricania melanoleuca was noticed from 2nd fortnight of July to end of October.

The population of Pyrilla being low (2-3 adults and 5 to 10 nymphs/100 clumps) redistribution of the parasitiod was not done.

In Shakarnagar area, pyrilla population was noticed at different villages, Dotpally, Kallur, Chandur, Minarpally, Khazapur, Hoponsa, Salura and Rajakura, but due to low build up of Epiricania melanoleuca elsewhere, the trial could not be taken up.

In U.P. too the population of pyrilla and its parasitoid was scarce in the field trial.

1.3.2.26. Effect of release of Epiricania melanoleuca cocoons for the control of Pyrilla perpusilla

The effect of releases of Epiricania melanoleuca cocoons was studied for the control of Pyrilla perpusilla. Two fields of sugarcane, Var. Coj 64 were selected at a distance of one Km from each other near village Moai (Distt. Jalandhar). In one of the fields cocoons of E melanoleuca @ 5000/ha were fixed under the sugarcane leaves with the help of paper pins or stapler. The cocoons were collected from different areas from sugarcane fields. The cocoons were released in the 1st week of August, 1993. The other field without release was kept as control. The observations on the population of pyrilla egg cluster, nymphs and adults per leaf were recorded from both the fields. Similarly observations on the egg cluster, cocoons, adults of E. melanoleuca and parasitized nymphs of pyrilla were also recorded from both the fields (Table 32). The observations were recorded from 5 units of 10 leaves each. The data presented in Table 33 of pyrilla was low in the parasitoid released plot compared with the control plot. However, there was also slight increase in the population of parasitoid in the cocoon release plot. It is concluded that by supplementing the population of E. melanoleuca by releasing its cocoons kept a check on the population of pyrilla.

1.3.2.27. Sugarcane scale insect, Melanaspis glomerata

The scale insect, Melanaspis glomerata infestation was not observed on sugarcane at Sardar Nagar. At Shakar Nagar, mild attack of scale insect (4.5 to 10.6 percent on stalk basis) was noticed on var. Coc 671 and Co 8014.

At Pravaranagar, observations were recorded on the incidence of scale insectin adsali and ratton crop at monthly intervals from May 1993 to March 1994 (Table 33).

Table 32. Effect of release of *Epiricania melanoleuca* cocoons to control *Pyrilla perpusilla* on sugarcane.

Treatment	Cocoon/ha released	Month of observation	**Mean population in different months						
			P. perpusilla/leaf			*E. melanoleuca*/leaf			
			E.	N	A	E	C	A	PN
Epiricania melanoleuca (Cocoons)	500	*August	1.0	2.2	0.3	0.5	0.6	0.6	0.2
		+September	0.1	2.7	0.4	0.6	0.9	0.3	0.8
Control	-	*August	0.6	6.7	0.8	0.2	0.3	0.1	0.0
		+September	1.4	14.1	2.9	1.5	2.5	0.1	0.1

** Based on 5 units of 10 leaves each
* Mean of three observations
+ Mean of two observations
E= Egg cluster, N=Nymphs, A=Adult, C=Cocoon, PN=Parasitized nymph of pyrilla

Table 33. Sugarcane scale incidence, intensity and parasitism at Pravaranagar in 1992-93

Month (1993-94)	Adsali*			Ratoon**		
	Incid-dence (%)	Inten-sity (%)	Parasi tism (%)	Inci-dence (%)	Inten-sity (%)	Parasi-tism (%)
May	Trace	Trace	Trace	Trace	Trace	Trace
June	8.60	1.48	10.34	33.03	7.51	8.13
July	59.80	13.92	12.26	53.30	10.86	11.23
August	67.68	1.80	17.33	67.27	17.26	15.24
September	85.17	25.20	20.36	76.50	24.12	19.72
October	91.34	25.98	21.58	84.30	29.89	20.06
November	95.33	35.83	18.24	92.48	30.30	17.10
December	98.63	42.43	16.29	100.00	43.00	15.12
January	100.00	43.48	14.68	100.00	51.38	14.71
February	@	@	@	100.00	61.46	11.88
March	@	@	@	100.00	59.61	13.48

*Average of two fields; **observation of one field
@ : crop harvested

In adsali crop peak of scale insect infestation was reached in January while in ratoon crop in February. The peak parasitisation was recorded in October. The major parasitoids recorded on scale insect were, *Adlencyrtus mayurai*, *A. moderatus* and *Botryodeclava bhartiya*.

1.3.2.28. Field evaluation of Fusarium subglutinans against scale insect

The fungus F. subglutinans was evaluated as stubble drench treatment against scale insect in two sugar mill areas in Tamil Nadu. The fungal suspension at 10^8 spores/ml concentration was applied as stubble drench in fields that showed severe scale incidence in the previous season. Observations of scale incidence on grown up stage of the experimental crop (Table 34) indicated no specific trend between treated and control plots. Although scale incidence was noticed, the intensity was verylow and the colonies comprised very small numbers.

Table 34. Field evaluation of Fusarium subglutinana against scale insect

Factory/site	Scale incidence (%)		Scale incidence (%)	
	Treatment	Control	Treatment	Control
(a) Tiruttaani Co-op. Sugars				
Factory farm	25.0	22.2	7.0	9.4
Farmers' field	15.0	23.5	18.8	11.8
(b) Sakthi Sugars				
Factory farm	Nil		Nil	
Farmers' field	12.1	9.1	26.4	11.1

1.3.3. BIOLOGICAL SUPPRESSION OF COTTON PESTS

Development of biocontrol based IPM for the suppression of cotton pests

1.3.3.1. TAMIL NADU AGRICULTURAL UNIVERSITY, COIMBATORE

An experiment was conducted at Alandurai in a randomized block design replicated 10 times with three treatments. An area of 1000 m^2 was chosen for each treatment and subdivided into ten sub plots (100 m^2 each) with variety MCU 5. The three treatments given were as follows

I : Treatment (as per AICRP programme)

i) Spraying of oxydemeton methyl (0.05%) 23 DAS (days after sowing)against the leafhopper, *Amrasca biguttula biguttula* Ishida and the whitefly, *Bemisia tabaci* (based on ETL upto 30 days).

ii) Release of *Chrysoperla* 30,37 and 44 DAS(2-3 days old larvae) @ 50000/ha.

iii) Release of *Trichogrramma chilonis* @ 150000/ha 51,58,65, 72,79,86,93,100 DAS.

iv) Need based application of insecticides viz., endosulfan (0.07%) 107 DAS, monocrotophos (0.04%) 121 DAS, against bollworms, HaNPV @ 500 LE/ha 128 DAS against *Helicoverpa armigera*.

v) Neem oil (0.5%) + teepol (0.5%) 135 DAS and acephate 1.30 kg/ha on 149 DAS against white fly.

II : Treatment (as per TNAU recommendation)

i) Spraying of oxydemeton methyl (0.05%) 23 DAS, against leafhopper and whitefly

ii) Need based application of insecticides against bollworms (spotted, american and pink) endosulfan 2 l/ha 37 DAS, phosalone 2.5 l/ha 51 DAS, quinalphos 2 l/ha 65 DAS, endosulfan 2 l/ha 93 DAS, phosalone 2.5 l/ha 121 DAS.

iii) Spraying of HaNPV @ 450 LE/ha 128 DAS against *H. armigera*

iv) Neem oil (0.5%) + teepol (0.5%) 135 DAS and acephate 1.30 kg / ha 149 DAS.

III: Treatment (Farmers' method)

i) Spraying of dimethoate(0.06%) 15 DAS and oxydemeton methyl (0.05%) 23 DAS against sucking pests.

ii) Spraying against bollworms

Endosulfan	2.5 lit/ha	30 DAS
Phosalone	2.0 lit/ha	44 DAS
Monocrotophos	1.5 lit/ha	58 DAS
Quinalphos	2.5 lit/ha	72 DAS
Endosulfan	2.5 lit/ha	86 DAS
Permethrin	100ml +	
Monocrotophos	1.0 lit/ha	107 DAS
Quinalphos	2.5 lit/ha	121 DAS

iii) Spraying against whitefly

Neem oil (0.5%) + Teepol (0.5%) + Quinalphos 1 lit/ha 135 DAS.
Acephate @ 1.30 kg/ha 149 DAS

Leafhopper and whitefly on three leaves per plant selected at random from lower, middle and upper region of the canopy were recorded at weekly intervals and the results showed that in case of leafhoppers one round of spraying with oxydemeton methyl (0.05%) as per AICRP and TNAU recommendation 23 DAS was on par with two rounds of sprays with dimethoate (0.06%) 15 DAS and of oxydemeton methyl (0.05%) 23 DAS by farmers method. Early stage occurrence of whitefly was controlled with single spray of oxydemeton methyl (0.05%) under set I and II treatments and two sprays of dimethoate (0.06%) and oxydemeton methyl (0.05%)under set III treatment.

Late stage reoccurrence of whitefly as induced by the farmer following the application of permethrin + monocrotophos 107 DAS was controlled by neem oil (0.5%) + Teepol (0.5%) spray 135 DAS and acephate 1.30 kg/ha 149 DAS under set I and set II treatment while the farmer could control the pest with neem oil (0.5%) + Teepol (0.5%) + quinalphos 1 lit/ha 135 DAS and with acephate twice 142 and 149 DAS.

Release of Chrysoperla @ 50000/ha thrice was able to reduce the whitefly population considerably when compared to set II and set III with insecticides.

The number of healthy and damaged squares / bolls due to bollworms from five tagged plants per replication at weekly intervals were recorded and percentage of damage was worked out.

Yield data were recorded from each sub plot in different harvest, pooled and analyzed statistically. Yield data were commuted per hectare. All the data were subjected to DMRT.

Bollworms: Release of *T. chilonis* @ 150000/ha at weekly intervals 8 times from 51 DAS followed by need based application of endosulfan 0.07% 107 DAS and monocrotophos 0.04% 121 DAS and one round of HaNPV @ 500 LE/ha was on par with TNAU recommendation in reducing the bollworm damage on cotton. These two sets of treatments were superior to farmers method of spraying insecticides (7 rounds) in controlling the incidence of bollworms.

Spraying with a combination of permethrin and monocrotophos induced the resurgence of whitefly.

Yield: Among the sets of treatments, AICRP (Set I) was superior to set II (TNAU recommendation) and set III (farmers' method) in recording higher yield (2000 kg/ha), while the set II and set III recorded a yield of 1850 and 1475 kg/ha respectively (Table 35).

Table 35. Data on the incidence of pests and yield of cotton

Treatment No.	Mean leafhoppers (DAS)						Mean population of whitefly (DAS)					
	23BT	30	37	44	51	58	23BT	30	37	44	51	58
I	0.50	0.13[a]	0.16[a]	1.32[c]	0.41[a]	1.41[a]	0.83	0.12[a]	0.16[a]	0.45[a]	0.45[a]	0.21[a]
II	0.41	0.13[a]	0.43[a]	0.85[a]	0.40[a]	1.20[a]	0.65	0.32[b]	0.43[a]	0.23[a]	0.79[b]	0.55[b]
III	0.21	0.34[b]	0.64[a]	1.00[b]	0.63[b]	0.99[a]	0.56	0.52[c]	0.64[a]	0.45[a]	0.97[b]	0.79[c]

* Mean of 10 replications BT : Before treatment DAT : Date after sowing

Treatment	Bollworms damage* (%) DAS							Yield	
No.	65(BT)	79	93	107	121	135	149	(kg/100m^2)	per ha
I	4.2	(9.63)	(8.91)	(20.18)	(13.05)	(15.89)	(15.89)	20.00[a]	2000[a]
II	12.5	7.7[b] (16.11)	4.2[a] (11.83)	7.5[a] (15.89)	6.7[ab] (15.00)	11.2[a] (19.55)	15.0[b] (22.79)	18.50[b]	1850[b]
III	19.9	5.8[b] (13.94)	19.7[b] (26.35)	27.9[c] (31.88)	10.5[b] (18.91)	15.0[b] (22.79)	28.6[c] (32.33)	14.75[c]	1475[c]

Figures in parentheses are arcsin transformed values. BT : Before treatment

1.3.3.2. PUNJAB AGRICULTURAL UNIVERSITY, LUDHIANA

In Punjab, State Department of Agriculture and Department of Entomology, Punjab Agricultural University, Ludhiana jointly carried out research cum demonstration trials on IPM in cotton during 1993, at three locations, viz.,Jawaharke (Mansa), Sandhwan (Kotkapura) and Barriwala (Faridkot District). In these experiments the following were the four treatments.

(i) Release of bioagents - (Trichogramma + Chrysoperla),
(ii) PAU recommended spray schedule,
(iii) Farmers' spray schedule and
(iv) Control (untreated check)

The plot size in the case of control was 2000 sq ft. where as in the remaining three treatments it was 6,000 sq ft. each. The insecticidal sprays both of the recommended spray schedule and the farmers' spray schedule were given at 10 day intervals during the effective boll formation period. The number of sprays against bollworms at Sandhwan were 6 and 9, at Jawaharke 7 and 5, and at Barriwala 9 and 9 in case of recommended spray schedule and the farmers spray schedule respectively. In addition, one insecticidal spray was made in all the treatments expect untreated check against sucking pests at all the places.

In the bioagent treatments, Trichogramma chilonis @ 60,000 per 0.2h was released at 10 day intervals during the effective boll formation period. There were six such releases at Sandhwan and Barriwala and only five releases were made at Jawaharke (Mansa). In addition, the predator Chrysoperla carnea was also released once during the first half of August, 1993 @40,000/0.4h at Jawaharke and Sandhwan and no release of predator could be made at Barriwala. The freshly shed fruiting bodies in different treatments were examined twice a week in between the two insecticidal applications for determining the bollworm incidence. The population of naturally occurring biocontrol agents were also recorded regularly in all the treatments at the three locations. The incidence of bollworms was recorded both on the boll and loculi basis. The yield of seed cotton was recorded on whole plot basis. The data was subjected to statistical analysis.

The observations on naturally occurring biocontrol agents showed that the population of different biocontrol agents, both predators and parasitoids was observed to be extremely low in the insecticidal treatment at all the places throughout the cropping season. The birds were observed to be the main predators of Helicoverpa larvae. The population of Chrysoperla increased near the maturity phase of the crop at Jawaharke (Mansa) especially in the bioagent treatment and untreated check. The coccinellid predators were also observed only near the maturity phase of the crop.

Bollworm incidence showed a similar trend in various treatments at Jawaharke (Mansa) and Barriwala (Faridkot). The recommended spray schedule and farmers spray schedule were at par with the bioagent. In the three treatments, bioagents, recommended spray schedule and the farmers spray schedule, the incidence of bollworms both on boll and loculi basis was significantly less as compared with the untreated check (Table 36).

Table 36. Bollworm incidence in different treatments at Jawaharke

Treatment	Bolls attacked				Loculi
	ABW	SBW	PBW	TOTAL	attacked(%)
1.Bioagents* (*Trichogramma chilonis* + *Chrysoperla carnea*	19.4^a	20.0^a	25.3^a	64.6^a	19.1^a
2.PAU spray	21.0^a	16.2^a	16.9^a	54.1^a	14.3^a
3.Farmers' spray schedule	28.4^a	14.9^a	24.0^a	67.4^a	17.8^a
4. Control	25.4^a	33.8^a	46.0^b	82.1^b	37.4^b

* Bioagents + 5 sprays

ABW : American bollworm; SBW : Spotted bollworm;
PBW : Pink bollworm

Dates of spray and dosages

1.	14-08-1993	Monocrotophos	: 1.500l
	18-08-1993	-do-	-do-
	26-08-1993	Fenvalerate	: 0.250l
	23-09-1993	Fenitrothion	: 1.125l
	26-09-1993	Acephate	: 2.000kg
2.	08-08-1993	Endosulfan	: 2.500l
	18-08-1993	Monocrotophos	: 1.500l
	26-08-1993	Deltamethrin	: 0.400l
	04-09-1993	Fenitrothion	: 2.125l
	15-09-1993	Fenvalerate	: 0.250l
	22-09-1993	Acephate	: 2.000kg
	26-09-1993	-do-	: -do-

Dates of spray and dosages

3.	08-08-1993	Monocrotophos	: 1.500l
	18-08-1993	Endosulfan	: 2.500l
	28-08-1993	Fenvalerate	: 0.500l
	15-09-1993	Quinalphos + Cypermethrin	: 1.500l : 0.315l
	29-09-1993	Endosulfan + Quinalphos	: 2.500l : 2.000l

A similar situation with respect to the bollworm incidence was observed at Barriwala (Table 37).

Table 37. Bollworm incidence in different treatments at Barriwala in American cotton (var.F 1054)

Treatment	Boll attacked (%) ABW	SBW	PBW	Total	Loculi attacked (%)	Seed cotton yield (kg/ 0.4ha)
Bioagent (*Trichogramma* + 5 sprays)	2.47[a]	7.80[ab]	9.93[a]	20.03[a]	5.14[a]	638
PAU spray schedule	3.80[a]	4.76[b]	13.43[a]	22.06[a]	5.53[a]	652
Farmers spray schedule	5.50[a]	2.03[a]	10.16[a]	17.73[a]	5.41[a]	634
control	4.47[a]	14.07[c]	43.93[b]	62.53[b]	26.26[b]	468

ABW : American bollworm; SBW : Spotted bollworm and PBW : Pink bollworm

Date and dosages of spray/h

1.	27-07-1993	Oxydemeton methyl	: 0.750l
	02-08-1993	Endosulfan	: 2.500l
	13-08-1993	Monocrotophos	: 1.500l
	24-08-1993	Folithion	: 2.125l
	02-09-1993	Fenvalerate	: 0.312l

Dates of spray and dosages

2.	27-07-1993	Oxydemeton methyl	: 0.750l
	02-08-1993	Endosulfan	: 2.500l
	13-08-1993	Monocrotophos	: 1.500l
	24-08-1993	Folithion	: 2.125l
	02-09-1993	Fenvalerate	: 0.312l
	10-09-1993	Quinalphos	: 2.000l
	14-09-1993	-do-	: -do-
	27-09-1993	Cypermethrin	: 0.315l
	09-10-1993	Carbaryl	: 2.500kg
3.	27-07-1993	Oxydemeton methyl	: 0.750l
	02-08-1993	Monocrotophos	: 1.500l
	13-08-1993 :	Same as 2	
	To :		
	09-10-1993 :		

The trend in the bollworm incidence once however was observed to be different at Sandhwan both on boll and loculi basis. The incidence of bollworms was significantly less in the recommended spray schedule and the farmers spray schedule as compared with that in the bioagent plot and the untreated check. The bollworm incidence as observed in the bioagent plot was significantly lower than was observed in the untreated check. The variety at Sandhwan was not the one recommended in the package of practices but it was a mixture, predominantly Jhurar.

The difference in the incidence of bollworms in the three treatments at different places could be attributed to the differences in the varieties of cotton. The incidence of different species of bollworms among the freshly shed fruiting bodies could only be recorded and compared for Sandhwan and Jawaharke (Table 38).

The incidence of various bollworm species among the shed fruiting bodies was comparatively low in the bioagent and their recommended spray schedule treatment at Sandhwan. The minimum incidence of *Helicoverpa* was observed in the recommended spray schedule at Jawaharke (Mansa). The overall results of observations at the three locations suggested that the bollworm incidence at Jawaharke (Mansa) and Barriwala in the bioagent treatments was comparable with that observed in case of insecticidal treatments even during the year of heavy bollworm infestation. At Sandhwan, even the bioagent treatments proved significantly better than the untreated check in reducing the bollworm incidence .

Table 38. Bollworm incidence among the freshly shed fruiting bodies in different treatments at Sandhwan and Mansa

Treatment	*Incidence (%)			
	PBW (Sandhwan)	SBW (Sandhwan)	*Heliothis*** (Sandhwan)	(Mansa)
Bioagents (*Trichogramma* + *Chrysoperla carnea*) + 2 sprays	1.41	10.82	13.59	19.43
PAU spray schedule	1.06	9.65	12.18	13.63
Farmer's	2.23	14.53	22.06	27.34
Control	2.00	15.59	19.48	17.65

PBW : Pink bollworm; SPW : Spotted bollworm
* Mean of 17 observations from 20-08-1993 to 23-10-1993
** Mean of 11 observations from 21-08-1993 to 29-09-1993

Date of spray and dosage of insecticide/h

1.27-07-1993	Oxydemeton methyl	0.7501
10-08-1993	Endosulfan	2.5001
2.27-07-1993	Endosulfan	2.5001
28-08-1993	Fenvalerate	0.2501
06-09-1993	Quinalphos	2.0001
16-09-1993	Cypermethrin	0.2001
27-09-1993	Formothion	2.0001
08-10-1993	Deltamethrin	0.4001
3.27-07-1993	Oxydemeton methyl	0.7501
10-08-1993	Monocrotophos	1.5001
14-08-1993	-do-	-do-
26-08-1993	Fenvalerate	0.5001
06-09-1993	Cypermethrin	0.2001
16-09-1993	Quinalphos	2.0001
27-09-1993	Cypermethrin	0.2001
08-10-1993	Deltamethrin	0.4001
08-11-1993	Acephate	2.0001

Seed-cotton yield

The yield of seed cotton obtained at Jawaharke (Table 39) showed a similar trend in the treatments of bioagent and the farmers spray schedule. The recommended spray schedule had an edge over other treatments in yield of seed cotton and the minimum yield was recorded in the untreated check. The yield of seed cotton at Jawaharke (Mansa) was relatively more in the bioagent plot followed by the recommended spray schedule and the untreated check. Very poor yield was obtained in case of farmers spray schedule at this location (Table 39).

Table 39. Seed cotton yield obtained in different treatments at Jawaharke (Mansa) (var.F 846)

Treatment	No. of sprays	No. of natural enemy releases	Seed cotton yield (per kg 7200 yard)
Bioagents	5	5	526
PAU spray schedule	6	–	517
Farmers spray schedule	5	–	441
Control	0	–	511

The yield of seed cotton obtained at Sandhwan (table 40) was comparatively more in the recommended spray schedule

Table 40. Seed cotton yield obtained in different treatments at Sandhwan

Treatment	No.of sprays	No.of natural enemy releases	Total cost/ 0.4h (Rs.)	No.of plants/ 0.4h	Seed cotton (kg/ 0.4h)	Seed cotton (kg/ 0.4h)
Bioagents	1 + 1	7	386+*	9738	402	402
PAU spray schedule	1 + 6	–	891	8805	569	630
Farmer's spray schedule	1 + 7	–	1,408	8980	439	476
Control	1 + 0	–	66	8804	400	442

* Cost towards the natural enemies

followed by the farmer's spray schedule. The seed cotton yield in the bioagent plot was even lower than that recorded in the untreated check. The low yield in the bioagent plot at Sandhwan could be owing to the shade effect of the tree line growing along the bank of a canal in the southern side of the field. The observations relating to the incidence of bollworms indicate that the releases of *Trichogramma* could lead to a reduced level of the pest possibly by combining the insecticidal spray with releases of biocontrol agents. There is a need to carry out further studies at least for 2-3 seasons more to derive tangible conclusions.

1.3.3.3. ANDHRA PRADESH AGRICULTURAL UNIVERSITY, HYDERABAD

A field trial with cotton var. Lam Hybrid-1 was taken up in an area of 4000 m2 at RARS, Lam (Guntur). There were two treatments viz, integrated management plot and conventional method of control (Farmer's practice).

In integrated management plot, the cotton crop was grown with groundnut as an intercrop in a plot where crop rotation was followed. The cotton seed was treated with carbofuran @ 20 g/kg seed before sowing and 25 days after sowing granular insecticide (Carbofuran 30) @ 1 kg/ha was applied in order to avoid external sprays and to conserve natural enemies. Pheromone traps for *Heliothis* were installed @ 10 /ha in the field to monitor the pest. Inundative release of *Trichogramma chilonis* and *Chrysoperla carnea* @ 50, 000 each were carried out twice during the egg and early larval stage of the pest. The subsequent treatments of spray application of neem seed kernel extract (NSKE) @ 1.5%, Ha NPV @ 450 LE/ha *B.t.* (Dipel) were given at 7 to 10 days interval. During the later part, spray applications of conventional insecticides viz., monocrotophos, endosulfan, fenvalerate and acephate were given at 7 to 10 days interval in IPM plot.

In the farmers' practice plot (chemical intensive management), the following spray applications viz., monocrotophos, acephate, endosulfan, chlorpyriphos, fenvalerate, phosphamidon, quinalphos , neem oil, nimbicidine, neem + Delfin, cypermethrin were given two to three times as indicated in the table 41.

The data on the incidence of *Heliothis* in terms of adults, eggs and larvae were recorded at weekly intervals on 20 plants in each plot in the fixed five blocks. Four tagged plants from each block were used for collecting the data. For counting the eggs, top canopy leaves, squares, flowers were closely observed. The population of sucking pests viz., Jassids and whiteflies was recorded on three leaves/ plant selected at random from lower, middle and upper region of the plant.

Table 41. Evaluation of IPM technology of cotton

Particulars (1)		IPM (2)	Farmers method (3)
I. Sucking pests			
	Jassids (No./leaf)	0.90	0.82
	Whiteflies (No./leaf)	1.50	3.65
II. Boll worms			
	<u>Heliothis</u> eggs (No./plant)	1.27	0.90
	Larvae (No./plant)	0.92	0.10
III. Damage(%)			
	Squares	10.445	1.61
	Bolls	4.14	1.42
IV. Natural enemies			
	Coccinellids, spiders and syrphids etc. (No./plant)	0.82	0.00
	<u>Trichogramma chilonis</u> (% parasitisation)	11.11	0.00
V. Yield (Q/ha)	Kapas	17.6	36.02
	Groundnut	5.3	
VI. Cost benefit ratio		1:627	1:346

<u>Inputs</u>	<u>Rs.</u>	<u>Inputs</u>	<u>Rs.</u>
Seed dressing	50	1. Monocrotophos 1 L/ha	365
Soil insecticide	1,320	2. -do-	365
NSKE @ 1.5%	400	3. Acephate 5 kg/ha	305
Release of <u>Trichogramma</u> @50,000 /ha	100	4. Monocrotophos 1.25 L/ha	456
		5. Endosulfan 1.5 L/ha	237
		6. -do-	237
Ha NPV	300	7. Chlorpyriphos 1.5 L/ha	360
<u>B.t.</u> (Dipel)	500	8. -do- 1.875 L/ha	450
Conventional insecticides (4times)	2,000	9. Fenvalerate 1 L/ha	276
		10. Chlorpyriphos 1.875 L/ha	450
		11. Phosphamidon 0.75 L/ha	225
Labour cost	380	12. Quinalphos + Blitox (2.5 L/ha) (0.75 kg/ha)	788

Total	5,050	13. Chlorpyriphos (2.5 L/ha)	600

(1)		(2)	(3)
		14. Neem oil (2.5 L/ha)	250
		15. Endosulfan (2.5 L/ha)	395
		16. Chlorpyriphos 2.5 L/ha	600
		17. Endosulfan + sesame oil (2.5 L/ha + 2.5 L/ha)	495
		18. Endosulfan 2.5 L/ha	395
		19. Fenvalerate+Dithane M 45 (1.0 L/ha + 0.75 kg/ha)	411
		20. Nimbicidine+ Blitox (2.5 L/ha + 1.25 kg/ha	438
		21. Neem oil + Delfin (2.5 L/ha + 0.5 kg/ha)	750
		22. Endosulfan + Dithane M 45 (2.5 L/ha + 0.25 kg/ha)	671
		23. Endosulfan 2.5 L/ha	395
		24. Nimbicidine 2.5 L/ha	250
		25. Fenvalerate 1.25 L/ha	345
		26. Chlorpyriphos 2.5 L/ha	600
		27. Acephate 1 kg/ha	610
		28. Chlorpyriphos 2.5 L/ha	600
		29. Cypermethrin 1 L/ha	400
		30. Chlorpyriphos 2.5 L/ha	600
Labour charges		Labour charges	2,250
Total	5,050	Total	Rs. 15,569

Yield			Yield	
Groundnut	5.3 Q/ha	5,300	Kapas yield 36.02 Q/ha	54000
Kapas	17.6 Q/ha	26,400		
Total		31,700		
Cost benefit ratio - 1 : 6.27			Cost benefit ratio - 1 : 3.46	

The results presented in the table 41 indicated that the incidence of jassids was almost similar in both IPM plot and chemical control plot, whereas the build up of whitefly was significantly more (3.65/leaf) in chemical control plot.

The attack of Heliothis in terms of eggs and larvae was 1.27 /plant and 0.92 /plant in IPM plot, where it was 0.90 and 0.10 /plant respectively in chemical control plot . The damage both in terms of squares and bolls was negligible in chemical control plot (1.61 and 1.42%) where it was 10.45 and 4.14% in IPM plot. The presence of predatory fauna and parasitisation was significantly felt in IPM plot when it was almost negligible in the plot treated with chemicals.

The chemical control plot - farmers level of protection (30 times insecticide sprays at frequent intervals) gave 36.02 Q/ha of seed cotton yields whereas through IPM plot only 17.6 Q/ha of cotton and 5.3 Q/ha groundnut was obtained. However , when the cost benefit ratios were evaluated, the IPM treatment gave 1:6.27 and chemical in the control treatment the realization was only 3.46 for every one rupee of investment (Table 41).

1.3.3.4. MAHATMA PHULE KRISHI VIDYAPEETH, COLLEGE OF AGRICULTURE , PUNE CENTRE

The multilocation trial was laid out at Cotton improvement project, MPAU, Rahuri in plot size 0.2 ha/treatment. The experiment was sown on 5th July, 1993 with the following treatments.

1) Biocontrol

i) One blanket application of methyl demeton was given one month after sowing i.e. on 6th August, 1993, for the control of jassids.

ii) Released Chrysoperla carnea two times @ 50,000/ha on 45th and 60th day and 3rd release @ 1,00,000/ha on 130th day after sowing against aphids, thrips and whitefly.

iii) Ten releases of Trichogramma chilonis was released @ 1.5 lakh/ha/release from 70th day after sowing.

iv) One spray of HANPV @ 450 LE/ha was given against H. armigera.

2) Chemical Control

As per the plant protection practices recommended by the Department of Agriculture, Maharashtra State,

i) Two sprays of methyl demeton @ 2ml.lit. of water first on 25th day and 2nd spray on 45th day after sowing.

ii) For the control of bollworms following spray schedule was given at 15 days interval starting from 60th day after sowing.

3rd spray with endosulfan	@ 2.00 ml/lit of water
4th spray with fenvalerate	@ 0.50 ml/lit of water
5th spray with monocrotophos	@ 1.70 ml/lit of water
6th spray with cypermethrin	@ 0.40 ml/lit of water

3. Control

Observations were taken on the population of aphids, trips and whitefly on selected five plants and three leaves /plant at random from 5 different spots in each treatmental plot. Jassids were recorded from three sweeps from 5 spots. Bollworm counts were taken on 25 selected plants in each treatmental plot. The observations on healthy and infested bolls of locules were also recorded and yield data on seed cotton at the time of harvest and the data is presented in table 42.

Table 42. Development of bio-control based IPM for cotton pests

Treatment	Average population of sucking pests				Mean infestation (%)		Yield of seed cotton (kg/ha
	Jassid	Aphid	Thrips	White fly	Bolls	Locules	
Biocontrol	83.6	118.4	335.0	30.4	68.66	39.27	888.11
Chemical control	129.2	98.8	332.0	69.4	46.08	26.64	1121.39
Control	75.12	191.4	323.8	52.2	83.88	56.22	415.89

It could be seen from the data that there was no significant difference of thrips population in all the treatments. Jassid and whitefly population was higher in chemical treated plot than biocontrol plot, whereas aphid population was less in chemical treatmental plot. The data on bollworms damage in bolls and locules indicated that the treatment with insecticidal spray schedule was found superior in reducing bollworm infestation in bolls and locules. The bollworm damage in boll and locules was 46.08 and 26.64 per cent in chemical control treatment as against 68.66 & 39.27 per cent in biocontrol treatment respectively. The percentage of parasitization in retrieved egg cards was 58 per cent.

The insecticide treated plot gave higher yield (1121.39 kg/ha) as against biocontrol plot (888.11 kg/ha) and control (415.89 kg/ha).

1.3.3.5. GUJARAT AGRICULTURAL UNIVERSITY, ANAND

An experiment was laid out to evaluate the efficacy of IPM module against the pest complex at the college farm during the year 1993-94 in a CRD design with 10 replications. Hybrid Cotton-6 was sown on 11-07-1993 with a spacing of 120 x 60 cm in three plots of 0.2 ha size. These plots were kept at about 500 meter apart to avoid possible migration of the bioagents. Each plot was divided into 10 equal divisions considering one division as one replication. The following are the treatments:

I : Treatment

i) Blanket application of oxy demeton methyl @ 0.05% during early part of the season i.e. 30 days after germination.

ii) Three releases of Chrysopa @ 50,000 larvae (2-3 days old) per hectare per week starting from 20-9-93.

iii) Eight releases of Trichogramma chilonis each @ 1,50,000 per hectare per week starting from 18-10-93.

iv) Need based application of endosulfan 0.07% and monocrotophos 0.04% alternatively after 8th release of Trichogramma. For deciding application of insecticides in this treatment, twenty randomly selected plants were examined thoroughly by walking in the form of English letter 'W', covering the whole field and the number of E. vittella and Heliothis larvae were recorded everyday. If the number reached 20 and 15 respectively, insecticidal application was resorted to.

II Treatment (as per GAU recommendation)

Following insecticides were sprayed on the dates shown against them.

Methyl demeton	(0.03%)	:	06-09-1993
Fenvalerate	(0.015%)	:	19-09-1993
Monocrotophos	(0.04%)	:	05-10-1993
Endosulfan	(0.07%)	:	19-10-1993
Monocrotophos	(0.04%)	:	05-11-1993
Endosulfan	(0.07%)	:	19-11-1993
Monocrotophos	(0.04%)	:	04-12-1993

III Control

To record the observations on aphids, jassids, thrips and whiteflies 5 plants in each plot were selected randomly and tagged. Population counts were taken at fortnightly intervals on three leaves selected at random from lower, middle and upper regions of each plant. Healthy and damaged buds/bolls were counted from each tagged plant at fortnightly intervals and the percentage of damage was worked out for each replication.

The data on total number of aphid, jassid, and whitefly per 15 leaves / 5 plants / replication were subjected to ANOVA after following $\sqrt{X+1}$ transformation. The data on per cent damaged buds and bolls were subject to ANOVA after following arcsin transformation. The data on pest population and per cent infestation were also pooled over period so as to see the consistency or otharwise the treatment performance.

Parasitism :

Eggs of bollworms were collected at fortnightly intervals covering the whole plots under different treatment and kept individually in glass vials to record extent of parasitism. To find out the larval parasitism larvae from the bolls were collected at fortnightly intervals covering the whole plots under different treatments and were reared in the laboratory to record the extent of natural parasitism by different parasitoids. The mummified larvae due to parasitisation by Rogas observed in the field during the course of observations were also collected and added to the number of larvae collected while working at per cent parasitisation.

Observations on the number of predators in different stages i.e. Cheilomenes sexmaculatus, Geocoris bicolor, spiders and staphylinid, P. fucipes fucipes were recorded on each tagged plant at fortnightly intervals. The results are presented in Tables 43 to 49. Observations recorded on sucking pests like aphids (Aphis gossypii), jassid (A.biguttula biguttula), and whiteflies (Bemisia tabaci) showed that the population was significantly less in T1 and inseecticidal treated block than control. The combined application of Chrysopa and insecticides gave significantly better protection to the aphids (4.86), jassids (7.88) and whitefly (8.67) when compared with control plot which recorded 7.64, 11.67 and 13.44 respectively. The population of aphids, jassid and whitefly in insecticidal treated plot was 7.24, 7.53 and 8.30 respectively, which was also less than the control plot.

The bud and boll damage was significantly less in T1 (IPM) and T2 (insecticidal treated) than control (untreated). Both Trichogramma and Chrysopa exerted effective check on the bollworms which resulted in 19.18% and 19.13% bud and boll damage respectively as compared to 26.13% and 26.74% damage in T2 (insecticidal treated). The percentage bud and boll damage in control was 30.32% and 36.37 respectively.

Table 43. Number of Jassids, A. biguttula biguttula in different treatments.

Treat-ment	Population of jassids / 15 leaves / 5 plants (at fortnightly intervals)								
	August	September		October		November		December	Pooled
	II	I	II	I	II	I	II	I	
T1	1.40 (0.96)	3.04 (8.24)	3.88 (14.05)	4.89 (22.91)	3.84 (13.75)	2.20 (3.64)	2.26 (4.38)	2.32 (4.38)	2.98 (7.88)
T2	1.42 (1.02)	2.08 (3.33)	4.54 (19.61)	5.08 (24.81)	3.71 (12.76)	2.52 (5.35)	2.18 (3.75)	1.85 (2.42)	2.92 (7.53)
T3	1.49 (1.22)	3.03 (8.18)	4.98 (23.80)	5.04 (24.40)	4.79 (21.94)	4.13 (16.06)	2.67 (6.13)	2.31 (4.34)	3.56 (11.67)
Mean	1.44 (1.07)	2.72 (6.40)	4.47 (18.98)	5.00 (24.00)	4.11 (15.89)	2.95 (7.70)	2.37 (4.62)	2.16 (3.67)	3.15 (8.92)
CD. (0.05) T	NS	0.58	NS	NS	0.66	0.60	NS	NS	0.21
P									0.33
TxP									0.57

T1 : IPM (Biocontrol + Insecticides); T2 : Need based application of insecticides ; T3 : Control; T : Treatment; P : Period; TxP : Interaction

Note: Figures in parentheses are retransformed values, those outside are jX+1 values.

Since T1 (IPM) received only two sprays, many of the bioagents were conserved (Tables 50). The noteworthy among them were Rogas aligarhensis, M. sexmaculatus, Geocoris which played their role in natural control of the pest. 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 from Table 7, that percentage parasitism by Rogas averaged 20.62% as against 39.30% parasitism in T1. Similarly, egg count of Chrysopa were 0.41/plant, coccinellid was 0.19/plant, and Geocoris was 0.20/plant.

Spiders (0.32/plant) and staphylinids (0.13/plant) were much less in T1 (IPM) and the population counts of Chrysopa, Coccinellids, Geocoris, spiders and staphylinids averaged 1.06, 0.30, 0.61, and 0.37 per plant respectively.

The effectiveness of the IMP module was further substantiated from yield records. The IPM module recorded higher cotton yield (621.39 kg/ha) than insecticidal treated block 529.17 kg/ha. The yield in untreated control was 372.23 kg/ha.

Table 44. Number of *A. gossypii* and cotton yield in different treatments

Treat-ments	Aphids per 15 leaves per/plant						Yield (kg/ha)
	August II	September I	September II	October I	October II	Pooled	
T1	2.41 (4.81)	3.59 (11.89)	1.64 (1.69)	1.75 (2.06)	2.71 (6.34)	2.42 (4.86)	621.39
T2	2.41 (4.18)	3.87 (13.98)	2.48 (5.15)	3.67 (12.47)	1.91 (2.65)	2.87 (7.24)	529.17
T3	1.97 (2.88)	4.03 (15.24)	2.80 (6.84)	2.64 (5.97)	3.25 (9.56)	2.94 (7.64)	372.23
Mean	2.27 (4.15)	3.83 (13.67)	2,31 (4.34)	2.69 (6.24)	2.62 (5.86)	2.74 (6.51)	
CD at T	NS	NS	NS	NS	NS	NS	
(P=0.05) P						0.76	
TxP						NS	

T1 : IPM (Biocontrol+Insecticide);

T2 : Need based application of insecticide,

T3 : Control;

T : Treatment;

P : period;

TxP : Interaction

Note: Figures in parentheses are retransformed values, those outside are Sine^{-1} ($\sqrt{x+1}$) values.

Table 45. Number of white flies in different treatments

Treat-ment	Population of white flies, jassids/15 leaves/ 5 plants (at fortnightly intervals)							
	September		October		November		December	Pooled
	I	II	I	II	I	II	I	
T1	2.43 (4.90)	3.24 (9.50)	3.37 (10.36)	3.71 (12.76)	3.92 (14.37)	2.42 (4.86)	2.61 (5.81)	3.11 (8.67)
T2	1.98 (2.92)	1.99 (2.96)	3.22 (9.37)	5.42 (28.38)	3.12 (8.73)	3.90 (14.21)	1.75 (2.06)	3.67 (8.30)
T3	1.90 (2.61)	3.38 (10.42)	3.82 (13.59)	5.56 (29.91)	5.22 (26.25)	3.21 (9.30)	3.49 (11.18)	3.80 (13.44)
Mean	2.10 (3.41)	2.87 (7.24)	3.47 (11.04)	4.90 (23.01)	4.09 (15.73)	3.19 (9.18)	2.62 (5.86)	3.32 (10.02)
CD T	NS	0.78	NS	0.69	0.81	0.73	0.86	0.32
P=(0.05) P								0.41
TxP								0.71

T1 : IPM (Biocontrol + Insecticide); T2 : Need based application of insecticide; T3 : Control; T : Treatment;

P : Period; TxP : Interaction

Note: Figures is parentheses are retransformed values, those outside are Sine^{-1} ($\sqrt{x+1}$) values.

Table 46. Extent of bud damage by E. vittella in different treatments

Treat-ments	Per cent bud damage at different months (at fortnightly intervals)							
	September	October		November		December		Pooled
	II	I	II	I	II	I	II	
T1	28.45 (22.69)	25.45 (18.52)	22.79 (15.00)	23.83 (16.32)	25.97 (19.18)	24.56 (17.28)	26.49 (19.90)	25.97 (19.18)
T2	33.06 (29.76)	28.20 (22.33)	35.21 (33.24)	29.55 (24.32)	29.89 (24.83)	32.02 (28.11)	27.29 (21.02)	30.74 (26.13)
T3	35.68 (34.02)	33.88 (31.08)	35.43 (33.61)	35.13 (33.11)	32.54 (28.93)	30.64 (25.97)	30.57 (25.87)	33.41 (30.32)
Mean	32.40 (28.71)	29.19 (23.79)	31.14 (26.74)	29.50 (24.25)	29.47 (24.20)	29.07 (23.61)	28.12 (18.02)	30.04 (25.06)
CD (P=0.05)								
T	4.54	2.84	3.55	2.77	4.77	5.14	2.87	2.45
P								1.98
TxP								3.42

T1 : IPM (Biocontrol + Insecticide);

T2 : Need based application of insecticide;

T3 : Control;

T : Treatment;

P : Period;

TxP : Interaction

Note: Figures is parentheses are retransformed values, those outside are $Sine^{-1}$ ($\sqrt{x+1}$) values.

Table 47. Extent of boll damage due to E.vittella in different treatments.

Treat-ments	Per cent bud damage at different months (at fortnightly intervals)							
	September	October		November		December		Pooled
	II	I	II	I	II	I	II	
T1	31.86 (27.86)	27.32 (21.06)	27.14 (20.81)	23.39 (15.76)	23.31 (15.66)	22.98 (15.24)	25.98 (18.62)	25.95 (19.13)
T2	41.09 (43.20)	33.28 (30.11)	34.02 (31.30)	26.76 (20.27)	26.83 (20.27)	30.30 (20.45)	25.68 (18.78)	31.14 (26.74)
T3	45.80 (51.40)	41.57 (44.03)	40.82 (42.73)	37.68 (37.36)	32.99 (29.65)	33.42 (30.33)	29.85 (24.77)	37.45 (36.97)
Mean	39.58 (40.06)	34.06 (31.37)	33.99 (31.25)	29.28 (23.92)	27.71 (21.62)	28.90 (23.36)	27.03 (20.65)	31.51 (27.32)
CD T (P=0.05)	6.80	4.06	3.53	7.75	4.11	5.21	NS	2.86
P								2.77
TxP								NS

T1 : IPM (Biocontrol + Insecticide);

T2 : Need based application of insecticide;

T3 : Control;

T : Treatment;

P : Period;

TxP : Interaction

Note: Figures is parentheses are retransformed values, those outside are Sine^{-1} ($\sqrt{x+1}$) values.

Table 48. Per cent parasitism by T.chilonis in the eggs of E. vittella

Period	T1		T2		T3	
	No. of eggs colle-cted	Parasi-tism (%)	No. of eggs colle-cted	Parasi-tism (%)	No. of eggs collec-ted	Parasi-tism (%)
25-08-93	20	5.00	25	4.00	25	4.00
03-09-93	25	8.00	20	5.00	20	5.00
18-09-93	20	10.00	30	6.67	30	6.67
04-10-93	30	10.00	27	3.70	30	3.33
18-10-93	30	13.33	25	8.00	35	2.86
04-11-93	28	17.86	30	6.67	30	3.33
18-11-93	32	12.50	25	8.00	25	4.00
03-12-93	20	25.00	20	5.00	20	5.00
18-12-93	12	16.67	15	6.67	25	4.00
Mean		13.15		5.97		4.24

T1= IPM (Biocontrol+Insecticide),
T2= Need based application of insecticides,
T3= Control.

Table 49. Per cent parasitism by R. aligarhensis in various treatments

Period	T1		T2		T3	
	No. of eggs colle-cted	Parasi-tism (%)	No. of eggs colle-cted	Parasi-tism (%)	No. of eggs collec-ted	Parasi-tism (%)
18-09-93	28	10.71	28	10.71	26	3.85
04-10-93	45	46.67	46	26.09	38	10.53
18-10-93	50	42.00	40	27.50	35	14.29
04-11-93	57	50.88	42	21.43	43	24.44
18-11-93	59	44.24	48	20.83	45	15.56
03-12-93	67	44.78	45	24.44	44	22.73
18-12-93	62	25.81	45	13.33	48	20.83
Mean		39.30		20.62		16.03

T1= IPM (Biocontrol+Insecticide),
T2= Need based application of insecticides,
T3= Control.

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

Month/ Fortnight		*C. scelestes*			*C. sexmaculatus*			*G. bicolor*			Spiders			Staphylinids		
		Eggs			ELPA*			Adults			Adults			Adults		
		T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
August	II	2	2	-	7	5	-	-	-	-	-	-	-	-	-	-
September	I	6	5	5	2	2	-	-	-	-	3	2	2	-	-	-
	II	56	18	25	7	13	7	15	7	4	29	19	18	-	-	-
October	I	92	77	41	19	11	8	16	14	15	37	31	34	-	-	-
	II	130	35	44	34	8	13	34	8	18	73	22	40	30	10	15
November	I	100	21	25	22	10	9	33	17	18	49	24	26	52	14	33
	II	32	18	15	10	11	8	21	16	20	31	31	27	42	16	33
December	I	33	6	12	13	2	11	22	10	22	41	14	27	41	18	37
	II	28	2	10	26	22	14	41	18	23	13	3	9	-	-	-
Average/ Plant		1.06	0.41	0.39	0.30	0.19	0.16	0.40	0.20	0.27	0.61	0.32	0.41	0.37	0.13	0.26

T1= IPM (Biocontrol + Insecticides),
T2= Need based application of insecticides,
T3= Control.
* ELPA : Egg, Larva, Pupa and adult

Thus, the studies showed that biocontrol based IPM module was not only better than control but proved more effective than insecticidal treatment. It was also clear that reducing insecticidal sprays in the ecosystem helps in conserving natural enemies, which in turn amounted to natural biological control.

1.3.4. BIOSUPPRESSION OF INSECT PESTS OF TOBACCO

1.3.4.1. Studies on the natural enemies of tobacco pink aphid, *Myzus nicotianae* Blackman

Forty days after transplanting of tobacco, observations were recorded at fortnightly intervals on one top, middle and bottom leaves of 20 plants for different stages of aphid predators and parasitoids. 20 plants were selected à 5 plants at random per shot at four spots in one ha of tobacco field. The predatory stages were collected and reared in the laboratory. The results are given in table 51.

Table 51. Predators on pink aphid *Myzus nicotianae* Blackman.

Stage/ Observation	Egg				Larva				Pupa				Adult			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
P1$1	-	-	C2	C1	S1	S3	S3+C2	-	-	S1+C1	S2+C2	S1+C1	S1	S2	S3+C2	-
P2$1	-	-	C1	-	-	S1	S5	-	-	-	-	S1+C1	S1	C1	S2	S1
P3$1	-	-	-	-	S1	-	-	-	-	-	S1+C1	S1	S1	S2	S2	S1
P4$1	-	-	-	-	-	S4	S3+C1	-	-	S1	S1	-	-	S1	S2	C1
P5$1	-	-	-	-	-	-	S3	-	-	-	-	S1	-	S2	S1	C1
P1$2	-	-	-	-	-	-	C	-	-	-	-	-	-	C1	-	-
P2$2	-	-	C1	C1	-	-	S4	-	-	-	-	S1	-	-	C1	
P3$2	C1	-	C2	-	-	S3	S4+C2	-	-	S1+C1	-	C1	-	-	-	-
P4$2	-	-	-	C1	-	S2	S3	S2	-	-	C1	S1+C1	-	S1+C2	S1+C1	-
P5$2	-	-	C2	-	-	-	-	-	-	S1	C1	-	-	-	C2	-
P1$3	-	C1	-	C1	S1	S2	S1	-	-	S1	S2	S1+C2	-	S1	S2	S1+C1
P2$3	-	-	-	-	-	S3	S4	S2	-	S1	C1	-	S1	S2+C1	S1+C1	-
P3$3	-	-	-	-	-	S3	-	S2	-	-	-	S1	-	S1	S2	S2
P4$3	-	-	-	-	S1	-	-	-	-	-	S1	C1	-	-	S1+C1	C2
P5$3	-	-	-	-	-	-	S2	S1	-	-	-	C1	S1	-	-	S1
P1$4	-	-	-	-	S2	S2	S3+C1	-	-	-	S2+C1	S1	S1	S2	S1+C1	-
P2$4	-	C1	-	C1	-	S2	-	-	-	-	-	-	-	-	-	-
P3$4	-	-	C1	-	-	-	S4	-	-	S1	-	-	-	-	-	-
P4$4	-	-	C2	C1	-	-	-	-	-	S2+C1	-	-	S1	S1	S2	-
P5$4	-	-	-	-	S1	-	S2	-	-	-	-	-	-	S2	S2	-
Total	C-20				S-79 C- 7				S-27 C-18				S-51 C-19			

Number and dates of observations : (I) 25-12-1993 (II) 08-01-1994 (III) 22-01-1994 (IV) 05-02-1994

P = Plant C = Coccinellid (*C. sexmaculata* , *C. transversalis*)
$ = spot S = Syrphids (*Xanthogramma scutellare*)

During the season under report the aphid infestation was observed to be at a very low level. Syrphids appeared immediately after the aphid colonization started. Coccinellid population was on a low level as compared to syrphids. Among the coccinellids, Cheilomenes sexmaculata (F) and Coccinella transversalis (F). were recorded. More number of syrphid larvae and adults were observed as compared to coccinellids. Among the coccinellids, adults were more in number as compared to other stages. More number of adult predators were observed on top leaves whereas the other stages were distributed on the entire plant i.e top, middle and bottom leaves more or less uniformly. Very low percent parasitism was recorded during the current season.

A sample of B. t. Var. aizawi (15000 TU/mg) was tested in the laboratory @ 150 gm/2150 lit. of water. The results indicated high degree of toxicity in a shorter duration to S. litura larvae (active feeding stage). The strain is highly promising. Further extensive laboratory and field trials will be taken up during 1994-95.

1.3.4.2. Evaluation of different formulations of Bacillus thuringiensis against Helicoverpa armigera on tobacco crop.

As soon as the tobacco plants have flowered and capsule formation has taken place, three numbers of active feeding stage larvae of Helicoverpa (bred in laboratory) were released per plant on five labelled plants per plot in the different treatments. Soon after, spraying was carried out with the treatments namely Bactospeine 1 kg/ha, Delfin 1 kg/ha, Dipel 1 kg/ha, endosulfan 1 ml/lit and control (no application). Observations on damage to the capsules were recorded in different treatments, after ten days of spraying. The results are statistically analysed and presented in the Table 52.

The results obtained were in conformity with that of the previous year. All the B.t. treatments and endosulfan were significantly superior to control. Delfin, Dipel and Bactospeine were significantly superior to endosulfan. However, Delfin and Dipel were on par with each other and significantly superior over Bactospeine. Thus it is concluded that the above B. t. strains can be effectively used against H. armigera in tobacco crop.

1.3.4.3. Evaluation of Apterochrysa Sp. and Chrysoperla carnea for the control of tobacco aphid.

As soon as the aphid population on tobacco leaves was above 1000 numbers on top and middle leaves and above 500 numbers in lower leaves, laboratory reared early 2nd instar chrysopid larvae were released on 5 labeled plants per plot

Table 52. Relative efficacy of different formulations of B. t. against H. armigera in tobacco field crop.

Treatment	Mean no. of capsules damaged
Delfin (B.t. Kurstakii Serotype a,b.)	1.71 (1.51)
Dipel (B.t. Kurstakii H.D-1 Strain)	1.19 (1.12)
Bactospeine (B.t. thuringiensis)	3.69 (3.48)
Endosulfan (1 ml/lit)	5.50 (5.20)
Control (No application)	14.02 (14.95)
CD at 5%	0.7211

(Figures in parentheses are transformed values)

at the rate of 6 numbers per plant and replicated seven times. For comparison, two similar sized plots were taken and one plot was treated with phorate granules 2g/plant and another plot left untreated to act as a control. The weekly observations on aphid population was recorded and given in the Table 53.

Table 53. Comparative efficacy of predatory chrysopids

	Mean Aphid/leaf	Total Aphid population
A. Treatment		
Chrysopid larvae released plot	9.36	89.89
Phorate (2g/Plant)	8.96	82.82
Control	35.29	1117.71
CD 5%	0.7827	

Table 53 contd. ...

B. Leaf position			
Top		17.76	425.06
Middle		18.89	527.34
Bottom		7.61	338.03
CD 5%		0.4519	

C. A X B Treatment x Leaf Position (Interaction study)

Treatments	Top leaf	Middle leaf	Bottom leaf
Chrysopa larvae	10.64 (114.27)	9.83 (97.06)	7.61 (58.36)
Phorate 10G	10.14 (104.77)	9.53 (91.25)	7.21 (52.45)
Control	32.49 (1056.14)	37.32 (1393.71)	30.04 (903.28)
CD 5%	0.7827		

(Figures in parentheses are original means)

Chrysopid larvae effectively controlled the aphid population and was on par with phorate granules @ 2g/plant and significantly superior to control wherein there was a progressive increase in aphid population in all the top, middle and bottom leaves. Thus the last year and this year results indicated that second instar larvae of chrysopa @ 6/plant if released at the initial stage of aphid infestation in tobacco field crop, can effectively check the build up.

1.3.4.4. Evaluation of Apanteles africanus against Spodoptera litura in tobacco nurseries.

Tobacco nurseries were raised in seed beds of 2x1 m. Three weeks after germination, five beds were covered with mosquito net and five beds were left without covers and surrounded by castor plants raised around. Every fortnight 500 first instar larvae (neonate) and 100 Apanteles adults (1 Female : 4 males) were released on all the beds both covered as well as uncovered. Similar way two times it was repeated twice at fortnightly intervals. Ten days after each release, observations were recorded on number of cocoons emerged out of the randomly collected larvae from the beds and reared in laboratory and cocoons were collected directly from the beds also. In case of the open beds cocoons were also collected from castor plants around. At the end of the experiment, observations were recorded on the number of seedlings damaged by Spodoptera litura. The results are given in Table 54.

Table 54. Evaluation of Apanteles Africanus against S.litura in tobacco nurseries.

Treatment	Percentage seedlings damaged
1. Caged	26.02 (19.27)
2. Uncaged	29.25 (23.93)
3. N.P.V.	24.79 (17.62)
4. Control	44.03 (48.34)
C.D. at 5%	3.43

(Figures in parenthesis are original means)

There is no significant difference in the number of cocoons obtained in the caged and uncaged beds but both the treatments were superior to control (Table 55). This evidently confirms that A. armigera can locate the host and concentrate there and effectively parasitize even without confining the parasitoid by means of cage or enclosure. Castor raised around the tobacco nurseries which were not covered, effectively attracted, trapped and retained the pest as well as the parasitoid which helped in conservation and encouragement of natural enemies.

In the case of mean percentage of damaged seedlings there is no significant difference between caged and uncaged beds. Both these treatments are superior to control (No application). Thus the effectiveness of parasitoid releases under field conditions is confirmed (Table 55).

Table 55. Mean number of cocoons recovered

Treatments	Cocoon Nos.
Caged	36.39
Uncaged	37.20
Control	15.67
CD at 5%	1.47

1.3.4.5. Study on bio-efficacy of B. t. strains against Spodoptera litura in tobacco nurseries.

In the tobacco nursery, 25 actively feeding and artificial inoculated second instar Spodoptera larvae were released per bed of 12m size when seedlings were five weeks old. After release, different B. t. formulations (Bactospeine, Delfin, Dipel) were sprayed immediately. Two control plots were maintained of which one plot was sprayed with NPV (250 LE/ha) and the other left as control. Ten days after treatment observations on percentage of seedlings damaged were recorded and the results are given in Table 56.

Table 56. Percentage of damaged tobacco seedlings

Treatment	Dosage	Seedlings damaged (%)
Bactospeine	1 Kg/ha	15.57
Delfin	1 Kg/ha	9.65
Dipel	1 Kg/ha	8.59
NPV	250 LE/ha	14.62
Control	-	47.32
CD at 5%		2.99

The results obtained are in conformity with previous years results. Ten days after spraying, Dipel and Delfin were on par and significantly superior to all other treatments and control in suppression of S. litura damage to tobacco nurseries. However, Bactospeine eventhough superior to control and on par with NPV was significantly inferior to Dipel and Delfin. Thus it is concluded from the two years results that Delfin and Dipel can be effectively used for biosuppression of S. litura in tobacco nurseries followed by Bactospeine and NPV.

1.3.4.6. Integrated Management of *Spodoptera litura* in tobacco nurseries.

In order to educate and demonstrate the effectiveness of the various bioagents and biopesticides in integration for management of *Spodoptera litura* in tobacco nurseries, a trial was laid out in 0.5 ha at a commercial tobacco nursery at Morampudi.

Details of the treatments

1. Neem Seed Kernel Suspension (1%) (NSKS) 2 weeks after germination and again NSKS (2%) at 4th week
2. *Apertochrysa* 60,000/ha 3 times
3. *Telenomus remus* 1,20,000/ha 3 times
4. SL NPV 250 LE + 0.25% boric acid 3 times
5. *Bacillus thuringiensis* Var. *Kustaki* HD. one spray 3 times
6. *Apanteles africanus* 10,000/ha in 3 fortnightly releases
7. Castor as an ovipositional trap crop to be raised 15 days before sowing in nursery.
8. Control (Distant nursery) (conventional chemical control)

Date wise schedule of natural enemy releases and other components of Integrated Pest Management.

Date of sowing of castor 20-08-1993
Date of sowing of tobacco 05-09-1993

Month (1)	Date (2)	Bio component (3)
OCTOBER	05.10.93	*T.remus*
	07.10.93	NSKS
	12.10.93	*Apanteles*
	14.10.93	*Chrysopa*
	19.10.93	NPV
	21.10.93	*T. remus*
	22.10.93	NSKS

(1)	(2)	(3)
	26.10.93	Apanteles
	28.10.93	B. t. k.
	29.10.93	Chrysopa
NOVEMBER	01.11.93	NPV
	05.11.93	T. remus
	08.11.93	B. t. k.
	10.11.93	Apanteles
	16.11.93	B. t. k.

Natural enemy wise	I	II	III
T. remus	05.10.93	21.10.93	05.11.93
Apenteles	12.10.93	26.10.93	10.11.93
Chrysopa	14.10.93	29.10.93	12.11.93
NPV	19.10.93	01.11.93	09.11.93
NSKS	07.10.93	22.10.93	
B. t. k.	28.10.93	08.11.93	16.11.93

Three fortnightly releases of T. remus an egg parasite, A. africanus a neonate larval parasitoid, predator C. carnea along with 3 sprays of NPV, and B. t. each (Dipel) were carried out. Further 2 sprays of NSKS an insect repellent was also integrated with the above bio agents, besides, a row of castor was raised around the tobacco nursery to lure the S. litura population away from tobacco nursery. The expenditure incurred and the returns from the sale proceeds of seedlings and chemical control is given in Table 57.

Table 57. Cost benefit ratio of IPM Programme (Area 0.5 ha)

Treatment	IPM (in Rs)	Chemical control (in Rs)
A. Cost of plant protection (Rs.)	5,275	10,000
B. Labour wages(Rs.)	100,000	1,00,000
C. Fertilizers (Rs.)	10,000	10,000
D. Miscellaneous (Rs.)	10,000	10,000
	1,25,275	1,30,000
Seedlings yield (no.)	28,61,500	16,72,000
Monetary Returns (Rs.)	3,43,496	1,98,645
Cost benefit ratio	1:2.74	1:1.52

(Average rate for bundle of 4000 seedlings Rs.475/-)

As seen from the table the CB ratio for IPM was 1:2.74 whereas for chemical control it was 1:1.52. The main advantage in the IPM is trapping S. litura to castor. This results in reducing the damage to seedlings of IPM plot and in increasing yield and returns in comparosion to chemical control. Further, the safety of this biological method over hazardous chemical control and also the perpetuation of bio agents leading to long term control, are some of the unaccountable bonus effects of IPM. Further observations were also recorded on estimation of damage and population dynamics of the pest both in tobacco and castor trap crop (Table 47,48 & 49) along with degree of parasitization both in castor and tobacco by the released parasitoids, which are given in Figs. 21 to 24.

The observations taken on indigenous natural enemies recorded in IPM (Castor and Tobacco) plots indicated that more pest population was revealed in castor along with higher degree of parasitization. The parasitoids collected were Telenomus rowanii Ashmead , Apanteles africanus Cameron, Apanteles ruficrus Hal., Charops obtuses Mor., Peribeas orbata Weid., Chelonus formosanus Sonan., Apanteles sp., Chrysopa sp., Harpactor costalis stal., Micromus timidus Hagen., Polistes Sp.

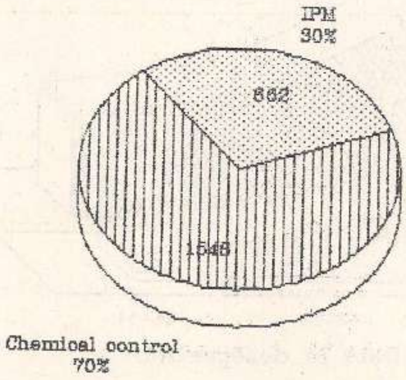


Fig. 21: Seedlings damaged in IPM and chemical control

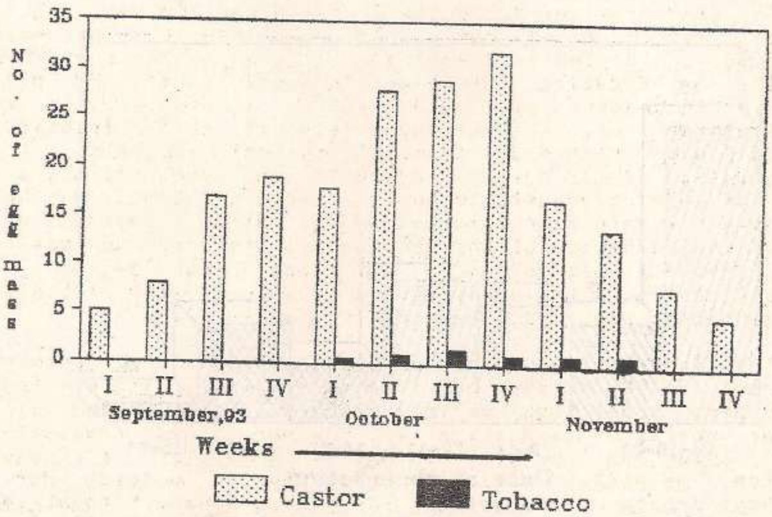


Fig. 22: Egg mass of *Spodoptera litura* collected from tobacco nursery and castor

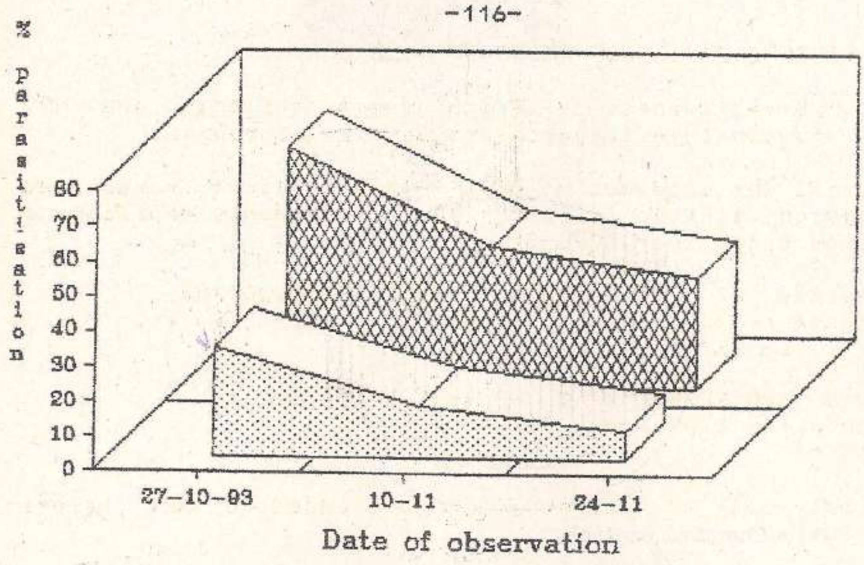


Fig. 23: Parasitisation of *Spodoptera litura* by *Apanteles africanus* on castor and tobacco

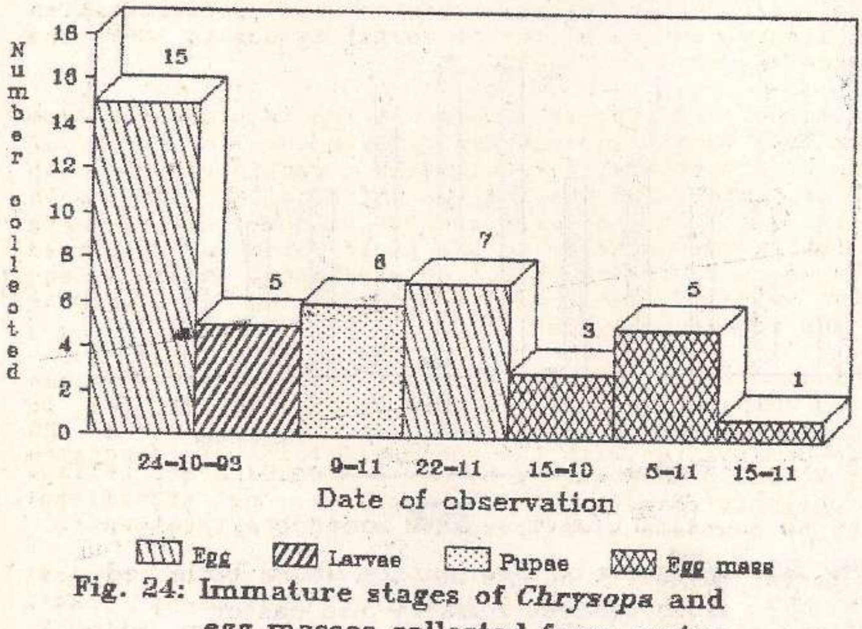


Fig. 24: Immature stages of *Chrysopa* and egg masses collected from castor

1.3.5. BIOSUPPRESSION OF PESTS OF PULSES

1.3.5.1. Effectiveness of *Trichogramma chilonis* and NPV against *Helicoverpa armigera* in pigeonpea.

A trial was laid out at APAU, Hyderabad in a randomized block design with the following seven treatments replicating four times using var.ICPL-87.

1. Releases of *Trichogramma chilonis* @ 50,000/ha,
2. Release of *T. chilonis* @ 1,00,000 /ha,
3. *NPV @ 123 LE/ha,
4. *NPV @ 250 LE/ha,
5. *NPV @ 125 LE/ha + *T. chilonis* @ 50,000/ha,
6. Endosulfan 0.07% and
7. Control

* Ranipal 0.1% and Jaggery 0.5% were added to NPV before application.

All the treatments were given during evening hours at 10 days interval for four times staring from flower initiation and also based on the information of monitoring of *Heliothis* through pheromone trap data and egg counts. Egg parasitoids were released a day before their emergence by stapling parasitized egg card bits on the lower surface of the leaves. The data on the number of pods and pods damaged by the larvae of *H. armigera*., extent of egg parasitisation by *T. chilonis*, extent of larval mortality due to NPV and yield, were recorded in Fig.25.

Male moths of *Helicoverpa* were noticed in pigeonpea from 2nd week of August and reaches to peak by 2nd week of September (18.4 moths/traps/week) and continued upto 4th week of September. Two weeks after noticing the peak moth population i.e., in the first week of october, *Helicoverpa* egg population was observed in the field which synchronized with the peak flowering period of pigeonpea. Maximum egg population (108/20 plants) was recorded in the first week of October and subsequently declined.

Although , no establishment of egg parasitoid was recorded, comparatively lowest pod damage (24.8%) due to *Helicoverpa* was recorded with the application of NPV @ 125 LE/ha in combination with the egg parasitoids *Trichogramma chilonis* @ 50,000/ha followed by NPV @ 250 LE/ha and release of *T. chilonis* @ 1,00,000 /ha However, no significant reduction of pod damage was recorded among the treatments.

The larval mortality due to NPV was found to be highest in both NPV at 125 LE/ha (87%) and at 250 LE/ha (73%). Application of NPV @ 125 LE/ha in combination with *T. chilonis* registered 47% larval mortality. There was no significant reduction of larval population among the

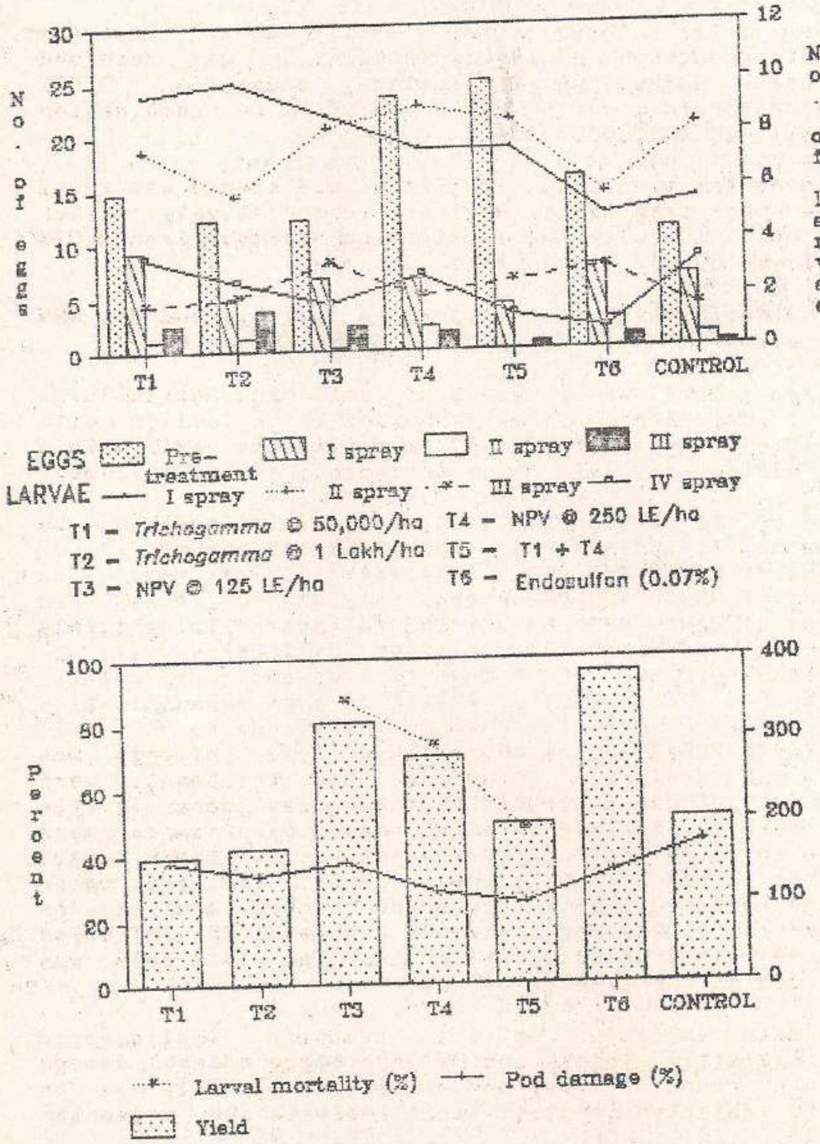


Fig. 25: Effect of *Trichogramma chilonis* and NPV against *Helicoverpa* on pegion pea

treatments after three spray applications. However, significant reduction of larval population was recorded after fourth spray. At this stage, endosulfan 0.07% performed better followed by NPV @ 125 LE/ha in combination with *T. chilonis* @ 50,000/ha.

Regarding the yield, no significant difference was found among the other treatments. However , comparatively better yield was obtained with the application of Endosulfan 0.07% alone followed by NPV @ 125 LE/ha.

1.3.5.2. Effectiveness of *Trichogramma chilonis* and Ha NPV against *Helicoverpa armigera* on pigeonpea

An experiment was conducted at Tamil Nadu Agricultural University, Coimbatore in a-randomized block design with seven treatments replicated four times with the variety Co 6 pigeonpea during rabi 1993. The treatments are as follows:

1. Release of *T. chilonis* @ 1,00,000/ha (5 times),
2. Release of *T. chilonis* @ 50,000/ha (5 times),
3. Spraying of HaNPV 250 LE/ha (thrice),
4. Spraying of HaNPV 125 LE/ha (thrice),
5. Spraying of HaNPV 125 LE/ha + and release of *T. chilonis* 50,000 /ha (thrice),
6. Endosulfan (0.07%)
7. Control

The first spraying of NPV/release of *T. chilonis* was made at 50% flowering stage and the treatments were continued at 10 day intervals. Spraying was done in the evening hours. The *Trichogramma* parasitized cards were stapled on the lower surface of the leaves. For HaNPV teepol (0.1%) and jaggery (0.05%) were added. The pod borer damage was recorded before each round of spray and at the time of harvest counts were taken on the total and affected pods from 15 plants selected at random. The yield data was also recorded at the time of harvest.

The data collected on the podborer (*Helicoverpa armigera*, *Exelastis atomosa* and *Melanagromyza obtusa*) damage before each round of spray and at harvest as well as on yield were subjected to statistical analysis and presented in Table 58.

Table 58. Data on damage by pod borers and yield of redgram CFo.6

Sl. No.	Treatment	Damage by pod borer (%)				Yield
		Before spraying	After ....spraying I	II	III	(kg/ha)
1	Release of *T. chilonis* @ 1,00,000/ha (5 times)	5.3	5.1[a] (13.05)	21.7[a] (27.76)	27.0[a] (31.31)	1191
2	*T. chilonis* @ 50000/ha 5 times	8.5	7.7[a] (16.11)	31.4[b] (34.08)	38.1[b] (38.12)	937
3.	HaNPV @ 250 LE/ha thrice	8.1	7.7[a] (16.11)	32.5[bc] (34.76)	34.8[ab] (36.15)	1297
4	HaNPV 125 LE/ha	7.2	7.3[a] (15.68)	33.8[c] (35.55)	37.5[b] (37.7)	922
5.	HaNPV 125 LE/ha + *T. chilonis* 50,000/ha thrice	8.3	4.3[a] (11.97)	34.5[c] (35.97)	38.3[b] (38.23)	1082
6.	Endosulfan 0.07%	6.7	5.3[a] (13.31)	37.4[cd] (37.70)	38.8[b] (38.53)	1573
7.	Control	10.0	13.5[b] (21.56)	45.3[d] (42.30)	53.8[c] (47.18)	751

The incidence of podborer was from 5.3 to 10% before the first round of spray. All the treatments were superior to control in controlling pod borer damage and the incidence in different treatments ranged from 4.33 to 7.7% against 13.5% in control. The podborer damage recorded before the third spray and at the time of harvest indicated that release of *T. chilonis* @ 1,00,000/ha (5 times) was superior at all the treatments but on par with Ha NPV 250 LE/ha thrice. The yield data were not significant among the treatments. However, spraying of endosulfan 0.07% (thrice), Ha NPV 250 LE/ha thrice, release of *T. chilonis* @ 1 lakh/ha 5 times and Ha NPV 125 LE/ha + *T. chilonis* 50000/ha thrice recorded yield of 1573, 1297, 1191 and 1082 kg/ha respectively as against 751 kg/ha in control (Table 58).

1.3.5.3. Effectiveness of Bacillus thuringiensis formulations against Helicoverpa armigera on pigeonpea

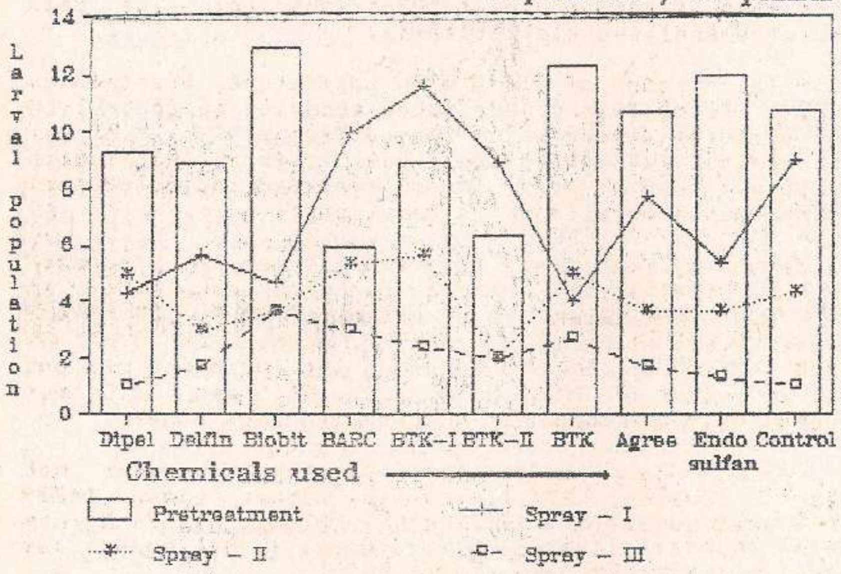
An experiment was conducted at APAU, Hyderabad in a randomized block design with ten treatments replicating thrice with a subjective variety ICPL-87 during kharif 1993. The treatments include different formulations of Bacillus thuringiensis viz., Dipel, Delfin, Biobit, BARC strain, BTK-I, BTK-II BTT and Agree at 0.5kg/ha. Endosulfan (0.07%) treated plot and control plot were separatly maitained for comparisons. Sprayings were done at 10 day intervals thrice starting from flowering initiation. Observations were made on the population of larvae from ten plants per plot selected at random in each treatment before each round of spray. The larvae collected after spraying were reared in the laboratory and the larval mortality with disease symptoms was recorded. The results in detail are presented Fig. 26.

The results presented in Fig.26 indicated that none of the B.t. formulations tested were found to be significantly effective in reducing damage or larval population with three rounds of sprays. However, Biobit (0.5 kg/ha) recorded lowest damage (26.83%) followed by endosulfan (0.07%) (27.16%) as against 57.84 damage in control. The highest larval mortality due to disease was observed in Biobit (53.33%) followed by Dipel and Delfin (40%) . The pupal deformities were also evident with all the B.t. formulations tested except with BTK-I. The natural occurrence of beneficial insects when considered, the treatment with BTK-I registered 20% larval parasitisation due to tachinids followed by Dipel (13.33%) and BTT (6.67%). No significant differences were observed among the treatments with respect to yield. However, on comparison better yield was obtained with BTK-II and Biobit.

1.3.5.4. Evaluation of Bacillus thuringiensis formulations against Helicoverpa armigera on pigeonpea

An experiment was conducted at the Tamil Nadu Agricultural University, Coimbatore in a randomized block design with eight treatments and 4 replications with the variety Co 6, during rabi 1993. The treatments consisted of formulations of B. thuringiensis viz., dipel, delfin, biobit,, B. t. BARC strain, BTK I, BTK II, BTT , all at 0.5kg/ha & endosulfan (0.07%) and a control.

Observations were made on the population of larvae of H. armigera from 15 plants/plot selected at random in each treatment before each round of spray. The total and effected number of pods from 15 plants/plot were also recorded and percentage damage was worked out before each round of spray. Four sprays were given at 10 day intervals



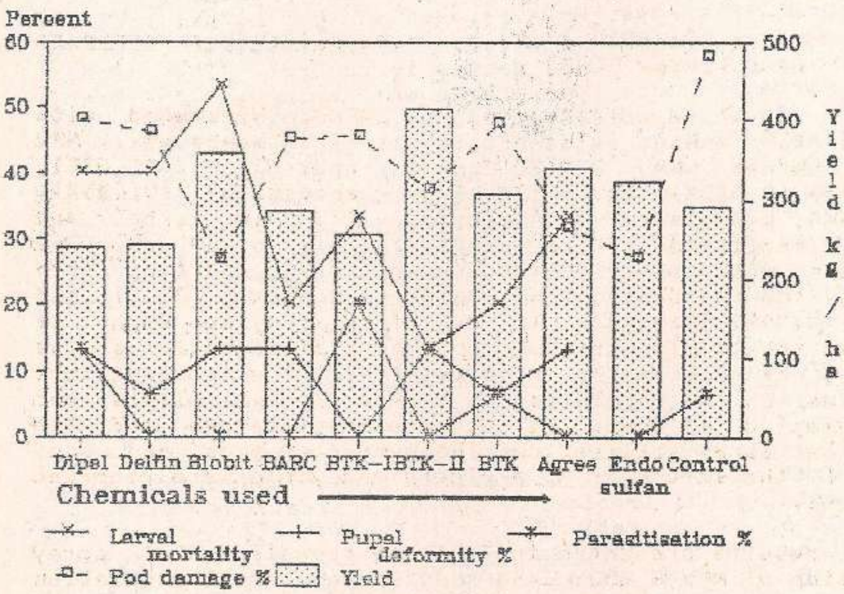


Fig. 26: Effect of formulations against *Helicoverpa* on pegionpea

commencing the first round at 50% flowering. The data collected were analysed statistically.

Until third round of spray with different treatments, all the B. t. formulations were found superior to control in reducing podborer damage which ranged from 5.1 to 8.6 per cent as against 7.4% in control. But, before the fourth round of spray, the pod borer damage recorded indicated that all the treatments were found to be at par .

The damage by pod borers recorded at harvest revealed that Delfin, Dipel and BTK were at par with each other in reducing pod borer damage to an extent of 20.9, 27.5 and 30.0 respectively while BTT I, BTK II, endosulfan 0.07 %, B.t. BARC strain, and Biobit recorded the incidence of pod borer to an extent of 31.6, 33.8,34.2,, 36.6 and 38.0 per cent respectively and were all on par with each other.

The yield data among the treatments were not significant. However, BTK I recorded higher yield (1239 kg/ha) followed by BTT II (1217 kg/ha), Biobit (1183 kg/ha) endosulfan (0.07%) (1133 kg/ha) and Dipel (1111 kg/ha) as against 661 kg/ha in control (Table 59).

1.3.5.5. Effectiveness of NPV against Helicoverpa armigera in chickpea.

Field trial was conducted at APAU, Hyderabad with chickpea (var. Annegiri) comprising six treatments viz., NPV @ 250 LE/ha; NPV @ 125 LE/ha, endosulfan (0.07%), endosulfan (0.035%), NPV @ 125 LE/ha + endosulfan (0.035%), Dipel 100 kg/ha, BYK-I 1.0 kg/ha, BTT 1.0 kg/ha. and control, replicated thrice with a plot size of 50 m2. The treatments were given during evening hours starting from noticing the incidence of H. armigera. Ranipal (0.1%) and jaggery (0.05%) were added to NPV before spraying. Spray of all these treatments was given only once after noticing the incidence of gram pod borer in the field. The observations were made on the population of larvae from 15 plants per plot selected at random in each treatment before and ten days after spray application. The number of pods and pods damaged by the larvae of H. armigera and yield were recorded at harvest.

The results presented in Table 60 revealed that spray application of NPV @ 250 LE/ha reduced the larval population significantly to a maximum of 83.3% followed by NPV @ 125 LE/ha (75%) and NPV @ 125 LE + Endosulfan 0.035% (63.9%). The B.t. formulations viz, Dipel 1.0 kg/ha, BTK-II 1.0 kg/ha and B.T.T. 1 kg/ha could not significantly reduce larval population. BTK-I at 1.0 kg/ha was found to be capable of reducing the larval population significantly Since the pest

Table 59. Data on the damage by pod borers and yield of redgram (CO 6) - Rabi, 1993

Treatments	Pod borer damage (%) before spray round				Final count at harvest	Yield (kg/ha)
	I spray	II spray	III spray	IV spray		
Dipel 500 g/ha	2.4	4.0[ab] (11.54)	6.7[ab] (15.0)	11.3 (19.64)	27.5[a] (31.63)	1111
Delfin 500 g/ha	3.4	3.1[ab] (10.14)	6.9[ab] (15.23)	7.1 (15.45)	20.9[a] (27.20)	905
Biobit 500 g/ha	4.0	2.9[ab] (9.80)	7.2[ab] (15.56)	8.9 (17.36)	38.0[b] (38.06)	1183
B. t. BARC strain	4.2	3.2[ab] (10.30)	5.8[ab] (13.94)	11.9 (20.18)	36.6[b] (37.23)	828
BTK I 500 g/ha	5.9	2.8[ab] (9.63)	6.3[ab] (15.54)	9.3 (17.76)	30.0[a] (33.21)	1239
BTK II 500 g/ha	4.2	5.2[b] (13.18)	5.1[a] (13.05)	10.4 (18.81)	33.8[b] (35.55)	967
BTT 500 g/ha	5.0	2.6[a] (9.28)	8.6[a] (17.05)	8.8 (17.26)	31.6[b] (34.20)	1217
Endosulfan (0.07%)	4.1	2.5[a] (9.10)	7.5[a] (15.89)	9.1 (17.56)	34.2[b] (35.77)	1133
Control	6.6	12.2[c] (20.44)	17.4[c] (24.65)	15.4 (23.11)	62.6[c] (52.30)	661

population was reduced, no further spray application was given. Regarding pod damage and yield, no significant differences were recorded among the treatments. These results indicate that NPV @ 250 LE/ha was found to be effective in reducing *H. armigera* on chickpea.

Table 60. Effect of NPV against *Heliocoverpa armigera* on chickpea

Treatment	Mean larval population/ 15 plants		Reduction of population over control (%)	Mean pod damage (%)	Yield (kg/ha)
	Pre-treatment	10 days after treatment			
NPV @ 250 LE/ha	9.67	0.33	83.3 (75.0)	10.77	164
NPV @ 125 LE/ha	9.00	0.67	75.0 (65.0)	9.76	138
Endosulfan 0.07%	12.00	1.33	52.8 (46.7)	7.52	180
Endosulfan 0.035%	9.00	1.33	52.8 (46.7)	11.49	171
NPV @ 250 LE/ha + Endosulfan 0.035%	9.33	1.00	63.9 (53.2)	8.04	217
Dipel 1.0 kg/ha	15.00	1.67	41.7 (35.0)	11.44	168
BTK-I 1.0 kg/ha	14.00	1.33	44.4 (41.7)	9.88	173
BTK-II 1.0 kg/ha	11.67	1.67	36.1 (36.7)	7.76	242
BTT 1.0 kg/ha	12.67	2.00	33.33(30.0)	10.73	219
Control	12.00	3.00	0.0 (0.0)	10.07	184
CD at 5%			(36.8)		

1.3.5.6. Effectiveness of HaNPV against *Helicoverpa armigera* on chickpea

An experiment was conducted in a randomized block design with 9 treatments, replicated thrice with the plot size of 40 m^2 at S.S. Kulam in farmer's holding (Tamil Nadu). The treatments consisted of:

(i) HaNPV 125 LE/ha + Teepol (0.5%)
(ii) NPV 250 LE/ha + Teepol (0.5%)
(iii) NPV 125 LE/ha + jaggery(0.5%)
(iv) NPV 250 LE/ha + jaggery(0.5%)
(v) NPV 125 LE/ha + jaggery(0.5%) + Endosulfan (0.035%)
(vi) NPV 125 LE/ha + Endosulfan (0.035%)
(vii) Endosulfan (0.035%)
(viii) Endosulfan (0.07%)
(ix) Control

Three rounds of sprays were given at 10 day intervals, commencing the first round from the stage of 50% flowering. The larval population was recorded from 10 plants per plot before each round of spray. Podborer damage was assessed by counting affected pods and total number of pods from 10 plants selected at random per plot and yield data was collected seperately at harvest.

Upto the second spray, all the treatments were superior to control in reducing population of H. armigera . Before the third spray, HaNPV 125 LE/ha + jaggery (0.5%) + endosulfan (0.035%) recorded less population of larvae/plant. The pod borer damage at harvest indicated that spraying of endosulfan (0.07%) recorded less percentage of pod damage 3.8% followed by NPV 125 LE/ha + jaggery 0.5% + endosulfan 0.035% (4.4%), HaNPV 250 LE/ha (4.8%), HaNPV 250 LE/ha + jaggery 0.5% (4.9%). HaNPV 125 LE/ha + endosulfan 0.035% (5.7%) as against 21.2% control. With regard to yield HaNPV 250 LE/ha recorded the maximum yield of 1310 kg/ha followed by HaNPV 125 LE/ha + jaggery 0.5% + endosulfan 0.035% (1222 kg/ha), endosulfan 0.07% (1105 kg/ha) and HaNPV 125 LE/ha + endosulfan 0.035% (1018 kg/ha) as against 580 kg/ha in untreated check (Table 61).

1.3.5.7. Monitoring of pod borer, Helicoverpa armigera with pheromone traps.

In order to monitor the pod borer, H. armigera , four pheromone traps were installed in pigeonpea field sown in the first week of August 1993 at Rajendranagar/Hyderabad. Pheromone traps were installed at one meter height above the ground level. The male moths caught in the traps were removed and counted daily starting from the first week of August and continued upto January 1994. The Pheromone dispenser was changed with a fresh one, once in three weeks. The information relating to the moth captures/week and egg and larval population from 20 plants in five locations from the field were collected at weekly intervals and presented in the Table 62.

Male moths of H. armigera started appearing on pigeonpea from 2nd week of August and reached a peak by 2nd week of September (84.5 moths/trap/week) and continued upto 4th week of September. Two weeks after noticing the peak moth population, that is in the first week of October, egg population of pod borer was observed in the field which synchronized with the peak flowering period of pigeonpea. Maximum population (108/20 plants) was recorded in the first week of October and subsequently declined steadily. The larval population to the maximum extent (67/20 plants) was noticed from the 2nd week of October.

Table 61. Evaluation of *Helicoverpa armigera* NPV and endosulfan against *H. armigera* on chickpea - Rabi, 1993

Treatment	Initial population	Larval count per plant before I spray	II spray	III spray	Pod borer damage at harvest (%)	Yield (kg/ha)
HaNPV 125 LE/ha + Teepol (0.5%)	0.5	0.20[a]	0.14[a]	0.47[ab]	6.8[c] (16.22)	830[cde]
HaNPV 250 LE/ha + Teepol (0.05%)	0.5	0.27[a]	0.10[a]	0.60[ab]	4.8[ab] (12.66)	1310[a]
HaNPV 125 LE/ha + jaggery (0.05%)	0.5	0.20[a]	0.10[a]	0.63[ab]	6.3[b] (14.54)	980[bcde]
HaNPV 250 LE/ha + jaggery (0.05%)	0.6	0.23[a]	0.10[a]	0.67[ab]	4.9[ab] (12.79)	688[e]
HaNPV 125 LE/ha + Jaggery (0.05%) + Endosulfan (0.035%)	0.8	0.30[a]	0.17[a]	0.43[a]	4.4[ab] (12.11)	1225[ab]
HaNPV 125 LE/ha + Endosulfan (0.035)	0.6	0.23[a]	0.20[a]	0.73[b]	5.7[ab] (13.81)	740[ef]
Endosulfan (0.036%)	0.5	0.37[a]	0.17[a]	0.67[a]	5.2[abc] (13.18)	1018[abcd]
Endosulfan (0.07%)	0.7	0.40[a]	0.20[a]	0.73[b]	3.8[a] (11.24)	1105[abc]
Control	0.7	1.00[b]	1.11[b]	2.13[c]	21.2[d] (27.42)	380[f]

(Figures in parentheses are arcsin transformed values)

Table 62. Monitoring of gram pod borer (H. armigera) through pheromone traps

Month and week		Moth captures/ trap/week	No. of eggs/ 20 plants	No.of larvae/ 20 plants
August 1993	I week	0	-	-
	II week	0.25	-	-
	III week	0.50	-	-
	IV week	6.00	-	-
September	I week	30.25	-	-
	II week	84.50	-	-
	III week	25.50	-	-
	IV week	58.50	-	-
October	I week	12.75	108	0
	II week	6.50	8	67
	III week	6.25	22	15
	IV week	0.25	5	31
November	I week	0	10	9
	II week	0	0	3
	III week	0	0	8
	IV week	0	0	2
December	I week	0	0	2
	II week	0	-	-
	III week	2.25	-	-
	IV week	3.25	-	-
January 1994	I week	1.00	-	-
	II week	0	-	-
	III week	5.50	-	-
	IV week	9.0	-	-

The second brood emergence, though not distinct was observed, as evidenced by the moth capture, on the 4th week of September and continued upto 3rd week of October and subsequently declined. The eggs and larvae of H. armigera were in large numbers to some extent in 3rd and 4th week of October, respectively and the larval population to a lesser extent continued upto 4th week of November.

During the season 53.4% pod damage due to Heliothis on pigeonpea was recorded at Rajendranagar, Hyderabad.

1.3.6. BIOSUPPRESSION OF RICE PESTS

1.3.6.1. Qualitative and quantitative estimation on the seasonal prevalence of natural enemies of rice pests

Fixed plot survey was conducted at Coimbatore to identify the natural enemies of rice stem borer. The egg parasitoids were recorded from April 1993 to March 1994 on eggmass basis and egg basis. Among the egg parasitoids, *Tetrastichus schoenobii* was found to be dominant followed by *Telenomus rowani* and *T. japonicum* parasitizing to an extent of 28.1, 25.9, and 5.2 per cent respectively. The maximum activity of *T. schoenobii* was observed during June (61.9%) whereas in *Telenomus rowani*, its activity was more in December (52.1 %). The extent of parasitism recorded due to *T. japonicum* was higher during June - July (10.6 %). The total parasitism by the three parasitoids on eggmass basis was found to range from 26.85 to 83.6 per cent during April 1993 to March 1994. The total parasitism was higher in the months of December (83.6%), March (76.9%), November (71.1%), October (69.3%), January (63.3%) and September (61.0 %) (Table 63).

Table 63. Parasitism by egg parasitoids on eggs of stemborer (1993-94)

Month (1993-94)	Parasitism (egg basis) by			Total Parasitism on egg mass basis (%)
	Tetrastichus schoenobii	*Telenomus rowani*	*Telenomus japonicum*	
April	27.1	9.6	2.5	38.9
May	8.9	8.8	8.5	26.8
June	61.9	18.0	10.6	46.4
July	35.7	42.3	9.5	48.3
August	19.4	9.8	8.5	35.1
September	36.7	30.0	6.5	61.0
October	31.5	30.1	3.5	69.3
November	23.3	32.4	2.5	71.1
December	31.5	52.1	0.5	83.6
January	28.6	39.3	5.0	63.3
February	16.8	14.2	2.1	60.4
March	16.3	24.0	2.5	76.9
Mean	28.1	25.9	5.2	56.8

1.3.6.2. Assessment of population dynamics of pests of rice and their natural enemies under field condition

An observational trial was laid out during kharif 1993 with two treatments as need based application of insecticides and control replicating seven times using the variety IR 20 at Coimbatore. Observations were made on the incidence of dead hearts, white ears and population of spiders on 30 and 50 DAT (Days after transplanting). Need based spraying of phosphamidon @ 300 ml/ha was given twice on 23 and 45 DAT when deadhearts exceeded 10% and yield data was recorded at the time of harvest.

The results of the trial revealed that spraying of phosphamidon @ 300 ml/ha as need based on 23 and 45 DAT recorded less percentage of deadhearts and whiteears due to stemborer when compared to control. The data on the population of wolf spider, (L. pseudoannulata) and web spider (Tetragnatha javana) were found to be non significant indicating that phosphamidon was not toxic to both the spiders, but yield recorded from the plots treated with phosphamidon (Table 64) was more.

Table 64. Effect of insecticides on incidence of pests and spiders (Kharif, 1993)

Variety: IR 20

Pest	Treatment: Chemical (ETL based)	Treatment: Untreated check	't' test of significance Yes/No
Stem borer			
Dead hearts (%)			
23 DAT	6.3	7.5	-
30 DAT	9.8	12.0	Yes
50 DAT	6.6	11.2	Yes
White ears (%)	4.3	2.6	Yes
Spiders			
Wolf spider(Lycosa pseudoannulata)			
23 DAT	0.31/hill	0.43/hill	-
30 DAT	0.65/hill	0.54/hill	No
50 DAT	0.70/hill	0.65/hill	No
Web spider(Tetragnatha javana			
50 DAT	0.60/hill	0.45/hill	No
Yield (kg/ha)	5290	4576	Yes

1.3.6.3. Evaluating the efficiency of *Trichogramma japonicum* against stem borer

1.3.6.3.1. (Kharif, 1993)

An experiment was conducted in a confounded block design with four treatments and seven replications with the variety IR 50 at Agricultural Research Station, Aliyarnagar (Tamil Nadu). The treatments consisted of

(i) Release of *T. japonicum* @ 1,00,000/ha at weekly interval from 30 DAT (5 times)
(ii) Release of *T. japonicum* @ 1,00,000/ha (4 times) followed by spraying phosphamidon @ 300 ml/ha on 37 DAT
(iii) Need based application of phosphamidon 300 ml/ha on 30 and 57 DAT and
(iv) Control.

Observations were made on the deadhearts (DH) by counting the total tillers and affected tillers from 10 hills / plot at weekly intervals from 30 DAT to 51 DAT and on white ears, a week before harvest and yield data at harvest.

The data on the incidence of stem borer (deadhearts), white ears and yield were analyzed statistically and the results are presented in table 61. The data revealed that release of *T. japonicum* @ 1,00,000/ha was on par with release of parasitoids followed by spraying of phosphamidon @ 300 ml/ha in reducing the number of dead hearts upto 44 DAT. However, on 51 DAT, need based application of phosphamidon (twice) was superior to the earlier two treatments in reducing the incidence of stemborer. With regard to white ears release of parasitoid and spraying of phosphamidon was superior to other treatments (Table 65).

1.3.6.3.2. (Rabi, 1993).

An experiment was conducted in a confounded block design, with four treatments and 11 replications with the variety Co 45 in wetland at Coimbatore. The treatments consisted of

(i) Release of *T. japonicum* @ 5 cc/ha on 23. 30, 37 and 44 DAT and *T. chilonis* @ 5 cc/ha on 50,57,64,71 DAT
(ii) Release of *T. japonicum* on 23, 37 and 44 DAT and spraying phosphamidon 85 WSC @ 300 ml/ha on 30 DAT
(iii) Spraying of phosphamidon @ 300 ml/ha on 30 and 44 DAT against stemborer and
(iv) Control

Table 65. Data on the incidence of stemborer and yield (Var.IR 50)

Treatment	Deadhearts (%) (DAT) 30	37	44	51	White ears	Yield (kg/ha)
Release of T. japonicum @ 1,00,000/ha at weekly interval	7.2 (15.56)	6.6 (14.89)	2.9 (9.80)	4.0 (11.54)	5.6 (13.69)	6288
Release of T.japonicum @ 1,00,000/ha followed by spraying phosphamidon @ 300 ml/ha once	8.9 (16.64)	6.6 (14.90)	4.1 (11.68)	4.7 (12.52)	3.9 (11.39)	6293
Spraying of phosphamidon @ 300ml/ha twice on 30 and 37 DAT (ETL based)	12.0 (20.27)	9.8 (18.24)	3.0 (9.97)	2.2 (8.53)	4.5 (12.25)	6638
Control	10.9 (19.28)	9.0 (17.46)	9.7 (18.15)	9.4 (17.85)	8.6 (17.05)	5526
CD (P=0.05)	–	3.05	2.65	2.45	1.70	630

(Figures in parentheses are arcsin transformed values)

Observations were made on the deadhearts by counting the total number of tillers and effected tillers from 10 hills per plot at weekly intervals from 23 DAT to 50 DAT and white ears a week prior to harvest and yield data at harvest.

The results of the trial indicated that on 30 DAT, deadhearts were less (4.7%) in the plots treated with *T. japonicum* @ 5 cc/ha (4 times) which was on par with release of *T. japonicum* thrice and spraying of phosphamidon once. On 50 DAT, release of *T. japonicum* @ 5 cc (four times) and *T. chilonis* @ 5 cc (4 times) (Table 66) considerably reduced the population of the stem borer.

Table 66. Data on the incidence of stemborer and yield (Rabi, 1993) - Co.45

Treatment	Stemborer damage				Yield (kg/ha)
	Deadhearts (DAT) (%)			White ears (%)	
	23	30	50		
Release of *T. aponicum* on 23,30,37 and 44 DAT and *T. chilonis* on 50, 57,64,71 DAT @ 5 cc/ha	0.50 (4.05)	4.7[a] (12.52)	1.6[a] (7.27)	6.2[a] (14.42)	4972[b]
Release of *T. japonicum* on 23,37 and 44 DAT and phosphamidon @ 300 ml/ha on 30 DAT	0.33 (3.29)	6.1[a] (14.3)	2.5[a] (9.10)	7.2[a] (15.56)	5607[a]
Spraying of phosphamidon @ 300ml/ha on 30 and 44 DAT	0.98 (5.38)	16.7[b] (24.12)	4.3[a] (11.97)	9.7[b] (18.15)	5640[a]
Control	0.80 (5.13)	14.7[b] (22.57)	5.5[b] (13.56)	12.3[c] (20.53)	3680[c]

Figures in parentheses are arcsin transformed values

Figures superscribed with similar alphabets are not significantly different by DMRT at 5% level

1.3.6.4. Evaluation of *Trichogramma japonicum* for the control of rice stem borer, *Scirpophaga incertulas*

The effect of *Trichogramma japonicum* was studied under field conditions for the control of rice stem borer *Scirpophaga incertulas* at Ludhiana. The number of parasitoids released was 50,000/ha at ten days interval. The releases were made from 7th August 1993 and continued upto 28th september, 1993. An area of 0.5 ha was selected for *T. japonicum* releases and same size area was also kept as control without release. The incidence of borer from each field was observed from 10 units and each unit consisted of 5 randomly selected hills. The figures given in the Table 67 are based on 10 units.

Table 67. Effect of *Trichogramma japonicum* for the control of rice stem borer, *Scirpophaga incertulas*

Rate of release : 50,000/ha at 10 day intervals
Dates of release : August 7th, 17th & 27th
September 8th, 17th & 28th
Place of release : CHEEMA

Treatment	*Mean cumulative incidence of *S. incertulas* per unit during different months (Per cent plant attacked)							
	August			Mean	September			Mean
	7	17	27		8	17	28	
Released plot	1.9	3.0	4.2	3.0	4.5	5.4	5.5	5.1
Control	1.7	15.4	18.0	11.7	18.2	18.9	20.6	19.2

*Average. of 10 units and each of 5 hills

The cumulative incidence of *S. incertulas* varied from 1.9% to 5.5% from 7th August to 28th September in the *T. japonicum* released plot. The corresponding figures in the control plot varied from 1.7% to 20.6%. Recovery tests were also carried out from both the plots three times during August to September 1993. The *T. japonicum* was recovered from the release plot three times and the parasitism per cluster varied from 69.9% to 94.1% (Table 68).

The number of egg clusters found parasitized by *T. japonicum* were 15% on 8.9.93, 27% on 17.9.93, and 30% on 28.9.93. The *T. japonicum* was absent in the control. *Telenomus dignus* was recovered from both the plots and not much difference was observed in the rate of parasitism in both the plots.

1.3.6.4.1. Evaluating the efficacy of *Trichogramma japonicum* against paddy stem borer, *Scirpohpage incertulas* Walker

The experiment was laidout at Paddy Research Station, Vadgaon (Maval Dist) Pune during kharif, 1993 with a plot size of 0.2 ha / treatment with 10 replications with a subjective variety Ambemohor 157 on 26th August, 1993 with the following treatments.

Table 68. Recovery tests for *Trichogramma japonicum*

Date of recovery test	Egg cluster collected (No.)	Egg cluster parasitized (No.)	Parasitism/cluster(%) *Telenomus dignus*	Parasitism/cluster(%) *T. japonicum*
T. japonicum				
07.8.93	2	0	-	-
17.8.93	5	2	54.5(2)	-
27.8.93	8	3	48.5(3)	-
08.9.93	12	7	72.7(6)	94.1(1)
17.9.93	14	8	79.5(6)	67.9(2)
28.9.93	16	10	81.1(5)	92.2(5)
Control				
07.8.93	3	0	-	-
17.8.93	5	2	52.5(2)	-
27.8.93	8	4	47.6(4)	-
08.9.93	12	8	80.0(8)	-
17.9.93	15	9	76.2(9)	-
28.9.93	16	9	77.0(9)	-

Figures in parentheses are number of egg clusters parasitized

1. Biocontrol

The paddy plot measuring 0.2 ha was divided into 10 equal sub-plots and *Trichogramma japonicum* was released @ 50,000 adults/ha/release. In all, 7 weekly releases were made during the crop growth. At each release, a trichocard bit containing about 1000 parasitized eggs was stappled at the centre of each sub-plot.

2. Chemical control

Endosulfan (0.07%) was sprayed twice.

3. Control

For studying recovery of parasitoids, the laboratory reared egg cards of *Corcyra cephalonica* was stapled at each biocontrol sub plot, was collected back after 2 days and observed in the laboratory for working out percentage parasitization. The incidence of stem borer was meagre during early stage of paddy crop. The crop was harvested on 18th December, 1993. However, the data given on the white ear heads due to stem borer was recorded just prior to harvest and presented in table 69.

Table 69. Evaluating the efficacy of T. joponicum against paddy stem borer.

Treatment	Dose (ha)	Intensity of infestation (T/W)	Average infestation (%)	Control (%)	Parasitization in retrieved egg cards (%)
Biocontrol (*Trichogramma japonicum*)	50,000	2844/ 245	8.82 (17.15)	43.89	75
Endosulfan (0.07%)	0.07%	1894 283	13.74 (21.44)	13.74	-
Control	-	2027 330	15.74 (22.72)	-	-

CD (P = 0.05) 1.88

The statistical analysis of the data revealed that the treatment with Biocontrol i.e. release of egg parasitoid, *Trichogramma japonicum* @ 50,000 adults/ha/release was found to be the most effective and significantly superior to chemical control and control. The parasitoid, *T. japonicum* suppressed the paddy stem borer to the extent of 43,89% over control as against 13.74% in endosulfan (0.07 %). The observations on retrieved egg cards showed 75% parasitization.

1.3.6.5. Evaluating the efficacy of *Trichogramma japonicum* against stem borer

The field evaluation of *Trichogramma japonicum* against yellow stem borer was conducted in farmers field located in Kakajan (Assam). The inundative releases of *T. japonicum* were made @ 50,000/ha/week.

The parasitoids were released in the farmers field in the rice ecosystem 30 days after transplanting. The observation on the occurrence of dead hearts was taken at weekly intervals and a pre - harvest record in the form of white earheads was also taken to assess the late infestation of stem borer. The results presented in table 70 revealed that during Rabi 1993 the infestation of dead hearts due to stem borer prior to field release of the parasitoid ranged from 2.97% - 9.62%.

Table 70. Effect of <u>Trichogramma japonicum</u> on the incidence of stem borer (rabi 1993).

Treatment	Dead heart(%) Pre-released plot	Dead heart (%) after releases (weeks)						White ear heads
		1st	2nd	3rd	4th	5th	6th	(%)
<u>T.japonicum</u>	9.62	-	-	3.4	1.89	-	2.21	1.10
Chemical control	2.97	-	-	2.21	5.09	-	4.98	3.20
Control	6.38	-	-	3.39	8.46	-	4.17	3.36

- Records could not be taken due to flood.

After the first release of the parasitoid there was continuous rainfall and the rice field was submerged under flooded water. As a result, infestation record of stem borer could not be taken in the 1st, 2nd and 5th week after the field release. But in the remaining periods, the weekly record of infestation was taken. The data recorded on 4th week after the field release showed that percentage dead heart in <u>T. japonicum</u> released plot was 1.89 % against 8.46 % dead heart in the control plot (Table 71).

Table 71. Effect of <u>Trichogramma japonicum</u> on the incidence of yellow stem borer (kharif 1993).

Treatment	Dead heart(%) Pre-released plot	Dead heart (%) after releases (weeks)						White ear heads
		1st	2nd	3rd	4th	5th	6th	(%)
<u>T.japonicum</u>	6.25	3.92	2.67	1.45	1.74	1.91	3.37	1.22
Chemical control	5.81	2.89	5.81	4.88	3.01	4.28	5.86	5.07
Control	8.36	8.32	7.73	9.27	8.33	7.52	5.01	5.65

The dead heart population ranged from 1.45% - 3.92% in the parasitoid released plot against 5.01%-9.27% dead hearts in the control plot. The data clearly showed that though the dead heart population was low during kharif 1993, still the parasitoid could check the formation of dead heart in the released plot and the effectiveness of the parasitoid was superior to chemical control plot. As regards field recoveries of the parasitoids to low population of stem borer in the experimental area moths were collected from the field and confined in wire mesh cages with potted rice plants, the egg mass thus obtained in the laboratory were implanted in the rice leaves and exposed for 24 hours for parasitism and reared the egg masses in glass vials. The field recoveries of T. japonicum was 10% and 23.3% during rabi and kharif 1993 respectively (Fig. 27).

1.3.6.7. Studies on Trichogramma Japonicum and Trichogramma chilonis

Field level trial using T. japonicum and T. chilonis for the biosuppression of paddy stem borer was conducted at Government Agricultural Farm, Mannuthy (Kerala) October-January, 1993-94. However, the biological control treatment was on par with control in yield parameters (Fig. 28).

1.3.6.8. Effect of Allorhogas pyralophagus against rice stem borer

Allorhogas pyralophagus, an exotic larval parasitoid of Mexican origin was tested against rice stem borer in the farmers' field located in Kakajan (Assam). The parasitoid was released in rice ecosystem @ 625 females/ha commencing from 30 days upto 75 days after transplanting at weekly intervals. The data presented in table 72 revealed that the percentage dead heart formation in the parasitoid released plot ranged from 1.48% - 4.76% against 5.01% - 9.27% dead heart in the control plot. The lowest population of dead hearts was recorded on the day of 3rd release of the parasitoid 1.48% dead hearts against 9.27% dead heart in the control.

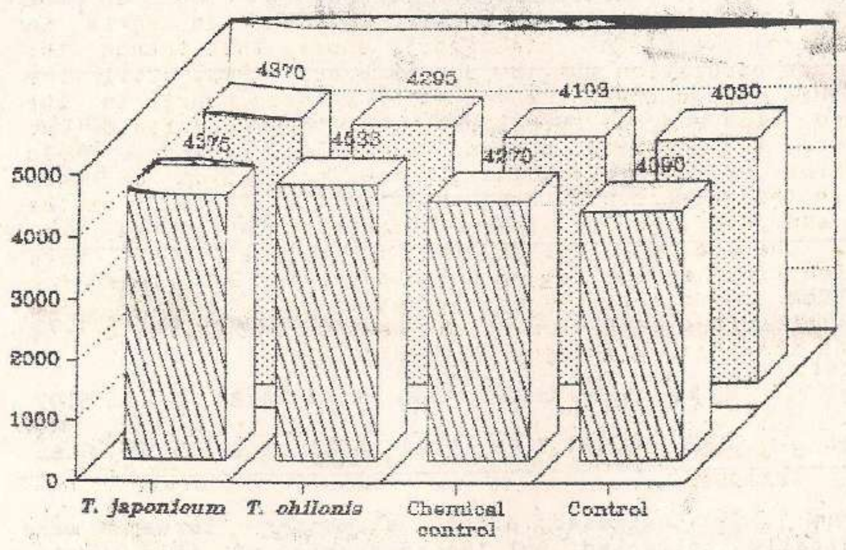


Fig. 27: Effect of *T. japonicum* and *T. chilonis* on the yield of paddy

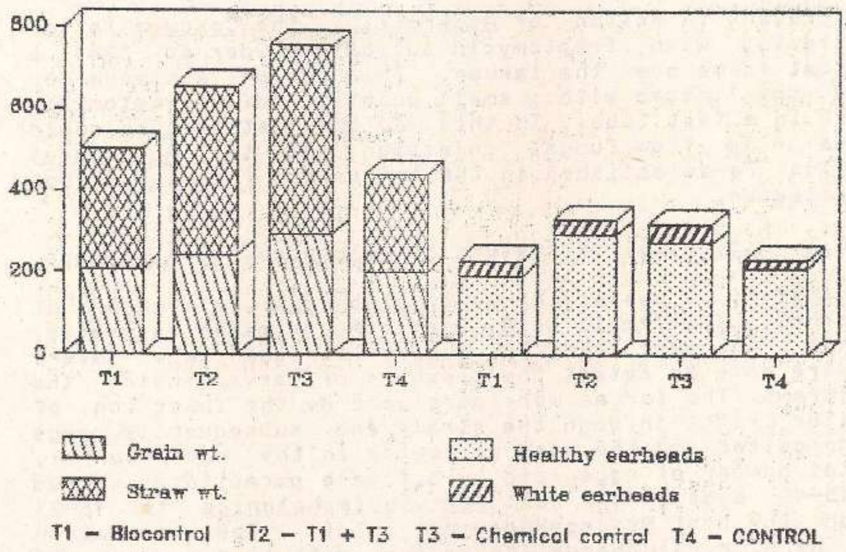


Fig. 28: Biocontrol of paddy stem borer using *T. japonicum* and *T. chilonis*

Table 72. Effect of Allorhogas pyralophagus on the incidence of yellow stem borer (kharif 1993)

Treatment	Dead heart(%) Pre-released plot	Dead heart (%) after releases (weeks)						White ear heads
		1st	2nd	3rd	4th	5th	6th	(%)
Allorhogas pyralophagus	4.09	2.80	2.80	1.48	3.77	3.40	4.76	1.90
Chemical control	5.81	2.89	5.81	4.88	3.01	4.28	6.86	5.07
Control	8.36	8.32	7.73	9.27	8.33	7.52	5.01	5.65

From the released plots, stemborer larvae were periodically collected, but the recoveries of this exotic parasitoid could not be made during kharif 1993. The evaluation of Allorhogas pyralophagus during rabi 1993 could not be made due to fungal infection.

1.3.6.8.1. Infection of Aspergillus flavus

To prevent infection of Aspergillus the Corcyra larvae were treated with streptomycin sulphate powder so that a fine coat forms over the larvae. This can be achieved by shaking the larvae with a small quantity of streptomycin sulphate in a test tube. In this way the host culture could be made free from fungal infection and the Allorhogas population re-established in the laboratory for subsequent field releases.

1.3.6.8.2. Biological parameters of Allorhogas pyralophagus

Biological parameters of A. pyralophagus was studied at AAU, Jorhat. The female of A. pyralophagus mated soon after emergence and were ready for oviposition two days later. They were able to detect the presence of larvae inside the paper straws. The larvae were paralyzed by the insertion of ovipositor right through the straws and subsequently eggs were deposited on the host or nearby in the host tunnel. The total number of eggs laid by a female parasitoid varied from 15-40 eggs on the host Corcyra cephalonica to 16-31 eggs on the host Scirpophaga incertulas. The incubation period of A. pyralophagus varied from 1.56 to 1.8 days on both the host C. cephalonica and S. incertulas. The parasite larvae fed externally throughout the development and as feeding progressed the host gradually collapsed. At completion of larval feeding, mature larvae spun an elongated cylindrical cocoon within the paper straw on or near the host remains in which they pupated. The pupal period ranged from 7 - 9.5 days on both the hosts. The total development period of the parasitoid on C. cephalonica and S. incertulas ranged from 12.06 - 14.84 days and 11.56 - 15.80 days respectively (Table 73).

Table 73. Duration in days of different stages of Allorhogas pyralophagus and sex ratio of progeny on Corcyra cephalonica and Scirpophaga incertulas

Host species	Incubation period (days)	Larval period (days)	Pupal period (days)	Sex ratio F : M	No.eggs laid/ female
Corcyra cephalonica	1.66 ± 0.03 (1.56 - 1.80)	3.71 ± 0.17 (3.00 - 4.04)	8.07 ± 0.23 (7.50 - 9.00)	1:0.20	25.50 ± 4.50 (15.00 - 41.00)
Scirpophaga incertulas	1.67 ± 0.06 (1.56-1.80)	3.73 ± 0.21 (3.00 - 4.50)	8.12 ± 0.45 (7.00 - 9.50)	1:0.23	20.90 ± 2.38 (16.00 - 31.00)

1.3.6.9. Parasitoids of leaf folders - Cnaphalocrocis medinalis and Marasmia patanalis

1.3.6.9.1. Leaf folders :

The extent of larval parasitism recorded during the period April 1993 to March 1994 on leaf folders due to different parasitoids at Coimbatore were recorded. The parasitoids, Trachoma cnaphalocrocis, Temelucha philippinensis, Xanthopimpla flavolineate, Brachymeria sp., Charops brachypterum, Elasmus sp. and Apanteles flavipes were recorded and the parasitism ranged from 2.3 to 7.0, 2.9 to 8.1, 0.2 to 11.3, 1.8 to 11.9, 0.2 to 1.4, 0.6 to 4.6 and 5.6 to 11.5 per cent respectively (Table 74).

Table 74. Extent of larval parasitism on the larvae of leaf folders (C. medinalis and M. patnalis)

Parasitoid	Period of activity	Extent of parasitism (%) (Range)
Trachoma cnaphalocrocis	April, June, August, October, November, December, January	2.3 to 7.0
Temelucha philippinensis	Throughout the year	2.9 to 8.1
Xanthopimpla flavolineate	April, September, October, January, March	0.2 to 11.3
Brachymeria sp.	May, June, August, September to March	1.8 to 11.9
Charops brachypterum	January	0.2 to 1.4
Elasmus sp.	May, August, October, January to March	0.6 to 4.6
Apanteles flavipes	July, August, September to December	5.6 to 11.5

1.3.6.9.2. Evaluation of Trichogramma chilonis for the control of rice leaf folder Chaphalocrosis medinalis

The effect of releases of Trichogramma chilonis was studied under field conditions at Ludhiana for the control of rice leaf folder Cnaphalocrocis medinalis. The T. chilonis was released @ 50,000 per ha at 10 days interval. The releases were started from 7th August, 1993 and continued upto 28th September, 1993. An area of 0.5 ha was selected for T. chilonis releases and same size plot without releases was kept as control. The incidence of the leaf folder was observed from 10 units and each unit consisted of five randomly selected plants and the data are presented in Table 75.

1.3.6.9.3.

Observations were taken on the experiment laid in wet lands at Coimbatore on the leaf folder damage by counting the total and affected tillers from 10 hills per plot at random at weekly interval from 51 to 78 DAT.

Table 75. Evaluation of Trichogramma chilonis for the control of Cnaphalocrocis medinalis

Rate of release : 50,000/ha at 10 day intervals
Dates of release : August 7th, 17th & 27th
September 8th, 17th & 28th
Place of release : CHEEMA

Treatment	*Mean cumulative incidence of C.medinalis per unit during different months (Per cent plant attacked)							
	August			Mean	September			Mean
	7	17	27		8	17	28	
Released plot	2.1	2.8	3.9	2.9	5.6	5.7	6.5	5.9
Control	2.9	5.4	9.6	6.0	11.0	12.2	13.5	12.2

*Average. of 10 units on each of 5 hills

The data presented in Table 75, revealed that the incidence of leaf folder in release plot varied from 2.1% to 6.5% from 7th August to 28th September. The corresponding figures in case of control plot varied from 2.9 to 13.5%.

The results of the trial conducted during Rabi 1993 indicated that leaf folder damage was less in both the treatments when compared to control and also gave more yield (Table 76).

1.3.6.9.4. Evaluating the efficacy of Trichogramma chilonis against rice leaf folder

The field evaluation of Trichogramma chilonis against rice leaf folder was conducted in farmers field located in Kakajan (Assam). The inundative releases of T. chilonis were made @ 50,000/ha/week. After the first release of the parasitoid there was continuous rainfall and the rice field was submerged under flooded water as a result infestation record of leaf folder could not be taken in the 1st, 2nd and 5th week after the field release but in the remaining periods, the weekly record of infestation was taken. The data recorded on 4th week after the field release showed that percentage leaf folder damage during rabi 1993 was low (0.78 to 1.63 %) (Table 77).

Table 76. Data on the incidence of leaf folder during rabi, 1993

(var. Co.45)

Treatment	Leaffolder damage(%) DAT 64	78
Release of *T. japonicum* on 23, 30,37 and 44 DAT and *T. chilonis* on 50,57,64,71 DAT @ 5 cc/ha	2.1[a] (8.33)	0.45[a] (3.85)
Release of *T. japonicum* on 23, 37 and 44 DAT and phosphamidon @ 300 ml/ha on 30 DAT	2.0[a] (8.13)	0.80[a] (5.93)
Spraying of phosphamidon @ 300 ml /ha on 30 and 44 DAT	2.8[a] (9.63)	2.1[a] (8.33)
Control	5.3[b] (13.31)	13.5[b] (21.56)

Figures in parentheses are arcsin transformed values

Figures superscribed with similar alphabets are not significantly different by DMRT at 5% level

Table 77. Effect of *Trichogramma chilonis* on the incidence of rice leaf folder *Cnaphalocrocis medinalis* (Rabi 1993)

Treatment	Pre rele-ased record (% LFD)	Leaf folder damage (%)after releases(weeks) 1st	2nd	3rd	4th	5th	6th
Trichogramma chilonis	1.25	-	-	1.63	0.78	0.80	0.83
Chemical control	1.16	-	-	3.24	1.78	3.31	2.77
Control	1.45	-	-	2.63	2.32	5.29	1.64

LFD : Leaf folder damage

Similarly during kharif 1993, the field releases were made with the same parasitoid at the same experimental location. The leaf folder population was (Table 78) very low and so proper evaluation could not made for the egg parasitoid *T. chilonis*.

Table 78. Effect of *Trichogramma chilonis* on the incidence of rice leaf folder, *Cnaphalocrocis medinalis* (Kharif, 1993)

Treatment	Pre released record (% LFD)	Leaf folder damage (%) after releases (weeks) 1st	2nd	3rd	4th	5th	6th
T. chilonis	2.96	0.77	0.68	0.42	0.85	1.58	3.55
Chemical control	1.34	1.84	1.36	2.69	2.28	4.05	1.46
Control	1.11	1.13	1.63	2.91	7.03	1.37	1.92

1.3.6.10. Evaluating the efficiency of mirid bug, *Cyrtorhinus lividipennis* against brown plant hopper

An experiment was conducted in a confounded block design, to evaluate the efficiency of mirid bug against BPH with three treatments, replicated seven times in wetlands with a variety IR 50 at Coimbatore. The treatments consisted of

(i) Release of 70 nymphs of second instar/m2 on 45th, 55th and 65th DAT
(ii) Application of carbofuran 3 G @ 33 kg/ha on 44 DAT after noticing the incidence of BPH.

Observations on the population of BPH, mirid bug from 44 to 72 DAT and of *Lycosa pseudoannulata* from 30 to 58 DAT and yield data were recorded at harvest.

The statistical analysis of the data revealed that release of mirid bug @ 70 nymphs/m2 thrice on 45,55 and 65 DAT and application of carbofuran 3 G @ 33 kg/ha on 44 DAT were on par in reducing the population of BPH and recorded higher yield but superior to control besides conserving the mirid bugs. The population of wolf spider, *Lycosa pseudoannulata* was on par among the treatments indicating the safety of carbofuran (3G) to the wolf spider (Table 79 and 80).

Table 79. Data on the population of brown planthopper

Treatment	Mean population of BHP/hill Days after transplanting (DAT)				
	44	51	58	65	72
Release of mirid bug @ 70/m2 on 45th,55th and 65th	1.28 (1.13)	1.21 (1.10)	0.62 (0.79)	0.48 (0.69)	0.38 (0.62)
Soil application of carbofuran 3 G @ 33 kg/ha on 44 DAT	1.04 (1.02)	0.98 (0.99)	0.83 (0.93)	0.31 (0.56)	0.74 (0.86)
Untreated check	0.90 (0.95)	0.94 (0.97)	2.04 (1.43)	1.37 (1.17)	1.04 (1.02)
CD (P = 0.05)	NS	NS	0.54	0.45	0.27

N.S.= Not significant

Table 80. Data on the population of mirid bug, wolf spider and yield

Tr. No.	Population of miridbug DAT (per hill)				Population of wolf spider/hill				Yield (kg)	
	51	58	65	72	30	44	51	58	Per plot $4m^2$	Per ha
1	0.85 (0.92)	2.31 (1.52)	1.61 (1.27)	1.85 (1.36)	1.15 (1.17)	1.32 (1.15)	1.06 (1.03)	0.77 (0.88)	2.99	7464
2.	0.77 (0.88)	1.15 (1.07)	0.90 (0.95)	0.87 (0.93)	0.96 (0.98)	1.12 (1.06)	0.83 (0.91)	0.83 (0.91)	3.19	7964
3.	0.72 (0.85)	1.77 (1.33)	1.25 (1.12)	1.39 (1.18)	1.30 (1.14)	1.06 (1.03)	0.96 (0.98)	0.76 (0.87)	2.26	5643
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	0.42	1050

1.3.6.11. Seasonal incidence of key natural enemies of rice hispa, Dicladispa armigera

Survey of natural enemies of rice hispa Dicladispa armigera was conducted in Dewan Gaon area of Kakajan and Disangmukh (Assam). The infested leaves were brought from hispa affected fields and reared in glass vials. The emergence of the parasitoids was recorded from the infested leaves, which contains egg,larval and pupal stages of hispa. It was felt difficult to rear the different stages of hispa individually and to work out the percentage parasitism by the different stages of natural enemies. The natural enemies recorded were Bracon hispa (Hymenoptera: Braconideae), Chrysonotomyia sp. (Hymenoptera: Eulophidae), Oligosita sp. (Hymenoptera : Trichogrammatidae) and Trichogramma sp. (Hymenoptera : Trichogrammatidae). Among the natural enemies mentioned larval parasitoid Bracon hispae and Chrysonotomyia sp. were dominant during both rabi and kharif 1993. In addition to the already identified species a few more species of parasitoids could be recovered from the larvae/pupae of hispa. These new species are under the process of identification.

1.3.7. BIOSUPPRESSION OF OILSEED CROP PESTS

1.3.7.1. Seasonal abundance of natural enemies of mustard aphid, *Lipaphis erysimi*

The survey in Punjab for the natural enemies (predators and parasitoids) of mustard aphid *Lipaphis erysimi* was carried out at different places from January to March, 1994. The studies on the natural enemies' population were based on randomly selected 5 units per field and each unit consisted of 5 cm twigs of two plants. The mustard aphid was observed in the middle of January and its number increased to a maximum of 295.2 ± 29.55 per two plants in the middle of February and thereafter it started declining by the end of March (17.6 ± 5.16 per two plants) (Fig. 29).

The observations on the natural enemies observed on it were initiated from 04-01-1994 (Fig. 29). No natural enemy was observed during 1st week of January and from 2nd week onwards the coccinellid beetles were found but their population was low till 1st week of February. However, from 2nd week of February to the end of March, 2 - 3 beetles per two plants were observed. The syrphids were observed from

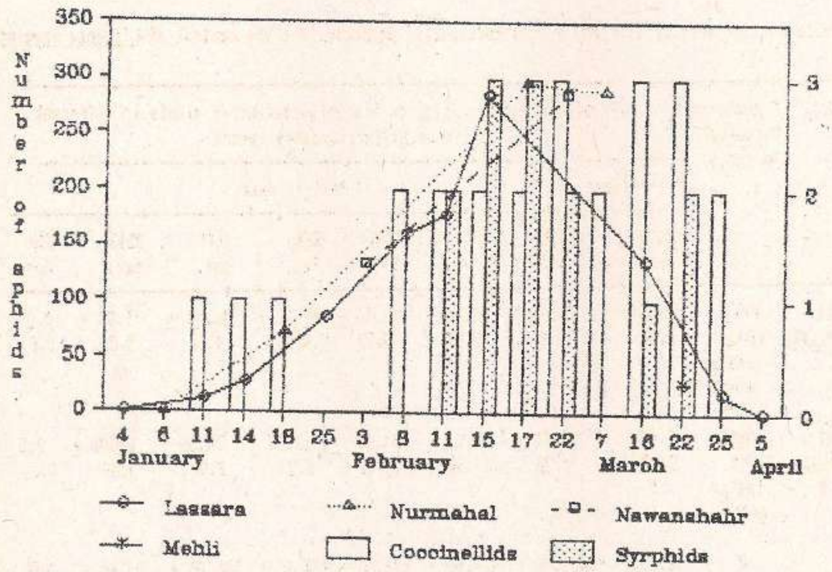


Fig. 29: Seasonal abundance of mustard aphid and their predators at different places of Punjab

2nd week of February to 3rd week of March. The parasitism by *Diaeretella rapae* was observed from first to last week of March and parasitism varied from 12 - 60 per cent. Among predators only one coccinellid, i.e *Coccinella septempunctata* and five species of syrphids., viz. *Episyrphus alternans*. *E. balteatus*, *Metasyrphus confractor*, *Scaevea latemaculata* and *Sparoporia indiana* were observed.

1.3.7.2. Field studies on the comparative efficacy of two coccinellid predators for the control of mustard aphid, *Lipaphis erysimi*

Experiment was laid out near the village Lassara (Punjab) to study the comparative efficacy of two species of coccinellid predators *viz*., *Coccinella septempunctata* and *Menochilus sexmaculatus* for the control of mustard aphid, *Lipaphis erysimi*. Three fields of mustard crop of the same stand and each plot measuring 0.4h and separated by about 0.5km were selected. The second instar larvae of *C.septempunctata* and *M.sexmaculatus* were released in two separate plots and a third plot without release to serve as control. The releases were made @ 1000 larvae/h on 11-01-1994. The pre-release observation on the population of *L. erysimi* were recorded on the same day (Table 81).

Table 81. Comparative efficacy of two coccinellid predators for the control of *Lipaphis erysimi*

Treatment	Predators released/ ha (no.)	Population of *L.erysimi* on 5cm inflorescence/2 plants in different units on different dates (mean)							
		Pre-release	Post-release						
		11th Jan.	25th Jan.	8th Feb.	15th Feb.	22nd Feb.	16th Mar.	25th Mar.	5th Apr.
Coccinella Septempunctata	1000 (2nd instar grubs)	12.00 ± 2.00	54.80 ± 5.81	43.40 ± 10.07	38.40 ± 9.97	47.20 ± 9.55	46.14 ± 4.58	19.00 ± 5.36	0.0 ± 0.0
Menochilus sexmaculatus	1000 (2nd instar grubs)	12.40 ± 2.87	70.80 ± 11.30	69.60 ± 11.34	81.60 ± 12.46	83.00 ± 8.31	74.80 ± 8.93	20.40 ± 4.40	0.0 ± 0.0
Control	0	13.60 ± 3.72	107.20 ± 12.89	127.80 ± 5.14	176.60 ± 9.55	274.60 ± 27.26	186.20 ± 4.62	91.40 ± 11.10	0.0 ± 0.0

Pre-release observations were recorded before releasing predators on 11-01-1994

The observations were recorded from randomly selected plants from 5 units per plot and each unit consisted of two plants. inflorescence/twig/plant of 5cm height was observed for counting the population of aphids. It is revealed from the data presented in table 80 that the pre-release mean population of the aphids/2 plants was 12.0 ± 2.0, 12.4 ± 2.87 and 13.6 ± 3.72 in plots selected to release C. septempunctata and M.sexmaculatus and the control respectively. Thereafter the maximum population was observed in the last week of February in plots where C.septempunctata and M.sexmaculatus grubs were released and in the control plot it was 47.2 ± 9.55, 83.0 ± 8.31 and 274.6 ± 27.26 respectively. Then the population started declining in all the three plots and the minimum population recorded in the last week of March in three plots was 19.0 ± 5.36, 20.4 ± 4.40 and 91.4 ± 11.1 in the same sequence. Aphids were not seen in all the three plots during the first week of April, 1993. The data showed that C.septempunctata was the best to control the aphid when compared to M.sexmaculatus but population was much less in both the plots where predators were released as compared to the control plots.

1.3.7.3. Laboratory studies on the feeding capacity of two coccinellid predators

Feeding capacity of the grubs of Coccinella septempunctata and Menochilus sexmaculatus was studied in laboratory by using aphid, Lipaphis erysimi as host. The number of aphids of uniform size consumed by the different larval instars of the two species were recorded and the data are presented in table 82. The data showed that the number of aphids consumed by the larvae increased with the age of the grub and the number of aphids consumed by I,II,III and IV instar grubs of M.sexmaculatus were 28.20 ± 10.49, 55.40 ± 6.11, 105.60 ± 12.42 and 115.10 ± 6.07 respectively. The corresponding figures for Coccinella septempunctata were 31.60 ± 7.92, 82.10 ± 10.51, 128.90 ± 9.38 and 137.80 ± 6.61. The total number of aphids consumed by the larval stage of M. sexmaculatus and C. septempunctata were 304.3 ± 35.75 and 380.40 ± 42.32 respectively.

At APAU, Hyderabad a trial was laidout with three treatments viz., (i) M. anisopliae @ 0.5 kg/ha (ii) B. popillae @ 0.5 kg/ha and (iii) control replicating seven times with a subjective variety ICGS-II of groundnut for testing against whitegrubs. The treatments were initiated by mixing with farm yard manure and then applied once in the furrow along with seed. The initial grub population was recorded while ploughing. The germination percentage, plant mortality at 15 days interval and at the termination of experiment, the plant stand and yield were recorded (Table 83).

Table 82. Laboratory studies on feeding capacity of grubs of two coccinellid predators

Predator	Feeding capacity of different instars (grubs)*				Total feeding capacity of grubs (Mean ± SD)
	I	II	III	IV	
Menochilus sexmaculatus	28.20 ± 10.49	55.40 ± 6.11	105.60 ± 12.42	115.10 ± 6.07	304.30 ± 35.75
Coccinella septempunctata	31.60 ± 7.92	82.10 ± 10.51	128.90 ± 9.38	137.80 ± 6.61	380.40 ± 42.32

* Average of 4 replications; SD : Standard deviation

Note : Uniform sized aphids were used throughout the experimental period

Table 83. Effect of _Metarhizium anisopliae_ and _Bacillus popilliae_ against white grub in Groundnut

Treatment	Initial grub population (m2)	Germination (%)	Plant mortality germination after(%)						Total mortality	Plant stand (%)	Yield (kg/ha)
			15	30	45	60	75	90			
M. anisopliae (0.5 kg/ha)	2.00	85.30	9.94	5.57	5.62	3.51	0.69	0.60	25.93	74.07	1209
B. popilliae (0.5 kg/ha)	2.28	83.86	12.14	5.50	6.49	0.96	0.35	0.41	25.85	74.14	1286
Control	2.43	85.82	15.99	5.80	7.55	0.81	0.45	2.22	32.82	67.18	1251
F test	NS		-	-	-	-	-	-	NS		NS

1.3.7.4. Testing of *Metarhizium anisopliae* and *Bacillus popillae* against white grub on groundnut.

The results presented in Table 83 revealed that the per cent plant mortality in the initial stage of the crop upto 45 days after germination was found to be high in all the treatments and at the later crop growth stage, the percentage plant mortality declined. Totally 25.93%, 25.85% and 32.82% plant mortality was recorded in the plots treated with *M. anisopliae*, *B. popilliae* and control respectively at all crop growth stages combined . However , there was no significant differences among the treatments. With regard to plant stand recorded at the termination of experiment, much differences among the treatments was not noticed. In respect of yield also, no significant differences were recorded among the treatments.

In order to confirm the infectivity of *M. anisopliae* and *B. popilliae* , periodical observations made at some pockets in the field revealed that the grubs remained active.

In a laboratory test conducted in pot culture also the grubs remained active and both these agents failed to infect and kill the grubs and finally the grubs entered into pupation. These results indicate that neither *M. anisopliae* nor *B. popilliae* effective against white grub of groundnut at 0.5 kg/ha.

1.3.7.5. Microbial control of castor semilooper, *Achaea janata*

At APAU, Hyderabad, an experiment was conducted to study the effect of certain microbial agents (NPV and Dipel) against castor semilooper, *Achaea janata*. There were eight treatments including control. The treatments and dosage are indicated in Table 83. Ranipal 0.1% and Jaggery 0.5% were added to NPV before spraying. The spray applications were given in the evening hours at the early larval stage of the pest. The observations on the population of larvae before and 10 days after spray application were made from five randomly selected plants in each treatment. Two days after spray application , ten larvae from each treatment were collected and reared in the laboratory to record the mortality due to natural parasitization.

The results presented in the table 84 indicated that spray application of Dipel at 0.5 and 0.75 kg/ha has reduced the larval population completely (100%). Dipel at 0.25kg/ha also significantly reduced the larval population to 94%. Spray application of NPV at 250 LE/ha, 125 LE/ha and 125 LE/ha + endosulfan 0.035% also resulted in significant reduction of larval population ranging from 75%, 80.7% and

82.4% respectively. NPV treatment at all these dosage was as effective as Endosulfan 0.07%.

The activity of the parasitoid Microplitis maculipennis was found to be high in all the treatments except in insecticide treatment plot. Application of either NPV or Dipel at all dosages has not affected the activity of M. maculipennis.

With regard to yields no significant differences were observed. However, comparatively increased yield were from the plot treated with NPV 125 LE/ha + Endosulfan 0.035% (1735 kg/ha) followed by NPV 125 LE/ha (1568 kg/ha).

These results indicated that dipel at 0.5 and 0.75 kg/ha was found to be highly effective followed by NPV 125 LE/ha + Endosulfan 0.035% without affecting the natural parasitoid activity. However, these results will be confirmed in the ensuing season.

Table 84. Effect of microbial agents against Achaea janata

Treatment	Pretreatment population larvae/ 5 plants	Activity of parasitoids	Larval population 10 days after treatment	Reduction of larval population (%)	Yield (kg/ha)
NPV @ 250 LE/ha	29.00	33.33	1.00 (1.33)	75.0 (70.0)	1469
NPV @ 125 LE/ha	23.33	40.00	1.00 (1.33)	80.7 (68.2)	1568
NPV @ 125 LE + Endosulfan 0.035%	20.33	26.67	1.00 (1.41)	82.4 (65.5)	1753
Endosulfan 0.07%	24.67	0.0	1.00 (1.33)	83.3 (75.0)	1346
Dipel 0.25 kg/ha	34.00	13.33	0.33 (1.14)	94.4 (82.0)	1383
Dipel 0.50 kg/ha	25.67	30.00	0.0 (1.00)	100.0 (90.0)	1383
Dipel 0.75 kg/ha	26.67	20.00	0.0 (1.00)	100.0 (90.0)	1358
Control	21.33	46.67	6.33 (2.68)	0.0 (0.0)	1185
CD at 5%	NS	-	(0.62)	(29.49)	NS

Figures in parentheses are transformed values.

1.3.7.6. Studies on the management of groundnut aphid

An observational trial was laidout at Rahuri (Maharastra) for the control of groundnut aphid using the predator Chrysoperla carnea and the results obtained are presented in Fig. 30. The predatory chrysopid could not effectively controll aphids on groundnut however, the same experiment will be repeated in the next season with a higher dosage.

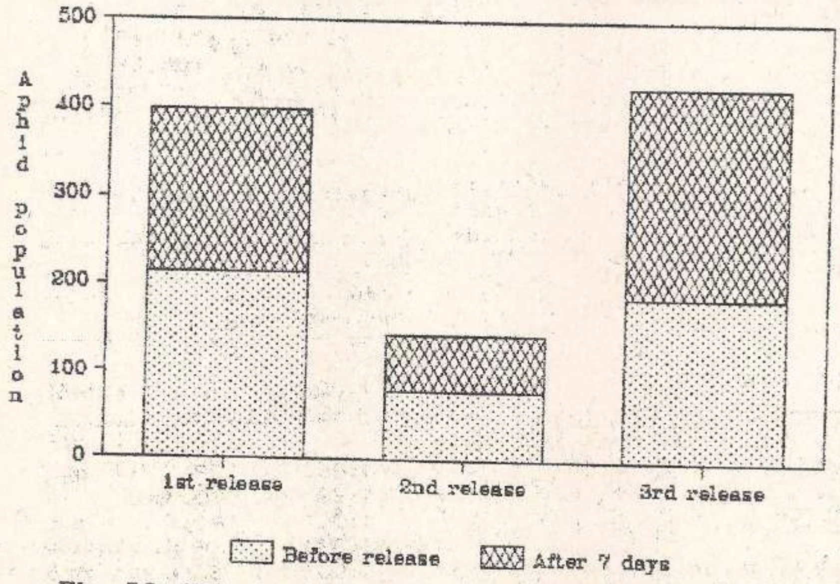


Fig. 30: Effect of *Chrysoperla carnea* on the aphid population in groundnut

1.3.7.7. Laboratory evaluation of chrysopids against aphid pests of rapeseed mustard, safflower and groundnut.

The culture of safflower aphid, Uroleucon carthami was brought from Agricultural Research Farm, (UAS), Annigeri and cultured on safflower plants at Project Directorate, Bangalore. The results revealed that M. boninensis consumed least number (126) of aphids whereas M. astur the highest (139). C. carnea consumed 133 aphids. The corresponding developmental period was 22-23 days in C. carnea, 23-30 days in M. boninensis and 32-42 days in M. astur. Further it was observed that male chrysopid larvae consumed less number of aphids (97 to 110) than the female larva (145 to 149).The studies indicated that this species of aphid is not preferred as a host for chrysopids as more than 50 per cent of the chrysopid larvae used for rearing on this species of aphid died without pupating.

Rapeseed mustard seedlings had the incidence of Lipaphis erysimi and this aphid was not preferred by all the species of chrysopids tested. Groundnut seedlings sown were free from the aphid incidence and will be retested during the next season.

1.3.8. BIOLOGICAL SUPPRESSION OF COCONUT PESTS

1.3.8.1. Mass multiplication of *Apanteles taragamae*

Techniques were standardized at Kerala for the laboratory multiplication of the endoparasitoid *Apanteles taragamae* parasitizing the second instar caterpillars of *Opisina arenosella* under laboratory conditions.

A. taragamae completed its life cycle in 10-25 and 11 - 24 days in case of male and female respectively. The adult longevity varied from 4 - 21 (male) and 4 - 22 (female) days and the percentage of parasitism was 51 and ratio for male to female was 1:1.2 at an average temperature of 26°C and 65% relative humidity.

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

Field experiment on the evaluation of the performance of the laboratory reared bethylid, elasmid and chalcidid parasitoids showed parasitism @ 20.5%, 49.4% and 31.9% respectively at Thodiyoor centre, Kollam Dist. (Kerala). Observations on the population of *O. arenosella* and the associated natural enemies were recorded. Results are presented in Fig.31. Data revealed that significant reduction in the incidence of the pest was noticed as compared to the pre-release condition. There was also an increased percentage of parasitism (25%) in the released plots as compared to low percentage in the pre-released condition.

Another experimental centre was selected at Kottepura, near Ullal. Dakshina Kannada, Karnataka, for the release of parasitoids for the control of *O. arenosella*, where epidemic outbreak of the pest was noticed in 1992. This area is constantly being monitored for pest incidence, for release of the parasitoids at the very initial level of infestation in the coming season.

1.3.8.3. Strain improvement of *Metarhizium anisopliae* with a view to utilize it against *Oryctes rhinoceros*

Studies were taken up on the strain improvement of *M. anisopliae*, the green muscardine fungal pathogen on *O. rhinoceros*. Five cultures (Nos. 549,872,808, 966 and 911) received from USA and the local strain were maintained in the laboratory in coconut water medium and studied for identification by their morphological and cultural characters. Production of enzymes by these strains on solid medium was also studied. From the growth, morphological and spore characters, the cultures were

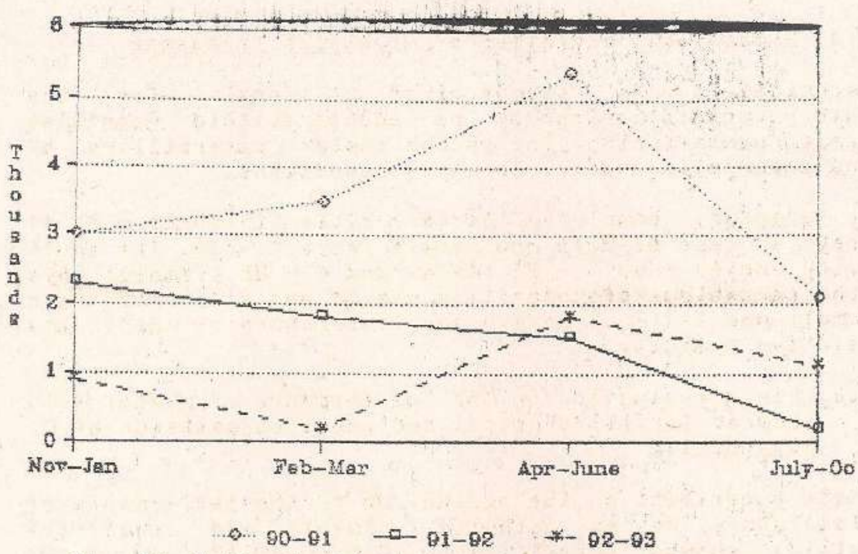


Fig. 31: Estimated larval population of *Opisina arenosella* at Thodiyoor

tentatively identified as M. anisopliae var. anisopliae and the local strain M. anisopliae var. major. Optimum growth and sporulation were recorded for culture no. 549, and nos. 549 and 872 were comparable to those of the laboratory culture. No variation in the production of lipase, chitinase and protease was observed when the five strains were grown in solid medium. Studies on the virulence of these cultures against rhinoceros beetle larvae are under progress.

1.3.8.4. Characterization and pathogenicity trials with viral and bacterial pathogens and cross infection with Bacillus thuringiensis , Bacillus popilliae and other pathogens

A rod shaped nuclear viral infection of Rhynchophorus ferrugineus was confirmed and polyhedra- like bodies were seen under EM. Purification and characterization of the polyhedra and the virions were tried by different physiochemical techniques. The polyhedra and the virions were sedimented and layered by high speed and gradient centrifugation, respectively. Variation of protein (qualitative and quantitative) could be noticed in diseased and healthy insects.

1.3.8.5. Studies on biological suppression of the lace bug *Stephanitis typica*

Population counts of the mirid predator, *Stethoconus praefectus* and the host lace bug, *Stephanitis typica* were taken at weekly intervals on 20% sample palms from the sub plots of 50 seedlings each at Cheppad and Nangiarkulangara centres, Alappuzha Dist., Kerala. The data recorded for the three year 1990-1993 were compiled for analysis.

Observations on the sample population collected from the field every month revealed that mirid and chrysopid predators were frequently associated with the lace bug colonies.

The chrysopid predator was identified as *Ankylopteryx octopunctata octopunctata* . Studies were initiated on the prey consumption, biology and seasonal occurrence of these predators.

A survey of the natural enemy complex of the tingid bugs was carried out at weekly intervals from Mannuthy and Irinjalakuda in Trichur district and Vytilla in Ernakulam district (Kerala). *Stethocorus praefectus* District was observed at Mannuthy and Vyttila but their population was too negligible to impose any check on the field population of *Stephanitis*. Various species of coccinellids were also spotted along with tingid population. But their predator status is doubtful and most of them appear to be fungal feeders.

1.3.9. BIOSUPPRESSION OF FRUIT CROP PESTS

1.3.9.1. Collection and identification of natural enemies of fruit crop pests.

Parasitoids and predators were collected in and around Bangalore from pests infesting pomegranate, mango, ber, guava, Star goose-berry, citrus etc. A total of 12 natural enemies were identified by International Institute of Entomology, London (Table 85).

Table 85. List of natural enemies collected and identified during 1993-94.

Pest	Natural enemy	Family, order
Lipaleyrodes euphorbiae (Star goose berry)	*Eretmocerus* sp.	Aphelinidae, Hymenoptera
	Pachyneuron sp(Hyper)	Pteromalidae, "
	Acletoxenus indicus	Drosophilidae, Diptera
	Mallada boninensis	Chrysopidae, Neuroptera
Aphis punicae (Pomegranate)	*Aphidius* sp.	Braconidae, Hymenoptera
	Trioxys sp.	" "
	Aphelinus sp.	Aphelinidae, "
	Signiphora sp.	Signiphoridae "
	Leucopis sp.	Chamaemyiidae, Diptera
	Pachyneuron aphidis (Hyper)	Pteromalidae, Hymenoptera
Aonidiella aurantii (Citrus)	*Pharoscymnus horni*	Coccinellidae, Coleoptera
Virachola Isocratus (Pomegranate)	*Telenomus* sp.	Scelionidae, Hymenoptera

The parasitoids *Aphidius* sp., *Aphelinus* sp., *Trioxys* sp. and *Signiphora* sp. and the predators *Leucopis* sp. and *Mallada boninensis* were reported for the first time on *Aphis punicae* infesting pomegranate. Similarly the aphelinid *Eretmocerus* sp. was collected for the first time in larger numbers from *Lipaleyrodes euphorbiae* infesting star gooseberry (Fig. 32). The record of predator like *Acletoxenus indicus* and *M. boninensis* appeared to be new on *L. euphorbiae*

1.3.9.2. Feeding potential and development of *Cryptolaemus montrouzieri* on the mango mealybug *Rastrococcus iceryoides*.

The mango mealybug *R. iceryoides* was maintained on ripened pumpkins in the laboratory and the predator *C. montrouzieri* was cultured on *R. iceryoides*. Fresh eggs of

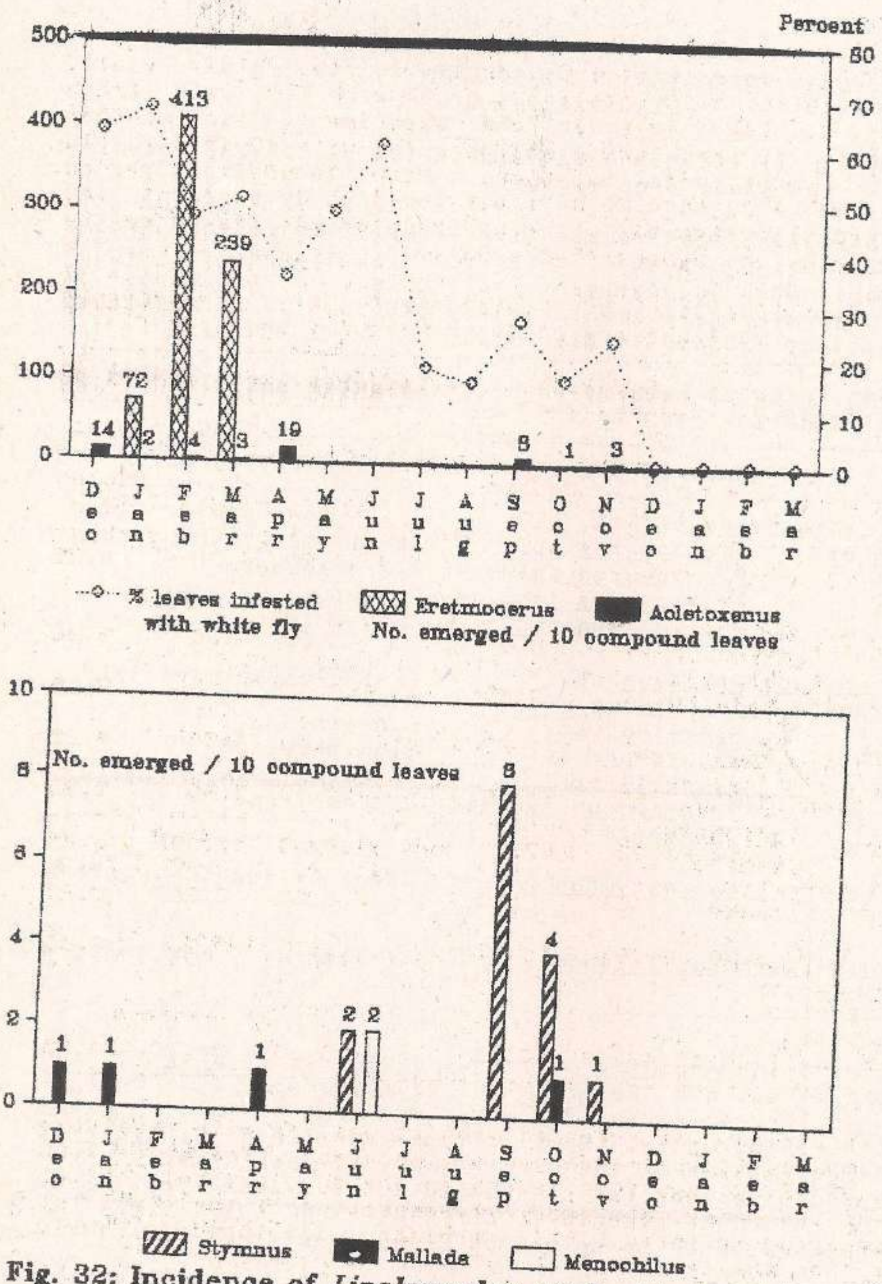


Fig. 32: Incidence of *Lipaleyrodes euphorbiae* and its natural enemies on star-gooseberry

Cryptolaemus were kept individually in the glass vials. After hatching, 10 Cryptolaemus grubs were fed with fresh eggs of R. iceryoides in one experiment. In another experiment,, 10 predatory grubs were fed with 10-15 day old mealybug nymphs until pupation. Mean incubation period ranged from 4.20 to 4.30 days but the grub development was influenced significantly when the predator was reared on the mealybug eggs and nymphs (Table 86).

Table 86. Duration of development of Cryptolaemus montrouzieri on Rastrococcus iceryoides

Stage of C. montrouzieri	Development period(days) when reared on					
	Mealybug eggs			Mealybug nymphs		
	Male	Female	Pooled mean	Male	Female	Pooled mean
Egg	4.40	4.20	4.30	4.20	4.30	4.25
Grub						
I instar	8.20	9.60	8.90	3.60	4.00	3.80
II instar	4.30	3.80	4.05	2.30	2.80	2.55
III instar	4.50	6.00	5.25	4.40	4.90	4.65
IV instar	9.40	9.50	9.45	5.10	5.40	5.25
Total	25.50	28.90	27.20	15.40	17.10	16.25
Pre-pupa	2.00	2.40	2.20	2.30	2.20	2.25
Pupa	8.20	8.40	8.30	8.70	8.30	8.50
Total developmental time (egg to adult)	40.10	43.90	42.00	30.60	31.90	31.25

The grub period was extended when it was fed with mealybug eggs compared to the feeding with the nymphs. The grub took a mean of 42.00 days when reared on the eggs but only 31.25 days on the mealybug nymphs. Irrespective of the stage of the mealybug offered, male predator developed slightly faster than the females.

The number of mealybug eggs consumed by the first, second, third and fourth instar Cryptolaemus grubs averaged 7.00, 14.80 138.45 and 195.10 respectively (Table 87).

Table 87. Predation of Cryptolaemus montrouzieri on the mealybug Rastrcoccus iceryoides

Larval instar of Cryptolaemus montrouzieri	Mealybugs consumed					
	Eggs			Nymphs		
	Male	Female	Pooled mean	Male	Female	Pooled mean
I	6.40	7.60	7.00	14.50	40.00	29.75
II	13.30	16.30	14.80	30.50	74.50	52.50
III	130.40	146.50	138.45	67.50	120.50	94.00
IV	184.60	205.60	195.10	240.00	403.00	321.50
Total	334.70	376.00	355.35	352.50	642.00	497.75

A total of 355.35 eggs of R. iceryoides were consumed by the grub during its development. Male Cryptolaemus consumed comparatively lesser number of mealybug than the female predator. A single predatory grub consumed 497.75 mealybug nymphs which were 10 to 15days old during the development. The fourth instar grub was found more voracious than the earlier instar grubs of C. montrouzieri. Female predator had eaten significantly more number of mealybug nymphs than the male.

1.3.9.3. Response of the ber scale parasitoid Anicetus ceylonensis to different pesticides.

Adult parasitoids emerged from the field samples were used as test insects. A total of 30 pesticides (17 insecticides & 13 acaricides / fungicides) were tested at field recommended doses. Potted ber plants were exposed to the adult parasitoids in the glass vials (15 x 2.5 cm). The response of A. ceylonensis adults to the treatment with different pesticides varied significantly (Table 88).

All the seventeen insecticides proved detrimental to the parasitoids. Initially there was low mortality of the parasitoids in the treatments with dimethoate, dichlorvos and phosalone which caused 100% mortality after 24 hrs of exposure. There was quick knock down effect on the adults with the insecticides like methyl parathion, quinalphos,fenvalerate, endosulfan, malathion and carbaryl inflicting 100% mortality of the parasitoids within an hour after application. None of the acarcide/fungicide was toxic to A. ceylonensis.

Table 88. Effect of different pesticides on the adults of *Anicetus ceylonensis*.

Pesticide (Concentration) (%)	Mortality of adults (%)				
	Hours after application				Mean
	1	3	6	24	
(1)	(2)	(3)	(4)	(5)	(6)
INSECTICIDES					
Fenthion (0.10)	0 (0.57)	100 (90.00)	100 (90.00)	100 (90.00)	75.00 (67.64)
Dimethoate (0.05)	0 (0.57)	0 (0.57)	0 (0.57)	100 (90.00)	25.00 (22.92)
Phosalone (0.07)	0 (0.57)	0 (0.57)	0 (0.57)	100 (90.00)	25.00 (22.92)
Methyl parathion (0.05)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)
Methyl demeton (0.05)	0 (0.57)	0 (0.57)	100 (90.00)	100 (90.00)	50.00 (45.28)
Acephate (0.01)	0 (0.57)	80.00 (63.41)	100 (90.00)	100 (90.00)	70.00 (60.99)
Quinalphos (0.05)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)
Dichlorvos (0.10	0 (0.57)	0 (0.57)	0 (0.57)	100 (90.00)	25.00 (22.92)
Fenvalerate (0.01)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)
Chlorpyrifos (0.05)	0 (0.57)	100 (90.00)	100 (90.00)	100 (90.00)	75 (67.64)
Deltamethrin (0.01)	0 (0.57)	100 (90.00)	100 (90.00)	100 (90.00)	75.00 (67.00)
Cypermethrin (0.005)	76.67 (61.19)	100 (90.00)	100 (90.00)	100 (90.00)	94.16 (82.79)
Monocrotophos (0.05)	0 (0.57)	56.67 (48.82)	100 (90.00)	100 (90.00)	64.16 (57.34)

(1)	(2)	(3)	(4)	(5)	(6)
Malathion (0.10)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)
Phosphamidon (0.10)	70.00 (56.97)	100 (90.00)	100 (90.00)	100 (90.00)	92.50 (81.74)
Carbaryl (0.10)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)
Endosulfan (0.07)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)	100 (90.00)
<u>ACARICIDES</u> & <u>FUNGICIDES</u>					
Dicofol (0.05)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)
Carvendrazin (0.10)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)
Copper oxychloride (0.20)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)
Mancozeb (0.20)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)
Sulphur 0.20% (0.20)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)
Zineb (0.20)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)
Chlorothalonil (0.20)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)
Tridemorph (0.10)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)
Dinocap (0.10)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)
Ziram (0.20)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)
Captan (0.20)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)
Triademefon (0.10)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)

(1)	(2)	(3)	(4)	(5)	(6)
Thiophanate Methyl (0.10)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)	0 (0.57)
Mean	24.88 (22.35)	41.22 (37.82)	46.67 (42.00)	56.67 (51.00)	-

	SEm	Level of significance	CD (P=0.05)
Treatments (A)	3.07	0.01	8.61
Hours after applications (B)	1.23	0.01	3.14
Interaction(A x B)	6.15	0.01	22.75

1.3.9.4. Field performance of Cryptolaemus montrouzieri against mango mealybug, Rastrococcus iceryoides

The mealybug infestation was observed in severe form in mango varieties at Indian Institute of Horticultural Research farm, Bangalore. In this orchard, a total of 189 trees comprising 63 varieties were maintained and out of which, 72 trees were affected with R. iceryoides. in May 1992. The total number of healthy fruits and mealybug infested fruits were observed to work out the percentage of infested fruits. Subsequently a total of 6135 larvae of C. montrouzieri were released @ 30/tree from September 1992 to December, 1992. Releases were not made from January to July since insecticides were employed to control the other major pests of mango. To see the effect of release of predator, again the observations were recorded on the mealybug infestation of fruits in May 1993. In some varieties like Langra, Totapuri, Gola, Black Andrews, Janardhan Pasand, there was no mealybug infestation in 1993. However, the mealybug were observed in few other mango varieties in the same orchard. Hence releases of the predator were made again during September - December, 1993.

1.3.9.5. Evaluation of the natural enemies against the mealybug infesting pomegranate.

In IIHR Farm at Bangalore, severe mealybug infestation on the fruits of pomegranate was observed in March'94, inspite of regular application of insecticides. The two year old pomegranate orchard consisted of 437 plants (Cultivar - Ganesh) of which 52 plants were affected with the mealybug. The mealybug Planococcus citri was observed on 20 plants and Maconellicoccus hirsutus on 32 plants. On the affected plants, the mealybug infested fruits ranged from 25.00 to 100% with a mean of 56.55% in April '93.

To suppress the mealybug on pomegranate, a coccinellid predator (C. montrouzieri) and two parasitoids(Leptomastix and Coccidoxenoides peregrinus) were released in fields. The release of natural enemies were initiated by the end of March '93 and continued upto August '93 and again in March '94. As on 31st March '94, mealybugs were not observed on the plants. The observation on the fruit infestation in April '94 would reveal the effectiveness of natural enemies against pomegranate mealybugs.

1.3.9.6. Demonstration trials on the biological control of mealybugs

GUAVA

A severe outbreak of the mealybug mainly Planococcus citri and also Ferrisia virgata was observed in guava (Var. Lucknow - 49) at Hosakote. The infestation was noticed inspite of regular application of insecticides like methyl parathion, quinalphos etc., in July '93. A total of 1275 C. montrouzieri and L. dactylopii were released in the second week of July. By mid September 93, complete control was achieved with the biotic agents. Several coccons of L. dactylopii and larvae of C. montrouzieri were observed in the field during the experimental period. The mealybug ceased to be a pest since September 1993.

In yet another guava orchard, the mixed mealybug population of P. citri, F. virgata and M. hirsutus were observed in January 1994. A total of 1000 Cryptolaemus larvae and 600 Leptomastix adults were released in January-February. The mealybugs were brought under control by the end of March '94.

The mealybug and scales on guava plot at IIHR Farm were controlled by releasing 360 grubs of C. montrouzieri.

GRAPEVINE

In the grape breeding block of IIHR, the mealybug (M. hirsutus) was noticed by the middle of December '93 on the flower panicles. Releases of Cryptolaemus were initiated from 17th December and continued upto 21st February '94. A total of 6990 larvae of C. montrouzieri were released in the above period. The observation taken in March '94 revealed the bunch infestation was below 5%.

At APAU, Hyderabad, the performance of Cryptolaemus montrouzieri in suppression of grape mealy bug was demonstrated in farmer's grape garden at Shamshabad. Soon after harvest, the mealy bug (Maconellicoccus hirsutus)infestation was recorded and the grubs as well as adults of C. montrouzieri were released. The adult beetles and grubs were released @ 10/vine on 15 vines at two locations. At periodical intervals , the mealy bug population on the twigs and the number of grubs or cocoons or adults of the predator are being recorded. The released grubs were allowed to pupate at the feeding site and the cocoons recovered.

1.3.9.7. Maintainenance of cultures

The centre at SKUAS and T, Srinagar (Kashmir) maintained one host culture - Quadraspidiotus perniciosus, two parasitoid cultures of Aphytis proclia, Encarsia perniciosi and a predator (Chilocorus bijugus) for research purpose.

1.3.9.8. Studies on the relative effectiveness of parasitoids and predators against San Jose scale

1.3.9.8.1. PARASITOIDS

In Srinagar, two old orchards one at Methan and other at Magam were selected. Four trees from each orchard of uniform size and age of about 7 years, variety Golden Delicious were marked . These trees were kept free from use of insecticides but for the control of scab and other related diseases fungicides were used. Two parasitoids viz; Aphytis procia and Encarsia perniciosi were released during 3rd week of June and 2nd week of July @ 2000 per tree. The increase or decrease in parasitism was recorded. The results revealed that the release of biotic agents have reduced the infestation to a considerable level by both species (Fig 33).

For raising the culture of the parasitoids Aphytis (Proclia group) and Encarsia perniciosi, at Solan these parasitoids were collected in last week August and released on two separate pumpkins having scale population. Only Aphytis sp. could be successfully reared in the laboratory but the number was insufficient to make field releases. The culture is being multiplied for field releases.

1.3.9.8.2. PREDATOR

In this case, five trees of the same age group having San Jose Scale infestation , free from the use of insecticides were selected near Ganderbal (Kashmir). The pre treatment (scale density/cm2) was recorded and after 0.6 hours predator, Chilocorus bijugus were released. The results presented in Fig. 33 indicated that the release of a predator reduced the scale density from 1.9 to 8.6 (less than the previous year 1992) thus suggesting that the number of the predators per tree should be increased.

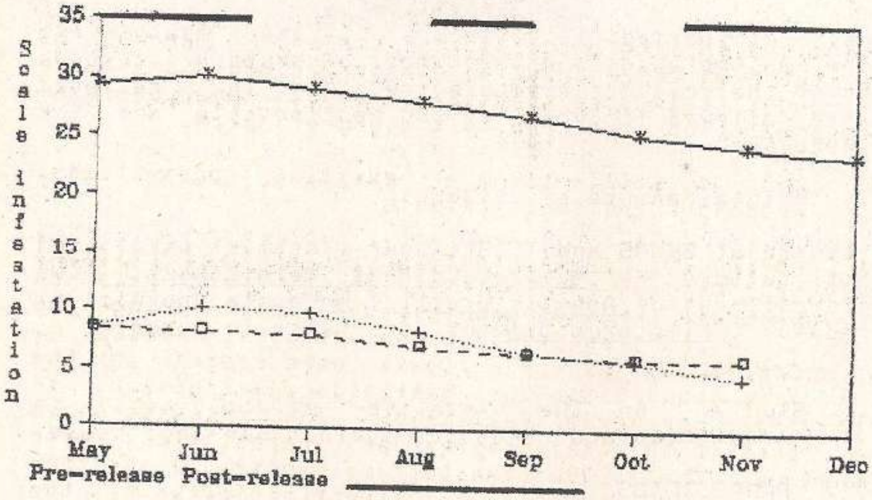


Fig. 33: Effect of predators and parasitoids on San Jose scale

1.3.9.8.3. Relative effectiveness of parasitoids and predators against the San Jose scale

Owing to non-availability of the ripened pumpkins in sufficient numbers in summer, culture of the San Jose scale and its predatory coccinellid Chilocorus bijugus could not be maintained in large number at Solan, hence early releases of the predator could not be made. From the field collected females, the culture of the predator was initiated in mid July and during the period July 1993 to March 1994, four generations were completed.

Neonate grubs of second generation were ready for the release in September. These were released on two apple trees @ 50 grubs/tree. On these trees, mean live scale population per cm2, as recorded at 70 patches, was 9.9. However, after one month of the release on these trees only 44% 4th instar grubs to pupal stage could be recovered, the live scale population per cm2 per tree was 8.2 . Thus on an average there was a reduction of about 17.2% in the live scale population on the released trees.

Grubs born in the first week of January were also released on 4 young apple plants (2-3 year old) badly infested with the San Jose scale @ 10 per plant. These plants had overlapping population of scales. By the end of February, there were 3 - 8 welfed 4th instar grubs on these plants. Under field conditions 2 - 4 adults emerged from the released plot on each tree by the end of March.

1.3.9.9. Mass multiplication of existing parasitoids, predators and their release

Mass rearing of Aphytis proclia, Encarsia perniciosi and Chilocorus bijugus and their subsequent field releases in San Jose Scale infested orchards were made during the period 1993. As many as 2,72,000 parasitoids (124000 A. proclia and 1,48,000 E. perniciosi) were reared in the laboratory and about 2,36,000 parasitoids were released in different apple orchards (Table 89). The releases have revealed that both the species of parasitoids were established at the released sites as indicated by the increase in parasitism and by the flight activity of the adult parasitoids.

Table 89. Studies on the release of parasitoids Aphytis proclia and E. perniciosi in Kashmir during 1993

Month (1993)	Location	Number released	
		A. proclia	E. perniciosi
May	Lalpora Beeru	9,337	-
	Sangam	-	13,297
June	Charus (Awantipora)	10,917	-
	Sumbal	-	14,591
July	Yachagam (Khan Sahib)	12,283	-
	Keller (Pulwama)	-	16,921
August	Tahab (Shopian)	25,670	-
	Aribal	-	29,863
September	Adipur (Sopore)	29,498	-
	Mattan(Anantnag)	-	28,614
October	Wakoora	18,289	-
	Aloosa	-	26,698
Total		1,05,994	1,29,984
Grand total		2,35,978	

Adult parasitoids of 7005 and 8500 numbers of both species reared in the laboratory were kept for use, for further multiplication in the laboratory.

In addition to above parasitoids, about 3207 Chilocorus bijugus were reared in the laboratory and released on 15 trees each at Jawahar Nagar and Zakura in San Jose scale infested trees.

Both the adults and grubs were recovered from the released sites (Fig.34).

1.3.9.10. Seasonal incidence of aphids and scales and its parasitoids

1.3.9.10.1. Seasonal incidence of the San Jose scale and woolly apple aphid in relation to natural enemies

Seasonal incidence of the woolly apple aphid (WAA) was monitored throughout the year along with the natural enemy activity at Nauni (Himachal Pradesh and the observations are presented in table 90

In April-May, colony count/replicate varied from 0.1 to 6, the mean colony size being 0.04-0.23 cm. The WAA population, thus, was negligible and predatory coccinellid activity was evident in second fortnight of April and first week of May. Even parasitisation with Aphelinus mali was noticed. In June when maximum temperature was above 31°C and rainfall was poor, there were no aerial aphid-colonies.

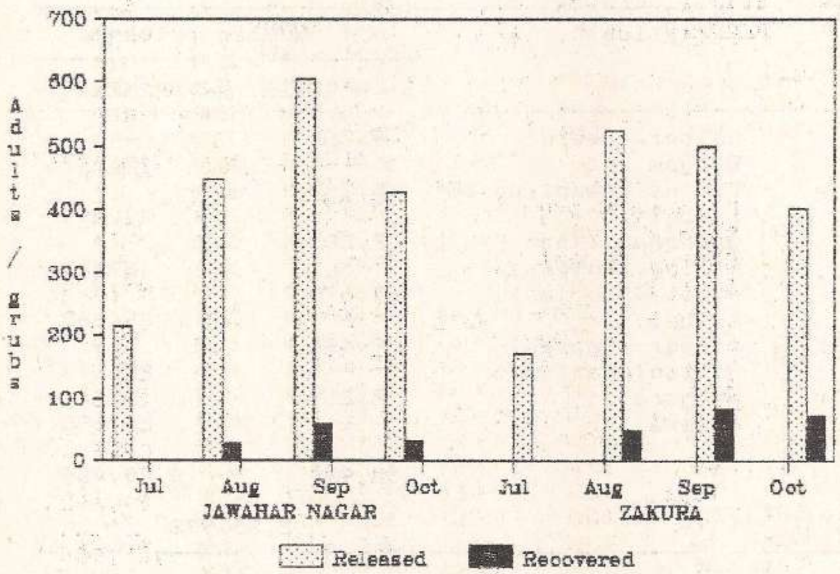


Fig. 34: Field release and recovery of *Chilocorus bijugus* in Kashmir valley

Table 90. Role of abiotic and biotic mortality factors on population build up of woolly apple aphid.

Date of sampling	Status of woolly aphid (Average of 8 replications)			Mean population of predators	Meteorological date(Mean values)			
					Temperature		Relative humidity (%)	Rainfall (mm)
	Mean colony length (cm)	Mean No. of colonies	Mean coverage of WA (cm)	Predators + <u>A.mali</u>	Maxi-mum (°C)	Mini-mum (°C)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
08.04.93	0.174	1.0	0.413	-	24.86	7.64	42.86	-
15.04.93	0.231	1.4	0.559	-	24.79	10.93	59.21	-
22.04.93	0.219	1.5	1.000	0.1 + 0	28.86	12.07	37.93	-
29.04.93	0.184	0.9	0.334	0.8 + 0.6	32.64	14.14	37.36	-
06.05.93	0.040	0.1	0.040	0 + 3.0	34.50	13.56	31.43	-
13.05.93	0.111	3.3	0.709	-	31.86	14.57	40.14	6.4
20.05.93	0.104	6.1	1.810	-	27.07	15.14	36.29	10.6
27.05.93	0.088	1.9	0.398	-	34.36	18.71	40.79	-
03.06.93	-	-	-	-	31.14	17.14	61.00	11.1
10.06.93	-	-	-	-	34.64	19.71	47.86	11.0
17.06.93	-	-	-	-	31.79	21.79	69.79	21.4
24.06.93	0.024	0.8	0.144	-	29.64	18.79	71.20	32.0
01.07.93	0.022	0.3	0.044	-	29.71	19.00	72.86	52.0
08.07.93	0.017	0.3	0.034	-	29.00	20.07	77.07	15.0
15.07.93	-	-	-	0 + 0.1	25.21	20.36	90.03	210.2
22.07.93	-	-	-	0 + 0.1	26.43	20.21	87.36	70.8
29.07.93	-	-	-	-	28.07	18.93	79.14	9.4
05.08.93	0.081	1.4	0.445	-	28.79	20.00	82.93	14.4
12.08.93	0.033	1.3	0.331	-	29.07	20.29	82.07	12.8
19.08.93	0.150	4.4	1.701	-	30.14	18.71	74.00	4.8
26.08.93	0.173	7.5	3.521	0.1 + 4.4	28.86	18.93	73.29	4.2
02.09.93	0.216	1.6	1.773	0.1 + 1.1	27.29	19.50	81.21	8.8
09.09.93	0.137	4.0	1.631	0.0 + 3.4	24.14	18.50	90.36	112.6
16.09.93	0.171	4.8	2.101	0 + 8.4	25.71	17.43	75.57	49.4
23.09.93	0.180	3.3	0.713	0 + 3.4	28.43	17.93	85.29	-
30.90.93	0.126	2.3	0.759	0 + 2.1	27.57	14.07	74.29	13.6
07.10.93	0.055	0.5	0.110	0 + 1.4	27.23	13.93	58.79	-
14.10.93	0.069	0.8	0.136	0 + 2.0	27.73	10.79	48.00	-
21.10.93	0.074	0.6	0.111	0 + 1.3	26.36	6.70	47.86	-
28.10.93	0.056	1.0	0.150	-	25.31	6.56	48.00	-
04.11.93	0.173	2.0	0.648	0 + 0.3	21.10	8.56	63.00	-
11.11.93	0.143	1.8	0.494	0 + 0.8	25.16	9.19	58.71	-
18.11.93	0.144	2.8	0.883	0 + 1.5	24.14	7.10	60.43	-
25.11.93	0.162	2.3	0.831	0 + 1.5	24.14	7.10	60.43	-
02.12.93	0.157	2.4	1.090	-	23.49	6.53	50.57	-
09.12.93	0.185	3.9	1.411	0 + 0.4	23.57	6.41	54.36	-
16.12.93	0.152	3.0	0.938	0 + 0.1	19.76	2.31	67.86	-
23.12.93	0.551	2.1	0.969	0 + 0.3	17.91	1.57	64.07	-
30.12.93	0.132	3.4	1.188	-	19.90	2.84	53.64	-

Table 90 contd. ...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
06.01.94	0.135	2.0	0.684	-	19.76	4.56	50.64	-
13.01.94	0.109	1.9	0.544	-	17.57	3.84	38.43	29.2
20.01.94	0.100	0.3	0.100	-	14.21	2.66	75.14	13.0
27.01.94	-	-	-	-	20.16	4.99	48.43	-
03.02.94	0.078	0.6	0.131	-	17.26	4.01	62.86	4.0
10.02.94	0.063	0.8	0.213	-	16.69	5.01	56.36	21.0
17.02.94	0.072	0.9	0.175	-	16.73	3.73	64.21	6.6
24.02.94	0.013	0.1	0.013	-	17.04	3.53	68.93	76.0
03.03.94	0.022	0.3	0.044	-	21.76	6.97	62.93	76.0
10.03.94	-	-	-	-	22.79	8.20	57.86	-
17.03.94	0.019	0.3	0.038	-	25.34	11.60	46.43	0.6
24.03.94	-	-	-	-	22.59	13.44	45.93	-
31.03.94	-	-	-	-	26.63	12.91	48.43	-

In July although maximum temperature was below 30°C and congenial for the aphid activity yet frequent and high rainfall prevented colonization of the aphid.

In August, population build-up of the aphid began by increase in size as well as by increase in number of the colonies and it continued till mid September. During this period there was a conspicuous increase in number of mummified aphids without the exit holes and a maximum of 8.5 mummies per replicate was recorded on September 16. A reduction in colony size in October was followed by an increase in November and December. However, parasitisation was low (0-2 mummies/replicate). During January to March, population was negligible and no parasitized/mummified aphid was visible on the marked twigs. On other trees, mummies were present near collar region and in cracks and crevices of the tree in which the parasitoid overwintered.

Parasitisation of the WAA by A. mali was noticed in areas where predator activity was low. At Dak Bangla in Shimla district (altitude ca 2000 m) high coccinellid activity was observed even in the month of September-October and there was no parasitisation of the aphid. In this area predation by chrysopids and syrphids was also evident.

San Jose scale infestation at altitude above 1500 m in Solan, Shimla and Kullu districts did not assume serious dimensions owing to poor infestation (10-20% trees having infestation of sparsely distributed population). Above all in these locations scale control was achieved by the late dormant-spray oil application. However, in valley area at lower altitude, scale attack was of concern due to rapid rate of multiplication and often attack appeared on the fruit. In most of these areas *Chilocorus bijugus* was frequently noticed predating on the scale at and below 1500 m altitude though its presence was observed in apple orchards upto 2000 m altitude. parasitisation due to *Aphytis* and *Encarsia perniciosi* was poor (0.4%).

1.3.9.10.2. Performance of *Aphelinus mali* and chrysopids against woolly aphid

In apple orchard where *A. mali* was introduced in 1991, the spread of the parasitoid was monitored at Nauni (Himachal Pradesh) during September 1993, from the centre of release. Tree to tree distance was 7.5 m. The parasitoid had uniformly spread throughout the orchard upto 90 m from the site of release. There was non-significant negative correlation (r=0.074) between the distance and number of mummified aphids without exit hole noticed upto 1.6 m height of the tree. The parasitization was evenly spread on the tree, irrespective of mean size of the colony. However, number of colonies and coverage of the aphid colonies (cm) on the tree had a positive and significant correlation with the aphid mummies (Table 91). Thus within a period of two years, *A. mali* had well established in the apple orchard in which the predator activity was relatively low.

Table 91. Value of co-efficient of correlation (r), depicting relationship between woolly aphid infestation and *A. mali* parasitisation

Character	Mummified aphids without exit hole	Total mummified aphids
1. Tree distance from the centre of release	-	- 0.089
2. Mean colony size (cm)	0.228	0.189
3. Number of colonies/tree upto 1.6 m height	0.833	0.789
4. Coverage of the aphid colonies on infested trees (cm)	0.850	0.785

1.3.10.9. Multiplication of entomopathogenic nematode *Heterorhabditis bacteriophora* and its application against the white grub *Brahmina coriacea* (Hope)

Corcyra cephalonica larvae of last and late penultimate instar were used for multiplication of the entomopathogenic nematode *Heterorhabditis bacteriophora* collected locally from the apple orchard. Petriplates of 9 cm diameter containing filter sheets with known number of dauer larvae of the nematode (usually @ 10/cm2 of the filter sheet). In each pair of plates, 15 to 30 larvae were released. Often it was found that 30-60% larvae escaped from the petri plate before getting any symptom of nematode attack. A set of experiments was laid out in which different methods were used to immobilise the larve, viz., (i) dip larvae in hot water (90°C for 1min, and 50°C for 1 min) (ii) cold treatment by keeping larvae in refrigerator for 30 minutes, (3) formaldehyde 0.1% dip for 1 hour followed by nematode treatment, and (4) larvae immersed in nematode suspension for 5 and 30 min and then shifted to petriplates containing filter sheet with nematode suspension. While in the first treatment, no larval infection occurred, the formaldehyde 0.1% dip for one hour and subsequent treatment with nematodes in petri plates provided infection to the extent of 60%. Surprisingly when the larvae were immersed into nematode suspension for 5 min to enhance the probability of contact with them and these were transferred to petriplates (without nematodes), symptoms appeared merely in 17% exposed larvae but upon prolonging the dip for 30 min and then placing the larvae in petri plates with filter sheets having nematodes @ 5/cm2, the symptoms appeared in 60% population. Escape continued, though these were tightly secured by rubber bands. In order to reduce the chances of escape, a cotton padding was tightly inserted between rims of the pair of petri plates and with this arrangement there was no larval escape and rate of infection was between 80-100%, except in one case when it was 66.7%. The overall average percent infetion ws 86.5 Symptoms appeard in 3-5 days of placement of larvae in the infection chamber.

The infected larvae put in the nematode harvest chamber and release of dauer larvae from Corcyra larvae continued for 12-19 days @ 234-373 (overall mean 294) dauer larvae/host larva/day. The maximum dauer larva yield was between 4-6 days of the harvest.But amongst these dauer larvae, mean alive population varied from 172-309 (overall mean 233/host larva/day). Thus live population was 61-89% . Overall harvest per larva was 3400-6711 with a mean value of 4463 while check alive dauer larvae was 2607-5556 (3495) per host larva.

The harvested larvae were stored in sponge placed in petriplates and for this purpose 0.1% formaldehyde was used. But these larvae survived hardly for 1.5 months in the middle chamber of the refrigerator.

Third instar white grubs collected from potato fields were put in earthern pots @ 15 per pot containing sporouted potato tubers. The soil was drenched with the nematode suspension @ 50 and 100 dauer larvae/ cm2 soil surface area in September, 1993. After 2 months, percent alive population was 60-67, 73.3 - 80 and 80 % in pots treated with 100 & 50 nematodes/cm2 and control. After 4 months, live population in these treatments was 40 - 53.3, 60-66.7 and 66.7 - 80 %, respectively. Since most of grubs were in earthern cells, the cells were partially broken to observe the state of development of grubs. Two cocoons of a parasitoid weree collected from the soil in March 1994. Many of the exposed larvae died due to failure to pupate, probably due to disturbance. Thus at a dose of 100 nematodes/cm2, less mortality occurred. Third instar grub stage is not very ideal stage for nematode- infection.

1.3.10. BIOSUPPRESSION OF VEGETABLE CROP PESTS

1.3.10.1. Collection and identification of natural enemies of vegetable crops.

Collection and identification of natural enemies of vegetable crop pests was made at Indian Institute of Horticultural Research, Bangalore. A coccinellid predator *Scymnus* sp. was found preying on *Aphis craccivora* and *Myzus persicae* that attacked peas. Three coccinellid predators viz., *Brumoides suturalis*, *Coccinella septumpunctata* and *Menochilus sexmaculata* were recorded on aphids, *A. craccivora* and *M. persicae* that attacked chillies.

1.3.10.2. Evaluation of *T. pretiosum* against *H. armigera* in tomato

Inundative releases of egg parasitoid *T. pretiosum* were made @ 2,50,000 adults and 5,00,000 adults/ha in different tomato fields against *H. armigera*. The egg parasitism level ranged from 29.03 to 69.57% with a mean of 42.05% in a field where 5 lakh adults were released. Mean borer infestation was reduced to 1.09% in parasitoid released field as against 8.22% in control. Due to poor incidence of *H. armigera*, no parasitoid was recovered from field where 2.5 lakh adults were released.

1.3.10.3. Studies on the parasitoid of tomato leaf miner *L. trifoli*

During the period under report the incidence of tomato leaf miner *L. trifoli* was very low ranging from 0 to 12.63% and no parasitoid was recovered from the field. Hence, no study could be carried out with the parasitoid of *L. trifoli*.

1.3.10.4. Biocontrol of aphids on chillies.

A preliminary trial was laid out for the control of aphids on chillies using green lacewing *Chrysoperla carnea* and compared with chemical treatments. The results indicated that a release rate of 3 larvae per plant resulted in good control of aphids over chemical treatments (monocrotophos and dimethoate), 2 larvae per plant and control.

1.3.10.5. Laboratory studies on the effect of *Bacillus thuringiensis* formulations for the control of *Earias* sp.

An experiment was laidout at Ludhiana to screen various commercial formulations of *Bacillus* against bhendhi fruit borer. Two dosages of Delfin at 1.0 and 2.0kg/h and two dosages of Dipel 8L at 1.0 and 2.0l/h were tested under laboratory conditions for the control of Earias sp.. The bhendhi fruit was chopped into small pieces and sprayed with required concentration of biopesticides and the spray fluid was allowed to dry. Thereafter six day old larvae of Earias sp. were released on each treatment. The larvae were allowed to feed for 24h and then they were provided untreated food, i.e. chopped bhendhi fruit. There were three replications. The mortality of the larvae were observed after 24, 48 and 72h. and the data is presented in table 92 which revealed that after 24h the mortality varied from 33.2 to 63.4%. After 48h and 72h the cumulative mortalities varied from 60.1 - 93.3% and from 76.8 to 95.4% respectively. The higher dosages of Delfin and lower of Dipel 8L gave better mortality.

Table 92. Laboratory studies on the effect of Bacillus thuringiensis formulations on the larvae of Earias sp.

Biopestcide formulation	Dosage (kg or l/h)	Mean mortality at various intervals (%) *		
		24h	48h	72h
Delfin	1.0kg	33.2	60.1	76.8
Delfin	2.0kg	56.6	86.9	95.4
Dipel 8L	1.0l	46.6	93.3	93.3
Dipel 8L	2.0l	63.4	80.0	86.9

* Average of three replications

1.3.10.6. Collection and identification of pests of vegetable crops and their natural enemies

To collect and to identify the pests of vegetables a survey was undertaken in a cruciferous vegetable area (0.75 hectare land) in District Srinagar from 2nd week of February to 2nd week of December, 1993. The field was arbitrarily divided into 4 sub plots and 40 plants were taken (10 from each plot) randomly to observe the insect pests. The major insect pests recorded were cabbage butterfly, cutworm, diamondback moth Lepidoptera), white grubs (Coleoptera) and aphids (Homoptera). The adults of cutworm and white grubs were recorded by using light trap near the field. The larvae/grubs of these were recorded by taking soil samples of 1m2. The larvae of cabbage butterfly, aphids and larvae/pupae of diamondback moth were recorded by observing the collected plants in the laboratory. The collected insects were kept in separate glass jars to facilitate the completion of their life cycle and observe the parasitism if any.

The incidence of cutworm was observed during 1st week of May and continued till 2nd week of August and after this only puape were observed.

The white grubs were found almost throughout the period, but with a low density from 1st week of May to 3rd week of December.

The diamondback moth larvae were observed from last week of May and continued till 3rd week of August and pupae were observed from 4th week of June to 2nd week of September.

The cabbage butterfly was recorded from 2nd week of April to 3rd week of November.

The aphids were recorded fromin 1st week of May to the end of December but later months they were recorded in whorls.

During the observation no parasitoid/predator on cutworm, white grub and diamondback moth was recorded. In case of cabbage butterfly, the larvae were parasitized by Apanteles sp., whereas the aphids were predated by coccinellids (Table 93). The same have been collected and preserved for identification.

Table 93. Studies on the collection and identification of pests of cruciferous vegetable crops and their natural enemies

Month	Week	No.of insects collected (Parasitized) Cutworm	Cabbage butterfly	White grub	Aphids		Diamond-back moth	
		L	L	G	N	A	P	L
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
February	II	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-
	IV	-	-	-	-	-	-	-
March	I	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-
	IV	-	-					

Table 93 contd. ...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
April	I	-	-	-	-	-	-	-
	II	-	1.0	-	-	-	-	-
	III	-	-	-	-	-	-	-
	IV	-	2.0	-	-	-	-	-
May	I	2	4.0	-	3	2	-	-
	II	1	2.0	1.0	4(1)	2	-	-
	III	2	-	-	5	1	-	-
	IV	2	-	-	2	1	-	-
	V	3	-	1.0	-	2	-	1
June	I	3	1.5	1.0	-	1	-	1
	II	2.0	-	1.0	3	1	-	2
	III	1.5	-	-	3(1)	-	-	3
	IV	2.0	2	1.5	4	-	1	2
July	I	1.0	3(1)	1.5	5(1)	2	2	-
	II	-	4(1)	1.0	7	2	2	-
	III	1	4	1.0	7(1)	-	2	1
	IV	1	2	1.0	7	-	-	1
August	I	1	3	1.0	5	-	-	1
	II	1.5	2	1.0	6	2	1	2
	III	-	2	3.0	4	2	1	1.5
	IV	-	-	2.0	2(2)	-	2	-
September	I	1p	-	0.5	3	-	-	-
	II	-	9.0(1)	-	0.5	7	1	-
	III	-	9.0(1)	0.5	8(1)	-	-	-
	IV	1p	6.0	0.5	8(1)	1	-	-
October	I	1p	9.1(1)	1.0	9(3)	1	-	-
	II	-	7.0	1.5	4	1	-	-
	III	-	8.0(1)	-	6	1	-	-
	IV	2p	-	-	16	2	-	-
	V	-	-	2.0	14	-	-	-
November	I	-	4(1)	-	10	2	-	-
	II	-	2	-	7(1)	-	-	-
	III	1p	2	1.0	8(1)	-	-	-
	IV	-	-	1.0	8(1)	-	-	-
December	I	1p	-	1.0	5(1)	-	-	-
	II	-	-	1.0	4(1)	-	-	-
	III	-	-	1.0	-	-	-	-
	IV	-	-	-	2(1)	-	-	-

L = Larvae ; P = Pupae ; G = Grub ; A = Adult ; N = Nymph

1.3.10.7. Incidence of Pieris sp. and its natural enemies

In order to record the pest and its parasitic fauna, egg and larval stages of Pieris sp. were collected weekly from the 2nd week of February till last week of November in 0.25 hectare land near Shalimar (Kashmir). The field was arbitrarily divided into four plots. The collections of the pests made in the field were brought to the laboratory and bred by providing regular food to complete the life cycle and to observe parasitism if any.

The eggs were parasitized to the extent of 25.0 per cent by hymenopterans during 1st week of September (Fig. 35). The parasitoids are under the process of being identified.

1.3.10.7.1. Seasonal incidence of *Pieris* spp. on cruciferous crops and their natural enemies

Pieris brassicae is an important pest damaging cruciferous crops in mid hills of Himachal Pradesh. Two clusters of late 1st instar larvae (55 and 33 larvae) could be collected on March 2, 1993, and in these lots, 96.4 and 87.9% were parasitized by the icheneumonid *Hypersota abeninus* Gravehorst. These larvae fed like normal larvae for the next 7-9 days and when in 4th instar, these transformed into capsule like structures - the mummies, with distinct head capsule (1.5 - 1.75 mm wide) narrowly constricted and attached to the anterior end of the body. Dissection of such mummies revealed presence of pre-pupa or pupa of the parasitoid inside it. Within 12-16 days of cocoon formation, adult parasitoids emerged which were in 1:1.36 (male: female) sex ratio on the basis of 64 emerged adults. The emerged adults had strong mating instinct and usually mated within 2 hours of emergence. The mating duration was 7 to 12 minutes.

The mated females were offered larvae of first, third and fourth instars and only those in the first instar were parasitized. Each female parasitized more than one hundred larvae and these females survived for 4 to 12 days. In these experiments, period taken from egg laying to cocoon-formation varied from 13 to 16 days. However, in many cases the grubs ruptured the larval cuticle and wriggled out. Some grubs often failed to pupate. Thus the parasitoid completed its life cycle in a month.

Larval population of *Pieris brassicae* was noticed on the crop during March-April only. On May 12, only one 5th instar larva was observed on one plant. Upto March 20, parasitisation was mainly by *Hypersota abeninus* and in the larval cluster of 67, 92.5% were parasitized. Even among larvae collected on March 31, 1993 82% were parasitized by it, but parasitization was below 12% by April 10. With the increase in temperature most of parasitized larvae died and the emerged adult parasitoids were mainly male. From cocoons formed between April 8-16, adult emergence was 41.4%. After March 20, parasitisation by *Cotesia glomerata* was evident but per cent parasitism was low, varying from 2.0 to 11.9% (mean 5.8%). By mid April there was negligible foliage of the cauliflower seed crop and egg laying was greatly reduced.

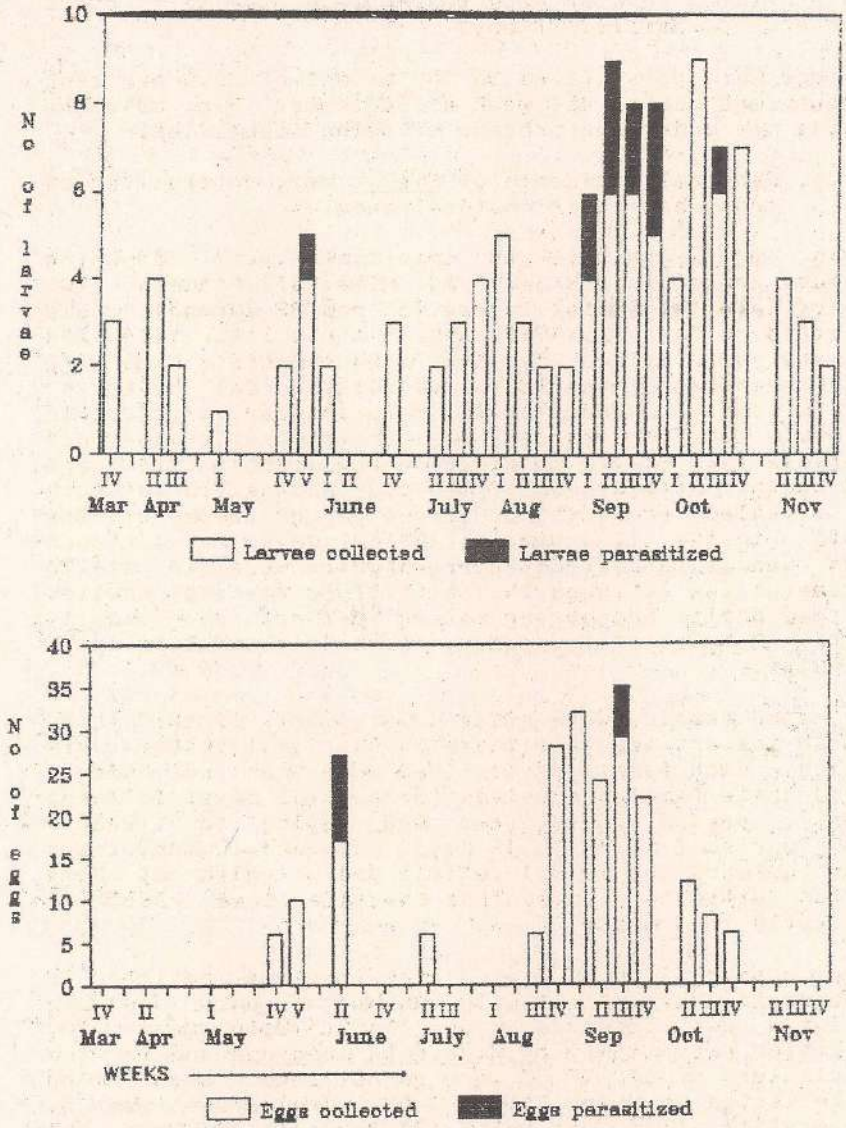


Fig. 35: Incidence of *Pieris brassicae* and its natural enemies

1.3.10.8. Evaluation of *Trichogramma pretiosum* against *Helicoverpa armigera* on tomato

Local varieties Solan Gola and Yashwant were grown at the Entomology Farm of the University at Nauni. Transplantation was done in the first week of May and crop stood in the field still July end. *Helicoverpa* eggs were seen at seedling stage in the nursery in the last week of April but hardly 4 eggs could be collected from about 400 seedlings and all these were parasitized by *Trichogramma*. Attack of *H. armigera* was very low except on May 12, when as many as 96 eggs were collected from 10 plants. Out of these, 25% hatched, 16.7% were infertile and 58.3% were parasitized by *Trichogramma* sp. On May 19, when 38 eggs were collected from 100 plants, 78.9% were parasitized. In June, egg count per 10 plants varied from 5-11 and all these collected eggs were parasitized. Caterpillars damaging the fruit crop were seen on May 26 (4 borers/100 plants), July 7 (3 borers/50 plants) and July 21 (3 borers/100 plants). From pupae collected in July, adult moths appeared during July 3rd week to August 1st week. The pre-pupal period was 2-3 days and pupal period was 10-11 days. Data on per cent fruit damage was collected on July 21 and 2.3% fruits were found to be damaged. Since parasitisation was high and pest population was low, the need to release *Trichogramma pretiosum* was not felt. In the farm of Department of Olericulture, also the egg laying was also scanty. Among 6, 12 and 7 eggs collected from large number of plants on May 28, June 5 and 30, 1993, 66.7%, 33.3% and 71.4% eggs were parasitized by *Trichogramma*. The parasitoids *T. pretiosum* procured from the Project Directorate of Biological Control, Bangalore, were released in a farmer's field adjoining the University area during July and in the farm of Department of Olericulture on June 22 and July 21, 1993. Eggs of semiloopers laid on tomato were also parasitized by *Trichogramma*.

1.3.10.9. Evaluation of nematode *Heterorhabditis bacteriophora* against cut worms

At Nauni, multiplication of entomopathogenic nematode, *Heterorhabditis bacteriophora* was done after harvest and was applied against the cutworms. The suspension was applied to rhizosphere of cauliflower seedlings transplanted in the field in October @ 2000 larvae/plant. But in the control as well as nematode applied plots, no incidence of cut worms appeared. The field treated with the nematode is under observation.

1.3.11. BIOLOGICAL SUPPRESSION OF POTATO PESTS

1.3.11.1. Mass Production

During the year 1993-94, mass production of, Copidosoma koehleri, Chelonus blackburni, Trichogramma chilonis, Trichogramma japonicum and Trichogramma pretiosum was done to utilize them for field and laboratory trials.

1.3.11.2. Studies on the efficacy of egg larval parasitoids, Copidosoma koehleri and Chelonus blackburni in comparison with Trichogramma chilonis and recommended insecticide for the control of Potato tuber moth, Phthorimaea operculella Zeller.

The experiment was laid out in cultivator's fields at Peth village in Pune district during kharif,1993 with a plot size 0.1 ha/treatment on 3rd, 5th and 6th July, 1993. The details of the treatment are as follows.

1) Biocontrol

i) Chelonus blackburni @ 12,500 adults/ha/release

ii) Copidosoma koehleri @ 37,500 adults/ha/release

iii) Trichogramma chilonis @ 62,500 adults/ha/release

The release of the parasitoids was started after the appearance of potato tuber moth (with the help of pheromone traps). In all, four releases were made at weekly intervals. At the time of release of parasitoids, the laboratory reared egg cards of potato tuber moth were placed in the treatmental plots and were retrieved after 2nd day and were reared in the laboratory.

2) Chemical control

Endosulfan (0.05%) was sprayed twice as per plant protection schedule recommended by Department of Agriculture (Maharashtra State).

3) Control

The observations on emergence of parasitoids from retrieved egg cards were recorded and percentage parasitization was worked out. The crop was harvested on 24th September, 1993. At the time of harvest the count on healthy and infested potatoes in different treatments were recorded and presented in table 94.

Table 94. Efficacy of parasitoids in comparison with recommended insecticide for the control of *Phthorimaea operculella*

Treatment	Dose (No./ha)	Average intensity of infestation. H/A	Average infestation (%)	Control (%)	Recovery (%)
Chelonus blackburni	12,500	521/27	4.92	58.65	66.7
Copidosoma koehleri	37,500	492/25	4.83	59.41	60.0
Trichogramma chilonis	62,500	537/36	6.28	47.22	46.7
Endosulfan	0.05%	514/41	7.39	37.40	-
Control	-	459/62	11.90	-	-

It could be seen from the data that the egg larval parasitoids *Copidosoma koehleri* and *Chelonus blackburni* were found to be effective in controlling the tuber moth infestation. The parasitoids suppressed the pest to 59.41 & 58.65% respectively as against 47.22 and 37.40 percent in *T. chilonis* and endosulfan spray treatments respectively. The percentage of parasitization in retrieved egg cards were 66.7, 60.00 & 46.7 % in *C. blackburni*, *C. koehleri* and *T. chilonis* respectively.

1.3.11.3. Host searching capacity of egg parasitoid, *Trichogramma chilonis*

A promising egg parasitoid, *Trichogramma chilonis* was tried against potato tuber moth for two seasons to find out its host searching capacity. The experiment was laidout in Bhugaon and repeated during next season in a village 15 km. away from pune city. The laboratory reared egg cards (about 50 eggs/card) were placed at four directions from the point of parasitoid release. The experiment was laid out at 10 different places having distances from one meter to 10 m from parasitoid release spots. About 100 *T. chilonis* were released from each point. The egg cards were retrieved 2 days after parasitoid release and brought to the to laboratory for further observations.

Observations were recorded on emergence of *T. chilonis* from retrieved egg cards. The percentage of parasitization were worked out and presented in table 95.

Table 95. Host searching capacity of Trichogramma chilonis

Distance from release point (m)	Number of egg cards placed	Number of parasitized egg cards	Parasitization (%)
1	8	5	62.5
2	8	6	75.0
3	8	5	62.5
4	4	2	50.0
5	4	2	50.0
6	4	2	50.0
7	4	1	25.0
8	4	0	0.0
9	4	0	0.0
10	4	0	0.0

It could be seen from the data that Trichogramma chilonis was able to search for the host up to a distance of 7 m from the release point. Also it was observed that the percentage of parasitization was higher at short distance (62.5 to 75%) upto 3 m from the point of parasitoid release and it goes on decreasing to 50% up to 6 m and reduced to greater extent (25%) at 7 m distance.

1.3.11.4. Field sustenance of Trichogramma chilonis Ishii through release of radiation sterilised females of potato tuber moth and its influence on population build up of the host

The experiment was conducted at Regional Fruit Research Station, Ganeshkhind, Pune, during rabi season (1993-94) with an objective to study the development of parasitoid in situ by providing additional host and its influence on pest control. The plot size was 400 m2/treatment and the planting was done on 28th December and the crop was harvested on 28th March. The treatments included were

1 Weekly release of parasitoids @ 5,00,000/ha

2 One release of parasitoids @ 5,00,000/ha followed by weekly release of sterile PTM females @ 15,000/ha.

3 Only one release of parasitoids @ 5,00,000/ha

4 Control (No release of parasitoids)

The crop was artificially infested with fertile PTM pairs @ 5000 pairs/ha after ascertaining absence of PTM incidence. Parasitoid activity was monitored throughout the crop season by placement and retrieval of the laboratory host egg cards @ 10 cards/treatment at least twice a week.

At the time of expected moth emergence of F1 generation pheromone baited traps were installed and number of moths collected daily were recorded for about one week. At harvest, samples from 2x2 m. unit area and 4 randomly selected locations in each treatmental plot were collected and brought to laboratory for ascertaining infestation level and moth emergence. Observations were recorded on percentage parasitization in retrieved egg cards, daily emergence of F1 generation moths in fields installing pheromone baited traps and infestation in harvested tubers.

Table 96. Activity of *Trichogramma chilonis* monitored by placement and retrieval of the host egg cards

Parasitoid generation	Per cent parasitization			
	T1	T2	T3	T4
P1	60	60	60	5
F1	60	55	10	15
F2	35	35	0	0
F3	35	40	0	0
F4	50	50	0	0

P1 = First release of *T. chilonis*
F1 to 4 = Successive generations of *T. chilonis*

T1 Weekly release of parasitoids @ 5,00,000/ha

T2 One release of parasitoids @ 5,00,000/ha followed by weekly release of sterile PTM females @ 15,000/ha.

T3 Only one release of parasitoids @ 5,00,000/ha

T4 Control (No release of parasitoids)

It is evident from the data (Table 96) that the parasitoid sustenance was augmented till F4 generation by release of sterile PTM females. Parasitoid recovery in retrieved host egg cards was almost same in case of T2 plot as compared to T1 plot, but in T3 where only one initial release of parasitoid was made and no sterile PTM females were released, the parasitoid population dwindled for lack of adequate host availability in time. The data in table 97 showed that lesser number of PTM moths were trapped in T1 & T2 where weekly parasitoid releases were made and where release of parasitoid followed by release of sterile PTM females were made respectively. Same observations were also found in case of infested tubers after harvest.

Table 97. Number of F1 potato tuber moths trapped in pheromone baited traps and infested tubers after harvest

Treatment	Moths trapped (number)	No. of infested tubers from 10 kg sample
Weekly release of parasitoids @ 5,00,000/ha	29	8
One release of parasitoids @ 5,00,000/ha followed by weekly release of sterile PTM females @ 15,000/ha.	23	9
Only one release of parasitoids @ 5,00,000/ha	44	12
Control (No release of parasitoids)	39	21

From the data it can be concluded that the parasitoid *Trichogramma chilonis* could be sustained under field conditions by providing additional host through the release of sterile PTM females and also reduce the pest infestation.

1.3.12. BIOSUPPRESSION OF WEEDS

1.3.12.1. Evaluation of biological control of Parthenium:

Potentiality of Zygogramma bicolorata in controlling Parthenium was assessed in two infested plots over a period of two years at Indian Institute of Horticultural Research, Bangalore . Plot No.1, covering about one hectare area was under banana cultivation until 1987 and was used for herbicidal studies. Plot No. 2, occupying about 7500 m2. area has been lying fallow since early 1970's. Both study areas were under Parthenium cover for about 4-5 years before initiation of the present studies.

In plot No. 1 complete defoliation of Parthenium was obtained by the last week of July 1992 due to the presence of 2.1 adults/plant of Z. bicolorata during June. Growth and flower production by the weed were also suppressed due to gregarious feeding by early larval stages on terminal and auxilary buds.

Parthenium was again noticed to germinate throughout plot No.1 after commencement of rains in May 1993. The estimated weed population was 52,000 for the whole plot, compared to 5,64,000 during the previous year, a reduction of 90.78%. Due to the presence of about 3.8 adults / plant, the weed was completely defoliated by the first week of July. It was also observed that the average height gained by the plant was only 78.36 cm as compared to 109.64cm during the previous year.

Sixteen different species of plants belonging to 5 families were seen growing in plot No.1 from June 1993, in addition to Parthenium, as compared to the same period during the previous year, when Parthenium alone was noticed. About 75% of the area was covered by grasses, mainly Cenchrus ciliaris. Mimosa pudica was found to cover about 9% of the area, while Bidens pilosa and Ageratum conyzoides occupied about 7% and 5% area respectively. The remaining plants occupied less than 0.25% area each (Table 98).

In plot No.2 also complete defoliation of Parthenium by Z. bicolorata was obtained during 1992. During 1993 only 1469 Parthenium plants could be counted, a reduction of 99.58% in weed infestation compared to the previous year. The area vacated by parthenium was overgrown by 31 different species of plants belonging to 13 families. About 92% of the area was found to be covered by grasses, mainly Chloris barbata. Among the other plants A. conyzoides, Croton bonplandianum and M. pudica were the most prominent.

Table 98. List of plants observed growing in the experimental plots in 1993* after defoliation of *P. hysterophorus* by *Z. bicolorata*

Plant species	Family	Area covered (m2)* Plot 1	Area covered (m2)* Plot 2
Amaranthaceae			
Amaranthus spinosus L.		3	-
Celosia argentia L.		-	S
Gomphrena celosioides Mart.		-	S
Asteraceae			
Acanthospermum hispidum DC		-	S
Ageratum conyzoides L.		500	350
Bidens pilosa L.		700	-
Blumea mollis (D.Mon.) Merr.		-	S
Ecli prostrata L.		-	S
Lagasca mollis Cav.		25	-
Tridax procumbens L.		15	-
Boroginaceae			
Trichodesma indicum(L) Lehm.		-	S
Convolvelaceae			
Convolvulus arvensis L.		-	S
Cyperaceae			
Cyperus esculentus L.		-	6
C. rotundus L.		20	20
Euphorbiaceae			
Croton bonplandianum Baill.		-	130
Euphorbia hyoericifolia L.		10	-
Phyllanthus fraternus Webster		-	S
Lamiaceae			
Leucas aspera (Willd.) Link		-	S
L. urticaefolia R. Br.		-	S
Ocimum canum Sims.		-	S

Table 98 contd. ...

(1)	(2)	(3)	(4)
Leguminosae			
Alysicarpus bupleurifolius (L.) DC		5	10
A. glumaceus (Vahl.) DC		S	-
Cassia tora L.		-	4
Crotolaria mucronata Desr.		8	-
Mimosa pudica L.		900	64
Malvaceae			
Sida acuta Burm. f.		-	3
Poaceae			
Cenchrus ciliaris L.		6100	-
Chloris barbata SW.		150	5600
Cynodon dactylon (L.) Pers.		60	250
Eriochloa polystachya H.B. etK.		100	-
Imperata cylindrica L. Beauv.		200	-
Rhynchelytrum villosum Chiov.		300	1000
Setaria glauce Fl and Fr.		-	10
S. verticellata (L.)		-	10
Rubiaceae			
Borreria articularis (L.f.) F.N.Will		-	S
Oldenlandia corymbosa L.		-	S
Solanaceae			
Datura stramonium L.		-	S
Solanum nigrum L.		-	10
Verbenaceae			
Lantana camara L.		-	10
Stachyterpheta jamaicensis Vahl.		-	S

* Estimation made during September 1993
S = Stray

The present studies clearly show that the defoliation pressure exerted by Z. bicolorata on P. hysterophorus can reduce the weed density and encourage the growth of vegetation, formerly suppressed by this weed. It was also indicated that the rate of reduction of Parthenium infestation may vary depending on the duration of occupation of a particular area by the weed, and also the presence of viable seeds of competing vegetation. The lesser degree of

Parthenium control and plant species diversity in plot No. 1 may be due to depletion of seed stock of competing plants following continuous crop production, combined with regular weedicide usage. Repeated defoliation over an extended period of time may be required to bring down Parthenium in areas which were under weed cover for longer durations.

Observation in Bangalore and surrounding areas indicated drastic reduction in Parthenium density and increase in the growth of a variety of plants. The studies carried out so far clearly establish the potential of Z. bicolorata in permanently reducing P. hysterophorus at least in areas experiencing moderate weather conditions, similar to Bangalore.

However, recent reports indicate that the beetle can cause defoliation of Parthenium in regions experiencing high summer temperatures also. Releases of about 1000 adults of Z. bicolorata in 1990 at Vindhyachal Super Thermal Power Project of National Thermal Power Corporation in Sidhi District of Madhya Pradesh has resulted in establishment. The insect has already dispersed throughout Vindhyanagar and surrounding areas, causing large scale defoliation of Parthenium. Promising results being achieved in the above area, which experiences temperatures upto 40°C during summer, indicates the potential of this insect in tackling Parthenium throughout its range of infestation. Extensive field releases of Z. bicolorata should therefore be undertaken expeditiously to bring to heel this noxious weed.

1.3.12.1.1. Survey in farmers' field in and around Bangalore for feeding by Z. bicolorata on sunflower.

Z. bicolorata was not observed to feed on sunflower in any of the farmers' field visited during kharif 1993 in and around Bangalore. Along with the Committee members, visited sunflower fields at 4 locations in Bangalore and Kolar districts. In no case any feeding was observed on sunflower plants. Some of the farmers who were contacted also confirmed that the beetle was never seen to damage sunflower crop throughout the season.

1.3.12.1.2. Studies on factors responsible for low egg hatchability of Z. bicolorata.

Studies were carried out at Bangalore to determine whether frequency of mating affected percentage of egg hatching. For this freshly emerged females were collected and released in individual cages. One male was released into each of the five cages for the repeated mated treatment, while females in 5 other cages were allowed to mate just once on the 4th or 5th day after emergence. Another 4 females were not allowed to mate.

It was observed that repeatedly mated females laid more eggs compared to single mated ones. However, unmated females were also observed to lay infertile eggs for about 66 days. During the first 5 weeks after emergence single mated females were observed to produce more fertile eggs compared to repeatedly mated ones. From the 6th week onwards the percentage hatching of eggs laid by single mated females was found to decline, although viable eggs were laid up to the 11th week (Table 99 and Fig.36).

Table 99. Effect of mating frequency on Z. bicolorata

Particulars	Unmated	Single mated	Multiple mated
Female longevity (days)	131.80 ± 45.13	98.00 ± 27.18	77.00 ± 25.32
Duration of egg laying (days)	66.40 ± 25.87	68.00 ± 30.08	64.00 ± 19.65
Total eggs/female	240.60 ± 182.08	1302.00 ± 801.24	1686.25 ± 337.74

During the course of the study it was observed that unmated females lived longer than single or multiple mated ones. Repeated mating was found to reduce female longevity. However, further confirmatory studies are in progress.

1.3.12.1.3. Studies on diapause in Z. bicolorata

Earlier studies at Bangalore had shown that adults of Z. bicolorata are capable of entering diapause throughout their breeding season starting from June. However, since observations were carried out with field collected adults it was difficult to determine the age of the adults. Therefore, during the present studies, observations on diapause were carried out with freshly emerged adults collected at weekly intervals.

Full grown larvae were collected from the field at weekly intervals starting from 7th June to 27th October 1993 and allowed to pupate in the laboratory. Newly emerged adults were released in insect rearing cages with moist soil and food.

The present studies confirmed earlier findings on the capacity of Z. bicolorata to diapause throughout breeding season i.e. June to October. It was also observed that the percentage of diapause increased with the approach of the dry season (Fig.37).

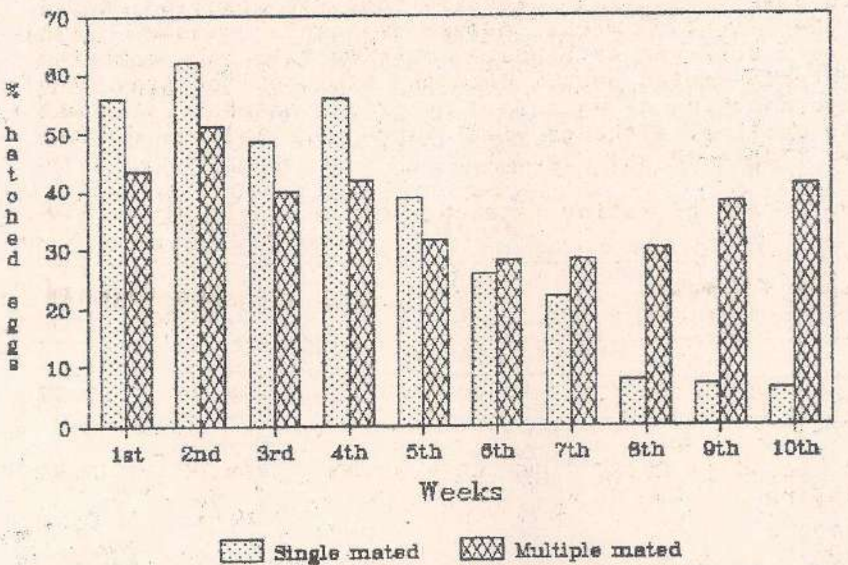


Fig. 36: Effect of mating of *Zygogramma bicolorata* on % egg hatching over a period of time

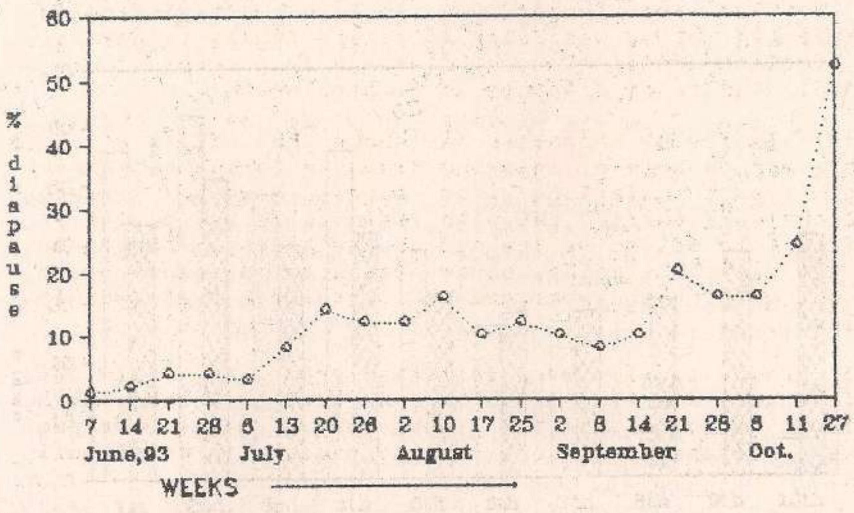


Fig. 37: Diapause of *Zygogramma bicolorata* over a period of time

1.3.12.1.4. Record of a tachinid parasitoid of Zygogramma bicolorata

During the course of the studies at Bangalore on diapause a tachinid parasitoid, later identified as Chaetexorista sp. was observed to emerge from the pupae of Z. bicolorata in August 1993. The insect was probably attacked during the larval stage. Therefore, weekly collections were made of full grown larvae from the field from September to study incidence of parasitism. The results of the study are presented in table 100.

Table 100. Incidence of parasitism by Chaetexorista sp. on Z. bicolorata

Date	Sample size	Parasitism (%)
02-09-1993	170	22.9
08-09-1993	120	1.7
14-09-1993	140	13.7
21-09-1993	85	4.7
28-09-1993	116	0
06-10-1993	80	2.5
11-10-1993	70	0
27-10-1993	30	6.7

Upto to 22.9% parasitism was obtained during September. This is the first report of a parasitoid attacking Z. bicolorata in India. Further studies are required to study the impact of parasitism on the biocontrol potential of the beetle.

1.3.12.2. Studies on the natural enemy complex of Ludwigia sp.

The aquatic weed Ludwigia sp. was found to be attacked by two species from coleoptera and one species from thysanoptera at Indian Institute of Horticultural Research, Bangalore. Seasonal incidence studies were carried out by collecting 10 samples each of 15-20 cm long twigs from two different ponds in Hessaraghatta at fortnightly intervals.

Larvae and adults of Haltica sp. (Chrysomelidae) were found to feed on the leaves of the weed throughout the study period. However, maximum leaf damage was found to be caused during August and January. It was also observed that severe damage by Haltica sp. was followed by regrowth of fresh leaves, which in turn were attacked by the insect. Probably because of this the weed was kept permanently under check and no increase in weed coverage was noticed.

Feeding by Scirtothrips dorsalis was found to cause leaf curling followed by browning. The occurrence of S. dorsalis on Ludwigia sp. was found to be seasonal and coincided mainly with periods when the population of Haltica sp. was low.

The curculionid beetle Nanophyes sp. was found to cause 100% damage to Ludwigia pods throughout the study period. Although a hymenopteran parasitoid was found to attack this insect, its impact was apparently insignificant (Tables 101 & 102).

1.3.12.3. Supply of natural enemies of weeds to different centres in the country.

During the period under report Indian Institute of Horticultural Research, Bangalore about 3200 adults of Neochetina eichhorniae and N. bruchi were supplied to District Health Offices in Salem and Dindigul (Tamil Nadu) Agricultural College and Research Institute, Madurai and College of Agriculture, Pune for releases against water hyacinth. Similarly 460 adults of Cyrtobagous salviniae were supplied to University of Agricultural Sciences, Shimoga for releases against Salvinia molesta, .

1.3.12.3.1. Biological control of water hyacinth by releases of Neochetina eichhorniae, N. bruchi and Orthogalumna terebrantis in Punjab

A pond measuring 0.5 ha having water hyacinth was selected during 1992 near Ludhiana and 400 adults each of Neochetina eichhorniae and N. bruchi and 1300 mites, Orthogalumna terebrantis were released on 24.7.92. The breeding of only Neochetina spp. were observed during 1992, 1993 and 1994. It seems that the Neochetina spp. have established well in the pond as water hyacinth damage was observed on leaves and bulbs. The weevils have also been found far away from the points of releases in the pond, but there appeared to be no impact on the weed as far its control is concerned.

1.3.12.3.2. Biological control of water hyacinth by release of Neochetina eichhorniae and N. bruchi in Assam

The field release of N. eichhorniae and N. bruchi have been made in the university ponds at AAU, Jorhat. Water hyacinth population was controlled upto 95% by the beetles, 21 months after the initial release of these beetles. In December, 1990 these beetles were released in Lakhaibill (Alengmara) about 25 km away from AAU campus Jorhat. These beetles gradually migrated to nearby areas of Lakhaibill occupying around 200 hectare. After confirmation of establishment of these beetle extensive surveys were carried out in different locations since these beetle can

Table 101. Natural enemy complex of Ludwigia sp. in pond near Hessaraghatta lake.

Date	Haltica sp.		S. dorsalis		Nanophyes sp.	
	No.of larvae	Leaf damage (%)	No. of thrips	Leaf damage (%)	No. of grubs	Pod damage (%)
10-06-1993	0	43.23	0	-	27	100
24-06-1993	8	36.96	140	93.93	72	100
22-07-1993	0	-	0	0.30	108	91
26-08-1993	3	65.35	0	-	56	100
11-09-1993	0	-	0	-	2	100
06-10-1993	17	30.16	0	-	-	-
15-11-1993	3	22.54	0	-	58	100
30-11-1993	0	7.20	6	2.7	9	100
19-12-1993	0	15.52	119	40.37	32	100
04-01-1994	11	62.24	0	13.53	-	-
20-01-1994	0	24.66	28	37.33	64	100
04-02-1994	4	15.13	0	-	14	100
22-02-1994	20	49.60	4	3.94	2	100
18-03-1994	3	21.49	0	-	-	-

Table 102. Natural enemy of Ludwigia sp. in a tank at Hessaraghatta

Date	Haltica sp.		S. dorsalis		Nanophyes sp.	
	No.of larvae	Leaf damage (%)	No. of thrips	Leaf damage (%)	No. of grubs	Pod damage (%)
10-08-1993	53	46.39	0	-	-	-
26-08-1993	9	76.17	0	-	56	100
06-10-1993	1	21.46	0	-	-	-
15-11-1993	15	20.19	0	-	58	100
30-11-1993	0	1.73	1	5.78	-	-
19-12-1993	0	9.27	140	56.95	26	100
04-01-1994	15	72.80	22	44.54	12	100
20-01-1994	3	27.91	23	64.34	12	100
04-02-1994	2	21.37	0	-	4	100
22-02-1994	18	54.54	0	-	-	-
18-03-1994	13	10.37	243	82.22	-	-

aerially migrate from one locality to another. It could be detected in some areas of water hyacinth infested by these beetle which are Jaysagar and Gaurisagar (80 km), Selenghat (50 km) build up and intensity of damage was recorded in these newly migrated areas excluding Titabar and Selenghat (Fig.38, 39 & 40).

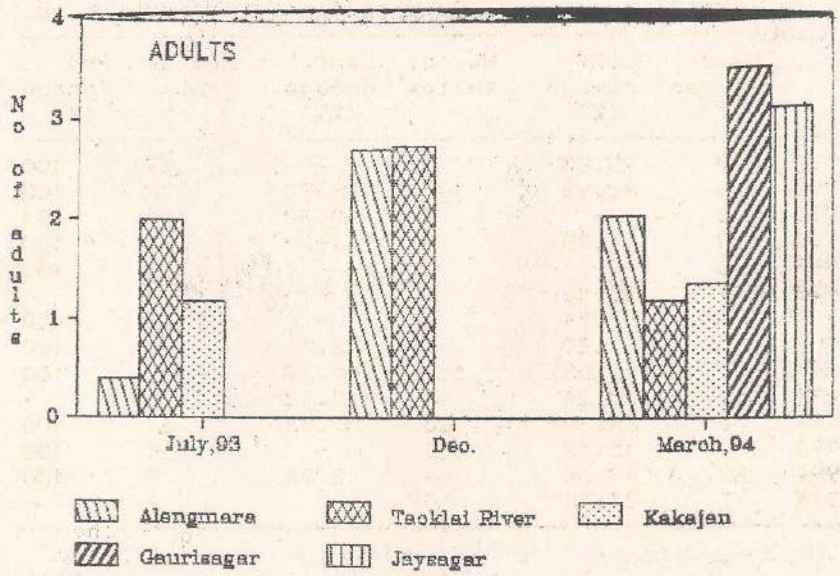


Fig. 38: Establishment of *Neochetina eichhorniae* and *N. bruchi* in Assam

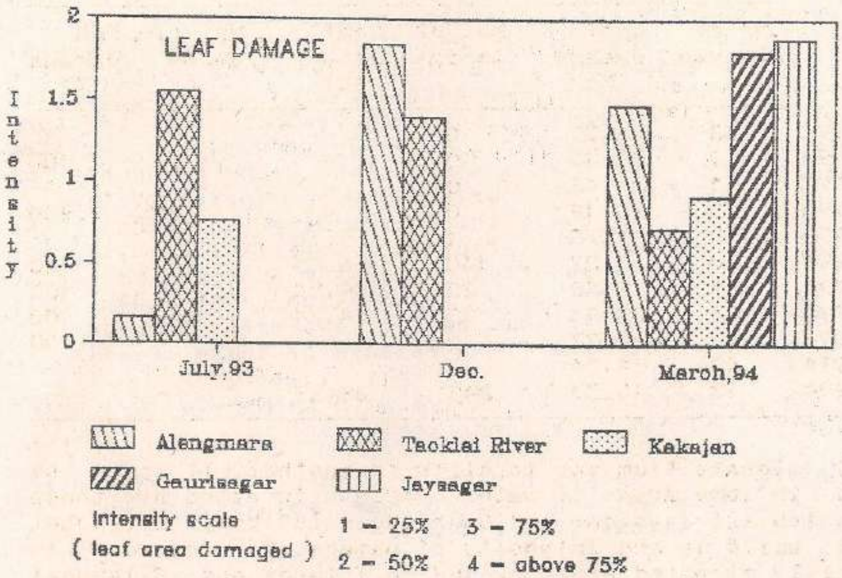


Fig. 39: Establishment of *Neochetina eichhorniae* and *N. bruchi* in Assam

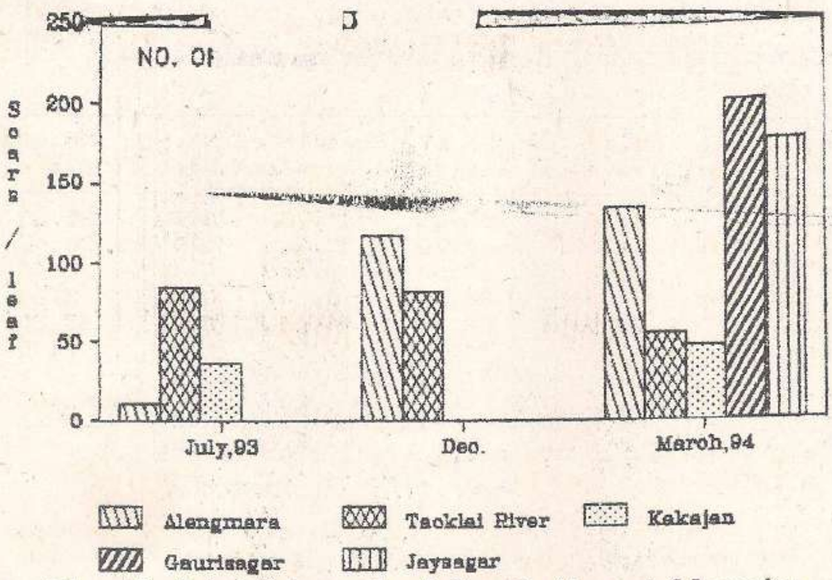


Fig. 40: Establishment of *Neochetina eichhorniae* and *N. bruchi* in Assam

Since Neochetina sp. has been establishing in the agro climatic condition of Assam and satisfactory control of water hyacinth has been achieved particularly in Lakhaibill (Alengmara) and surrounding areas, a team of Subject Matter Specialist of the State Department of Agriculture, Government of Assam and S.M.S. (Ext.) from the Directorate of Extension, AAU, Jorhat conducted a training programme in the Lakhaibill (Alengmara) and reported the satisfactory performance of Neochetina sp. Recently we have also visited Lakhaibill area and had a discussion with a number of villagers regarding the performance of these beetle in controlling water hyacinth. According to them the Lakhaibill and surrounding areas have been reclaimed and now fit for fish culture and fishing and the surrounding areas could be utilized for paddy cultivation. At Lakhaibill about 80% water surface has been cleared off of weeds in about 30 months after the field release of these weevils.

1.3.12.3.3. Control of water hyacinth in Kerala by using Neochetina eichhorniae Warner

Sampling of water hyacinth plants from Alleppey, Kottayam, Ernakulam and Calicut was maintained and the details are as follows (Table 103).

Table 103. Population of N.eichhorniae and morphological parameters of water hyacinth at different locations in Kerala

Location	Month (1993)	No.of leaves	Length of leaves(cm)	Breadth of leaves(cm)	No.of weevils	No.of scars
Alleppey	June	9.20	54.33	11.78	0.70	25.89
Alleppey	December	9.10	68.70	12.96	1.90	106.10
Kottayam	June	7.50	60.33	14.11	0.10	6.44
Kottayam	December	7.70	32.25	8.11	0.00	3.44
Ernakulam	June	7.25	58.30	14.16	2.75	63.30
Ernakulam	December	9.80	71.86	12.50	8.10	47.10
Calicut	June	------	All the plants dried up			------
Calicut	December	9.50	46.48	8.20	0.10	56.00

Note 1. All figures are the means of 10 plants each
2. All leaf measurements related to the fourth leaf

1.3.12.3.4. Biological control of water hyacinth by releasing N.echhorniae, N. bruchi and O. terebrantis at Anand

Releases of the weevils were made in ponds infested with water hyacinth on 27-6-92 at Anand (Gujarat). Periodical observations have revealed that the weevils have adopted to the new environment very well which is evident by the presence of larvae and adults in the bulbs and fresh damage on the leaves. The adult count varied from 6 to 42 per 25 plants and damage holes 30.31 per leaf.

1.3.12.4. Monitoring and evaluation of Pareuchaetes pseudoinsulata (Arctiidae: Lepidoptera)

Field releases of P. pseudoinsulata continued in Kerala for the control of C. odorata and the details are presented in the following Table 104.

There was severe incidence of NPV on Pareuchaetes during August, 1993 and it affected adversely the breeding programme during the most favorable Pareuchaetes breeding period i.e., August - November.

An experiment was conducted to find out the most preferred sex-ratio as well as the most effective food combination at 25°C and 75% RH for getting maximum hatching percentage. For this purpose adults were kept at three different sex-ratios namely 1:1, 2:1 and 1:2. At the same

Table 104. Releases of P.pseudiinsulata

Date	Number	Location	District
24-07-93	5,000	Kinaloor	Calicut
04-12-93	2,500	Central orchard, Pattambi	Palghat
06-01-94	4,500	Kinaloor Estate	Calicut
09-01-94	500	Moorkanikkara	Trichur
11-01-94	1,000	Vellanikkara	Trichur
18-01-94	800	Vellanikkara	Trichur
11-02-94	4,000	Kinaloor estate	Calicut
11-02-94	1,000	West Hill	Calicut
16-02-94	5,000	Central Orchard, Pattambi	Palghat
18-02-94	5,000	Veluppadam	Trichur
Total	29,300		

time different food combinations were supplied to the adults. The details are given below:

1. 50% honey in distilled water
2. 200 mg of vitamin E in 100 ml of 50% honey
3. 100 mg of sodium chloride in 100 ml of 50% honey
4. 100 mg of sodium chloride in 100 ml of 50% sucrose solution
5. 200 mg of vitamin E and 100 mg of sodium chloride in 100 ml of 50% honey
6. Water alone

The experiment was conducted in small plastic containers of 12 cm height and 8 cm diameter under laboratory conditions. Tender Chromolaena leaves were kept in the container for convenient resting and egg laying of the insect. For food supply, sterile cotton dipped in the nutrient solution was hung from the top of the container which was covered with white muslin cloth. Observations were made on the total number of eggs laid and the number of eggs hatched. Based on that, percentage hatchability was worked out.

The results (Table 105) showed that maximum hatching percentage was obtained with 1:1 sex-ratio for all the food combinations, even though more egg laying was recorded in 2:1 sex ratio. Most suited food combination was found to be 50% honey + sodium chloride combination (85.50%) followed by 50% honey + vitamin E (83.73%) in 1:1 ratio. In the case of 2:1 ratio, maximum hatching was recorded for honey 50% + Vitamin E (73%) closely followed by honey 50% + sodium chloride + vitamin E (71.86%) and honey + water (71.34). A hatching percentage of 79.40 and 77.06 was obtained for

Table 105. Studies on the effective feeding combination

Food combi-nation	1:1 ratio			2:1 ratio			1:2 ratio		
	laid	hatched	%	laid	hatched	%	laid	hatched	%
Honey + water	228	180.00	78.95	252.43	180.95	71.34	213.00	159.00	74.75
Honey + vit E	252	211.00	83.73	373.29	273.21	73.00	196.65	150.15	76.46
Honey + NaCl	269	230.00	85.50	362.00	182.50	50.41	243.25	192.95	79.40
Sucrose + NaCL	241	170.00	70.54	317.59	193.18	60.88	172.00	102.00	59.30
Honey + vit E+NaCl	174	138.00	79.46	410.86	295.35	71.86	246.95	190.30	77.06
Water	279	104.04	37.29	421.24	160.88	38.19	298.00	158.23	53.00

honey 50% + sodium chloride and honey 50% + sodium chloride + vitamin E respectively in the case of 1:2 ratio. In all the sex-ratios the sole nourishment on water recorded the least hatching percentage.

1.3.12.5. Monitoring of Orthogalumna terebrantis Wall work (Galumnidae: Acarina) in Kerala

Field releases of Orthogalumna commenced during 1990 and during the last four years, the mite has established all over the release sites. It has also managed to reach 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 Orthogalumna released locations. However the brownish or yellowish streaks which are typical symptoms of the mite infestation are confined to the older leaves and older plants.

In spite of the wide spread establishment of Orthogalumna, the overall impact of these mites on Eichhornia stand is not very satisfactory. This is probably because of the quick regrowth and multiplication of the weed under the favorable climatic and aquatic environment prevalent in Kerala.

Monitoring the field population of Orthogalumna at Alleppey, Moncompu, Kumarakom, and Trichur were continued (Table 106).

Table 106. Population of mites in different locations

Month (1993-94)	Mite population (average of 20 leaves) Alleppey	Kumarakom	RRS Moncompu inside	RRS Moncompu outside	Trichur
April	117.45	17.80	15.45	13.00	157.35
May	129.40	-	11.90	6.50	125.35
June	189.40	3.85	-	-	164.75
July	65.20	43.80	8.50	6.50	138.76
August	117.40	12.80	28.55	44.75	104.75
October	37.35	-	17.40	20.90	148.35
November	36.65	48.90	26.75	32.65	85.40
December	48.95	5.85	12.50	42.55	81.25
January	70.20	4.05	22.60	45.65	42.05
February	86.25	9.75	17.05	24.90	91.20
March	77.10	3.90	17.05	39.10	110.60

Note. Vacant spaces indicate that water hyacinth plants were not available for sampling during the month

Preliminary studies on the biology and nature of damage of O. terebrantis were conducted and the details are in table 107.

Table 107. Biology and nature of damage of O.terebrantis

State	Duration (Days)	Total length of galleries
Egg	5.80	-
Larva	3.00	0.156 mm
First inactive stage	1.60	-
Protonymph	3.00	1.094 mm
Second inactive stage	1.60	-
Deuteronymph	3.00	2.473 mm
Third inactive stage	1.60	-
Tritonymph	4.00	4.024 mm
Fourth inactive stage	3.00	-
Adult life span	-	-

N.B. All measurements are the mean of 10 replications

The preovipositional period ranged from 3 to 5 days. Males and females were indistinguishable and mating pairs were never noticed during the period of study.

Oviposition:

Females of *O. terebrantis* made circular holes, 0.08 to 1mm in diameter, by eating off the leaf tissue on the lower surface of the leaves, leaving the upper epidermis intact. They laid solitary eggs, mostly sideways to the oviposition holes, deeply embedded in the aerenchyma cells.

The number of ovipositional holes varied with the mite population and they were uniformly distributed on the leaves except for the thickened basal part of the petiole. Ovipositional holes per unit area ranged from 3 to 13 per cm2.

The length of galleries made by the larval and the nymphal stages increased with the development of the mites.

Field collected leaf samples too showed almost equal number of emergence holes on the lower and the upper leaf laminae.

Nature of attack:

The characteristic infestation symptom of the mite developed within 5 to 7 days after egg deposition. Small greyish-brown spots first developed on the lower surface. These brown spots extended to feeding galleries which contained the small larvae. The larval stage was followed by three nymphal stages and the continued feeding produced galleries that extended towards the apex of the leaf lamina between the veins and vice-versa. The basal part of the gallery appeared darker because of the accumulation of fras and debris from larval feeding. The length of the tunnels increased with the development of the mites and this was indicated by the elongation of the brown spots into longitudinal streaks on the outer leaf lamina. Such brown streaks later coalesed to form large brown areas leading to the drying up of the entire leaf.

Table 108. Damage potential of *O. terebrantis* on *E. crassipes* leaves of different population levels

No.of mites per plant	Total number of galleries/leaf mite after release		
	30 days	60 days	90 days
10	42.10	45.60	55.56
20	62.40	72.00	89.80
40	72.80	79.20	91.00
80	79.00	109.66	131.22
C.D. (0.05)	18.13	30.04	39.18

The data presented in the Table 108 indicate that 10 mites per plant caused the minimum number of galleries per leaf and it is significantly different from the effect of 20 mites, 40 mites and 80 mites per plant.

The analysis of data on reduction in plant population indicated conspicuous disparity between treatments after 90 days (Table 109).

Table 109. Effect of O. terebrantis on waterhyacinth population

Number of mites released / plant	Plant population of E. crassipes		
	30 days	60 days	90 days
10	4.73	6.30	6.50
20	4.53	5.60	5.53
40	4.73	5.83	4.01
80	4.20	5.13	3.27
C.D.(0.05)	NS	NS	1.69

Field samples showed that the maximum number of mite galleries per leaf was present on leaves with Neochetina feeding marks. Average number of galleries made by O. terebrantis along with Neochetina was 92.42 per leaf whereas, it was 65.70 galleries per leaf on Neochetina free plants. However, the difference was not statistically significant (Table 110).

Table 110. Number of galleries and mite population on leaves with and without Neochetina feeding

	With feeding marks	Without feeding marks	CD
No.of galleries per leaf	92.42	65.70	NS
No.of mites per leaf	66.00	28.70	25.48

NS : Not significant

1.3.12.6. Cyrtobagous salviniae Calder & Sands (Curculionidae : Coleoptera)

Field releases of Cyrtobagous weevils continued from the College of Horticulture, Vellanikkara; Rice Research Station, Moncompu and the Regional Agricultural Research Station, Kumkarakom.

Samples of *Salvinia* were collected from Alleppey and Kottayam to assess the field population of *Cyrtobagous* weevils, larvae and pupae and the results are given in Table 111.

Table 111. *Cyrtobagous* population and weight of *Salvinia* / m2 at Alleppey and Kottayam (average of five samples)

Month	Alleppey				Kottayam			
(1993)	Larva	Pupa	Adult	Wt. (g)	Larva	Pupa	Adult	Wt. (g)
April	9.00	5.40	34.20	5490	0.00	18.00	34.20	6660
August	16.20	1.80	18.00	5220	10.80	10.80	39.60	7290
December	248.40	46.80	100.80	4203	0.00	0.00	0.00	2160

1.3.12.7. Survey on the natural enemies of *E. retipes*, *Mikania micrantha*, *Pistia stratiotes*, and *Limnocharis flava*

The survey continued. *Pachypeltis* nymphs were observed on *Mikania* at Ernakulam and *Prodenia* caterpillars continued to be the most common insect enemy on *Limnocharis*.

CHAPTER-II

2. Functioning of the Project Directorate

2.1 Introduction of the Project Directorate

The erstwhile All India Coordinated Research Project on Biological Control of Crop Pests and Weeds was launched in 1977 under the aegis of the Indian Council of Agricultural Research with the funding the first two years from the Department of Science and Technology, Government of India. Since April 1979, the project has been included in the research activity of the Indian Council of Agricultural Research, New Delhi and with full financial support. In 1988, the Project Co-ordinator Cell and erstwhile CIBC unit were merged and the new headquarters of the project located at the premises vacated by erstwhile CIBC, Indian Station, Bangalore. In the VIII plan with a view to further strengthen the biocontrol work the centre has been upgraded to a Project Directorate of Biological Control with the same headquarters.

The initial 13 centres which were identified and functioning under the AICRP and 4 centres included later are continuing to work as the centres of the Project Directorate. The Project Directorate has been entrusted with the responsibilities of evolving effective biological control strategy for important pests and weeds, coordinating research on biological control aspects at national level, serving as nodal agency for introduction, exchange and conservation of biological control agents at national level and disseminating information and imparting training on biological control.

During VIII Plan period a new centre at GB Pant University of Agricultural sciences and Technology, Pantnagar was added in liew of Central Rice Research Institute, Cuttack.

The major crops and important pests on them have been identified and each centre has been assigned the task of working on natural enemies (predators, parasitoids and pathogens) of one or more crops important in that region. As such the crops covered are sugarcane, cotton, tobacco, oilseeds, rice, pulses, potato, coconut, fruits and vegetables. In addition, major terrestrial and aquatic weeds are included in the programme. Further in VIII plan a new centre has been started with a view to work on biological control of plant pathogens.The major thrusts are to encourage the existing natural enemies in the country, utilise indigenous as well as exotic natural enemies, as and when required, and promote biological control so that reliance on chemical pesticides is reduced followed by reduced environmental pollution and increased food and fibre production.

2.1.1. Location of Centres

1. Project Directorate of Biological Control, Bangalore
2. Indian Institute of Horticultural Research, Bangalore
3. Indian Institute of Sugarcane Research, Lucknow
4. Sugarcane Breeding Institute, Coimbatore
5. Central Plantation Crops Research Institute, Kayangulam
6. Central Tobacco Research Institute, Rajahmundry
7. Indian Agricultural Research Institute, New Delhi
8. Punjab Agricultural University, Ludhiana
9. Kerala Agricultural University, Vellanikkara
10. Gujarat Agricultural University, Anand
11. Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar
12. Andhra Pradesh Agricultural University, Hyderabad
13. Dr.Y.S.Parmar University of Horticulture and Forestry, Nauni, Solan
14. Assam Agricultural University, Jorhat
15. Tamil Nadu Agricultural University, Coimbatore
16. Mahatma Phule Agricultural University, Rahuri, Pune
17. G.B.Pant University of Agriculture and Technology, Pantnagar

2.1.2. Objectives

The major objectives are

1. To evolve effective biological control strategy for important pests and weeds.
2. To coordinate research on biological control aspects at national level.

3. To serve as nodal agency for introduction, exchange and conservation of biological control agents at national level.

4. To disseminate information and impart training in biological control.

2.1.3. Salient achievements till date

Import permits of 82 natural enemies of crop pests and weeds have been obtained. However, due to lack of sufficient time / funds only 62 natural enemies could be imported so far. Consignments (1246) of natural enemies have been supplied to the coordinating and other centres.

Improved laboratory techniques have been worked out for the multiplication of many natural enemies which include *Adelencyrtus mayuri* , *Allorhogas pyralophagus*, *Amblyseius tetranychivorus* , *Ankylopteryx octopunctata* , *Apanteles subandinus* , *Apertochrysa* sp., *Bessa remota* , *Bracon brevicornis* , *B. kirkpatricki* , *Campoletis chlorideae* , *Cheilomenes sexmaculata* , *Chelonus blackburni* , *Chilocorus bijugus* , *C. nigritis* , *Chrysoperla carnea* , *Chrysoserca* sp., *Copidosoma desantisi* , *C. koehleri* , *Cotesia flavipes* , *C. kazak* , *C. marginiventris* , *C. plutellae* , *Cryptolaemus montrouzieri* , *Curinus coeruleus* , *Cyrtorhinus lividipennis* , *Diadegma semiclausum* , *Eucelatoria bryani* , *Hyposoter didymator* , *Leptomastix dactylopii* , *Mallada astur* , *M. boninensis* , *Peribaea orbata* , *Pharoscymnus horni* , *Phytoseiulus persimilis* , *Plesiochrysa* sp., *Telenomus remus*, *Trichogramma* spp.(8 species and 12 strains), *Trichogrammatoidea* spp, (3) and others including weed insects like *Cyrtobagous salvinae* , *Pareuchaetes pseudoinsulata* , *Neochetina eichhorniae* , *N. bruchi* , *Orthogalumna terebrantis* and *Zygogramma bicolorata*.

Breeding techniques for host insects have been standardised including rearing on semi-synthetic diet. The cost of production on semi-synthetic diet of 100 pupae of *S. litura* was Rs.7.90 , for *H. armigera* Rs.100/- and for *Chilo partellus* Rs.16-18.

The mass rearing technique for *C. marginiventris* has been evolved involving mass exposure of the *S. litura* larvae. It is possible to obtain 2,300 parasitoids from 10 rearing units in 8 days. 2008-2500 adults of predator *Curinus coeruleus* could be reared every month by spending 2 hrs/person/working day. A parasitoid-host ratio of 1:4 in respect of *A. pyralophagus*: *C. partellus* was found to be optimum for laboratory rearing.

Mass production, and demonstration of the impact of Trichogramma, Chrysoperla, HaNPV and SlNPV has been conducted by the Biological Control Centre in Punjab, Andhra Pradesh, Karnataka, Maharashtra and other states.

With the financial help provided by the Department of Biotechnology, Trichogramma egg parasitoids were produced on large scale and were released in 1365 ha area under sugarcane, maize, sorghum, rice , tomato and co expenditure was required after the establishment of C. salviniae. An annual saving of Rs.68 lakhs is estimated only on account of labour. The navigational canals and paddy fields in Kuttanadan and Kole lands (Kerala) as well as Vembanad lake have been cleared.

Survey for natural enemies of key crop pests have been conducted and the list of predators, parasitoids and pathogens compiled . Many new natural enemies have been identified for study and utilisation for the biological suppression of pests.

Efforts are on to re-organise and catalogue the insect collections at Project Directorate, Bangalore so as to serve as reference collection for biocontrol workers.

To meet the increasing need of taxonomic support in biocontrol programmes, work on insect taxonomy was initiated. Morphometric studies on egg-burster, using 4 species of chrysopids namely Chrysoperla carnea , Mallada boninensis , M. astur and Apertochrysa sp. revealed that it could serve as a supplementary character in resolving taxonomic problems in this group. Similarly morphometric studies on pupal mandibles revealed that 3 parameters were significant, showing the potential of pupal mandibles as a taxonomic tool. A new species of Chrysocerca , a genus rare in collections and unrepresented in Indian subcontinent was collected on mango.

The predator, Sticholotis madagassa accepted Melanaspis glomerata , Quadraspidiotus perniciosus , Hemiberlesia lantaniae and Aonidiella aurantii. Developmental period was shorter on M. glomerata and fecundity, longivity and sex ratio was also better, followed by Q.perniciosus, A. aurantii and H. lataniae. Chilocorus bijugus preferred Q. perniciosus producing a progeny of 93 in 87 days on it. However, it reproduced only when the host density was high. C. nigritus could muitiply on six diaspine scale insects and proved more suitable for laboratory multiplication. Among the hosts tested i.e. Aphis craccivora, Myzus persicae , Uroleucon carthami and Brevicoryne brassicae, only the first two are most preferred and suitable for rearing coccinellid predator Cheilomenes sexmaculata.

Out of 6 diaspine hosts tested the parasitoid Aphytis proclia preferred Q. perniciosus followed by H. lataniae. It produced a progeny of 34 in 12 days on Q. perniciosus and 13 in 9 days on H. lataniae.

Exotic parasitoid Chelonus blackburni could complete its development on Corcyra cephalonica, Phthorimaea operculella and Achroia grisella. The fecundity and size of the progeny obtained was largest from A. grisella and smallest from C. cephalonica.

Results of exposure of Trichogramma spp. reared from C. cephalonica as well as Helicoverpa armigera showed that exposure to H. armigera increased the fecundity of many species of trichogrammatids indicating that rearing on H. armigera for at least one generation was beneficial for increasing the potency of Trichogramma spp.

Out of the five host insects viz., Chilo partellus, C. infuscatellus , Sesamia inferens , C. auricilius and C. cephalonica tested for parasitisation by Allorhogas pyralophagas , per cent parasitism ranged from 37.41 to 39.35 on the first four, but was markedly reduced on C. cephalonica (17.38). Developmental time was minimum and progeny production maximum when reared on C. partellus. In addition to the above mentioned hosts, the parasitoid could also be reared on Raphimotopus ablutellus , C. sachhariphagus indicus and Scirpophaga excerptalis.

Telenomus remus accepted eggs of Spodoptera litura , S. exigua , Corcyra cephalonica , Helicoverpa armigera , Plusia signata , P. nigrisigna , Agrotis segetum , A. ipsilon , A. spinifera , Achaeae janata and Mythimna loreyi . In addition to S. litura and H. armigera , P. signata has been identified as additional laboratory host for Cotesia marginiventris. It is capable of giving more than 90% parasitism of S. litura and C. cephalonica eggs upto five generations. Continuous rearing on Spodoptera eggs increased the efficacy of T. remus with respect to progeny production per female per day.

Screening of Trichogramma species against Plutella xylostella revealed that out of 10 different species tested only 4 could parasitise eggs of P. xylostella. In the laboratory, T. evanescens could parasitise (12.6%) eggs followed by T. pretiosum (10.5%), T. brasiliensis (8.0%) and T. chilonis (6.81%). Screening of Trichogramma species against Helicoverpa armigera and Agrotis spinifera in the laboratory showed that all 10 species accept both the hosts. Parasitism of H. armigera eggs was more by T. brasiliensis, T. chilonis , T. evanescens and T. pretiosum and of A. spinifera eggs by T. japonicum , T. achaeae , T. chilonis and T. pretiosum. In general all species parasitised H. armigera eggs more than A. spinifera eggs. In general 2-7 parasitoids emerged for one egg. Trichogrammatoidea armigera emerged in more numbers (6-7) than other species from a single egg.

Trichgrammatoidea bactrae which has been introduced from Taiwan parasitised upto 92.8% one day old eggs of P. xylostella in the laboratory. Under net house conditions 55% population of P. xylostella is reduced by Tr. bactrae .

Screening of trichogrammatids against Opisina arenosella eggs revealed that arboreal egg parasitoid, T. embryophagum could successfully parasitize the eggs.

Life cycle of the grape mealybug parasitoid Allotropa japonica was completed in 25.5 days and that of encyrtid Blepyrus insularis in 25-30 days. Parasitoid, Coccidoxenoides peregrina completed one generation in about a month on P. citri.

Faster development and better sex ratio were observed when A. japonica parasitised third instar nymphs of Maconellicoccus hirsutus. Exotic parasitoid Leptomastix dactylopii was unable to survive at higher temperatures (30° and 40°C) either in the form of cocoons or adult.

Hyposoter didymator completed its life cycle on Spodoptera litura larvae in 14.9 ± 0.61 days. The female lived for 8.6 days. When 5 days old larvae were exposed, 60% parasitism was obtained.

C. kazak introduced for the biological suppression of H. armigera completed its life cycle on this host in 13.1 days at 26°C, and the life cycle at 23° C was found to prolong by 2.7 days. The female could produce a progeny of 62.4. It has been worked out that diapause in its prepupal stage could be terminated by acclimatisation to lower temperatures followed by chilling and then gradual shifting to room temperature.

The singly laid eggs of Chilocorus bijugus hatched in 3-6 days. The average duration of four larval instars was 4.5, 3.4, 5.2 and 6.3 days, respectively The predator consumed 206 scales in adult stage while the third and fourth larval instars consumed 71 and 143 scales, respectively.

The laboratory rearing over eight generations of the mirid bug, C. lividipennis indicated 2.51 ± 0.48 rate of increase per generation. Predatory mite of whitegrubs Sancassania sp. produced 486 offsprings in bisexual and 1,159 in parthenogenetic life cycle.

A preliminary comparative study on the biology of PTM encyrtid parasitoids, Copidosoma desantisi and C. koehleri was done. It was found that it took from 22-29 days for C. desantisi to emerge as adults from the day of parasitisation of PTM eggs during various months of the year. The adult longevity ranged from 9-12 days. In the case of C. koehleri the emergence of adults took place 24-30 days after exposure of PTM eggs and the adult longevity was 9-11 days.

The chrysopid, Mallada boninensis completed its development in about 25 days on Maconellicoccus hirsutus. A single predatory larva of M. boninensis was found to prey about 240 grape mealybug nymphs. Feeding potential of Cheilomenes sexmaculata was 1135.2 aphids (Melanaspis indosacchari). A single grub consumed 142.8 and adult 992.4 aphids. Eggs numbering 2360 of the guava scale were consumed by Cryptolaemus montrouzieri. Larva of Metasyrphus confrater consumed 245-292 aphids in 13-14 days of its life.

In studies on the biology and feeding potential of Mallada astur and Cheilomenes sexmaculata on Aphis gossypii egg stage of M. astur lasted 4.12 ± 0.33 days in comparison to 2.0 ± 0.39 days in C. sexmaculata. The three larval instars of M. astur lasted 3.62 ± 0.48, 3.62 ± 0.49 and 5.37 ± 0.69 days and that of four larval instars of C. sexmaculata 2.0 ± 0.27, 1.0 ± 2.7, 1.15 ± 0.33 and 2.53 ± 0.49 days, respectively. Pupal period was 12.50 ± 0.5 in M. astur and 4.07 ± 0.26 days in C. sexmaculata. Feeding potential of larvae of M. astur was much more than C. sexmaculata. During I, II and III larval instars of M. astur 74.1 ± 13.55, 51.8 ± 37.95 and 269.5 ± 48.42 nymphs were consumed whereas four larval instars of C. sexmaculata consumed 84.7 ± 8.55, 91.9 ± 7.93, 109.3 ± 20.47 and 95.9 ± 20.77 nymphs, respectively. Adults of C. sexmaculata also fed 1455.3 nymphs (mean 29.7 ± 8.38 per day) whereas M. astur adults were not predaceous. Thus C. sexmaculata was more efficient than M. astur.

The competitive interaction studies between Cheilomenes sexmaculata and Chrysoperla carnea in presence and absence of Aphis gossypii revealed that in presence of aphids there was very less competitive interaction between the species while in the absence of aphids the greater mortality of C. carnea was observed.

With a view to identify the best chrysopid species for cotton and sunflower, potted plant studies were conducted with cotton and sunflower on which H. armigera eggs (pre counted) were released followed by release of predator larvae. Among the three species studied, C. carnea and M. astur were found to feed actively and consume 3128 and 380 H. armigera eggs, respectively. The number of larvae that remained on sunflower plant was comparatively less which may be due to the presence of hairs on the plant.

Feeding potential studies of chrysopids on the eggs of C. cephalonica and H. armigera revealed that M. boninensis consumed highest number of C. cephalonica (727.6) and H. armigera (437) eggs followed by Apertochrysa sp. for which the corresponding figures were 699 and 363, respectively.

Effect of different densities of Aphis gossypii on feeding by Mallada astur and Cheilomenes sexmaculata was studied by offering 25, 50, 75 and 100 nymphs daily to larvae of both species. At density of 25 nymphs during the larval period M. astur larvae consumed 189.40 nymphs in comparison to 113.0 by C. sexmaculata. Similarly at 50, 75 and 100 nymphs density M. astur larvae consumed 336.25, 474.30 and 496.40, and C. sexmaculata larvae 211.3, 272.8 and 350.1 nymphs, respectively. Larval period was less in higher host densities in comparison to lower densities in both the predators. M. astur produced a progeny of 68, 79, 93 and 116 in comparison to 43, 49, 52 and 59 by C. sexmaculata at densities of 35, 50, 75 and 100 nymphs/larvae, respectively.

Feeding potential of C. coeruleus and Chrysoperla carnea has been studied by feeding either eggs or nymphs of subabul psyllid. C.coeruleus grubs (4 instars) consumed on an average 15,080 eggs or 4,638 nymphs of subabul psyllid in 29.2 ± 1.16 and 26.8 ± 1.09 days respectively. On the other hand C. carneae larva (3 instars) consumed 3,645 eggs or 363 nymphs of subabul psyllid in 17.8 ± 0.74 and 15.8 ± 0.74 days, respectively.

The growth rate pattern studies on chrysopids revealed that net reproductive rate, precise rate of intrinsic increase per female progeny and finite rate of increase per female per day were 627.8, 0.184 and 1.2020 in Chrysoperla carnea and 278.8, 0.1812 and 1.1986 in M. boninensis. In case of M. astur and Apertochrysa sp. these figures were lesser indicating that C. carnea is more efficient followed by M. boninensis.

Life table studies of Curinus coeruleus on Heteropsylla cubana indicated that percent mortality (100 qx) and generation mortality (100 d x n) was highest during egg stage, mortality being 11.5942. Peak egg laying period was observed between 23rd and 41st days. Net reproductive potential (Ro) was 155.35, Tc 37.123, rc 0.13359, rm 0.1261, T. 40.01 and 1.134.

Life table studies on T.embryophagum and T. dendrolimi indicated that adults lived upto 18 and 12 days, respectively. For laboratory multiplication of T. embryophagum and T. dendrolimi, egg: parasitoid ratio has been worked out as 20:1 and 30:1 for the first exposure. Life table values of T. embryophagum worked out were Ro 60.23, Tc 14.27, rc 0.287, rm 0.292, T 14.03, and 1.34 and that of *T. dendrolimi* Ro 33.98, Tc 10.83, rc 0.325, rm 0.266, T 13.25 and 1.305.

Life table studies on six strains of *Trichogramma chilonis* indicated that net reproductive rate (Ro) of Bio C1, Bio C2, Bio C3, Bio C4, Bio C5 and Bio C6 was 22.05, 22.54, 20.08, 20.00, 18.30 and 17.60, respectively. Precise intrinsic rate of increase (rm) was higher in Bio C1 and Bio C2 in comparison to other strains, therefore, these two should be considered for release on cotton for suppression of *H. armigera*.

Fertility table studies were conducted by exposing *Spodoptera litura* eggs to *Telenomus remus* which were held individually and in groups. In the case of individual exposures, net reproductive rate (Ro) approximate generation time (Tc) approximate intrinsic rate of increase (Rc), precise intrinsic rate of increase (Rm), net generation time (T) and finite rate of increase were 120.53, 12.78, 0.375, 0.399, 12.00 and 1.491, respectively. However, in the case of group exposures, the values for the above parameters were found to be 65.03, 12.12, 0.344, 0.348, 12.00 and 1.416, respectively.

Effect of temperature on the adult biology of *Cryptolaemus montrouzeri* was studied. At 15° C the females failed to reproduce but the longevity was prolonged to 90 days. Similarly at 35°C the female reproduction was very poor and the adults lived only for 18 days. A temperature range between 25 and 30°C appears to be ideal for the optimum development of *C. montrouzieri* . The females at these temperatures produced 103 to 108 eggs and lived for 43 and 32 days, respectively. Storage of females for more than 20 days at 30°C and 35°C without offering sufficient mealybugs resulted in 80 per cent reduction in fecundity.

Response of *Aphis gossypii* to different temperatures and relative humidities and performance of *Cheilomenes sexmaculata* and *Chrysoperla carnea* studied at 18°, 22°, 26° and 30°C at 70% RH showed that development period of apterous and alate forms was reduced with increase in temperature. Alate forms take more time to complete development than apterous forms. Low humidity also increases developmental period. Percent mortality increases with increase in temperature. There was no mortality at 18° and 22°C whereas at 26° and 30°C at 70% RH 13.0 and 60.0% nymphal mortality was observed. Rate of multiplication was also high between 18° - 26°C. In general, *C. carnea* was found to perform better at temperatures between 22° and 30°C at 40% RH. But at 70% RH at 22°C, 89.2% and at 30°C, 98.6% aphid reduction was obtained due to predation. The temperatures between these ranges were not suitable for getting maximum aphid population reduction. *Cheilomenes sexmaculata* grubs at 26°C, 70% and 40% RH developed in 4.6 ± 0.48 and 3.5 ±

0.31 days, respectively. They consumed 308.7 and 223.0 nymphs and reduced aphid population by 99.5 and 71.0%, respectively. Performance of Cheilomenes sexmaculata in different temperatures and humidity ranges indicated that in general C. sexmaculata was able to bring down high aphid population and perform better at 22-26°C temperature and 70 % relative humidity.

Bracon kirkpatricki could not parasitise at low humidity of 40% RH at 18°C, 22°C and 26°C, but parasitism was obtained at 30°C.

Results of single and multi choice host plant tests indicated that Hyposoter didymator preferred to parasitise larvae of Spodoptera litura feeding on castor and beetroot followed by tobacco, cauliflower, cowpea, okra and cabbage. Larvae on tobacco var. Jayshree remained unparasitised. Similarly, Telenomus remus preferred to parasitise S. litura eggs on beetroot and castor while tobacco was least preferred. Cotesia kazak preferred its host H. armigera on cotton, tomato and okra rather than on dolichos, pigeon pea, cowpea and chickpea.

In net house condition T. evanescencs was released 6 times with a gap of 3 days for evaluating egg parasitism on cabbage and mustard. Parasitism of DBM eggs on cabbage ranged from 11.2 - 17.3% and on mustard 1.4 - 8.5%. Mustard served as trap crop for oviposition by P. xylostella. Number of eggs laid on mustard was 6-48 comparing 3-12 on cabbage and number of larvae observed on mustard ranged from 10-43 comparing 4-8 on cabbage. One spray of dichlorvos could effectively check population on mustard. Thus larvae were unable to move from trap crop to main crop. Moreover, spray on mustard did not adversely affect the efficiency of T. evanescens on cabbage. Parasitism and cocoon formation by Didegma semiclausam was more on cabbage and cauliflower than on rapeseed.

In Sunflower fields C. carnea , M. boninensis and Apertochrysa were collected while in cotton fields, in addition to these three species M. astur was also collected. No chrysopids were collected on tomato.

C. marginiventris preferred S. litura larvae on knolkhol, castor and cowpea. Female parasitoids after contacting tobacco leaves became inactive and died within an hour. T. chilonis preferred to parasitise S.litura on cotton and caulifower but only the top layer of eggs that too to the extent of 9.3 and 7.5 per cent, respectively, was parasitized.

Tomato, cotton, pigeon pea and chick pea plants were tested using H. armigera eggs on the leaves for the parasitizing ability of Chelonus blackburni reared from P.

operculella and C. cephalonica (laboratory hosts) and it was found that parasitizm of H. armigera was not very different amongst the three host plants and emergence was low.

In interaction between Sticholotis madagassa and Adelencyrtus mayurai, the latter alone was very effective parasitoid, parasitising 78.8% M. glomerata, whereas S. madagassa could predate only 53.4%. In all multiple combinations much higher parasitism was observed but effectiveness of S. madagassa was drastically reduced. In interaction studies it was found that Cotesia kazak dominated over Hyposoter didymator.

C. blackburni tested against potato tuber moth was more efficient parasitoid as compared to C.koehleri when both the parasitoids were used together. In multiparasitised sequences T. chilonis suppressed T. remus to an extent of even 100 per cent. But when multilayer eggs of S. litura were offered to both the parasitoids, T. chilonis emerged from the top layer and T. remus from the bottom layer of eggs.

The coccinellid predator, Cryptolaemus montrouzieri fed on the grape mealybugs which contained the early stage of parasitoid (Anagyrus dactylopii) but not the mealybugs mummified due to parasitisation.

Trichogrammatids in pupal stage are ideal for storage. Trichogramma achaeae and Trichogrammatoidea eldaneae were found to be more tolerant to low temperatures as compared to T. chilonis and T. japonicum. At 2°C, T. achaeae and Tr. eldaneae produced larger progeny than other species. Storage for 21 days at 2° C and 28 days at 5°C did not affect longevity. Tr. eldaneae could be successfully stored in host eggs up to 50 days at 5°C. Tr. armigera cannot endure long term storage, it could be stored for 10 days at 10°C. T. brasiliensis could be stored even up to 70 days at 7°C.

Storage of predator Sticholotis madagassa at 5°C and 10°C proved lethal, while it could be stored up to 60 days at 15°C without significant mortality. Storage at this temperature also did not affect fecundity and longevity of adults up to 45 days. Developmental period was found to be increased with increase in the period of storage.

Studies on the storage of Carcelia illota, a tachinid parasitoid of H. armigera, has shown that storage of the puparia of this parasitoid at 10°C resulted in reduced emergence even within 10 days of storage in comparison to the puparia retained at room temperature where 100 % emergence could be obtained.

At 5°C and 10°C adult females of Allorhogas pyralophagus could be stored for 20 and 50 days respectively. Males could not survive storage at 5°C, but at 10°C they could be stored for 20 days. Drastic reduction in the fecundity was observed when duration of storage was increased beyond 7 days at 5°C and 28 days at 10°C. Optimum temperature for storage of cocoons was 10°C. Mummies of Copidosoma koehleri could be stored for 20 days at 10°C. Adults of H. didymator could be stored for 20 days at 15°C. Adults of Chelonus blackburni could be stored for only 10 days at 5°C and 30 days at 10°C, but mortality was very high beyond 20 days at 10°C. At 5°C C. marginiventris could be stored only for 10 days. At 15°C L. dactylopii in the form of mummies in Planococcus citri , and puparia of Sturmiopsis inferens could be stored up to 30 and 60 days, respectively. Storage of Pareuchaetus pseudoinsulata for up to 45 days with feeding at 7-10 days intervals did not significantly affect pupation, adult emergence, fecundity and viability of eggs.

In a study conducted to compare different geographical strains of Campoletis chlorideae (viz., Rahuri, Sehore, Bangalore and Kanpur), it was found that in the first generation highest fecundity was recorded in the Sehore strain followed by Bangalore and Rahuri strain and least in Kanpur. Percent adult emergence and longevity was also lowest in the Kanpur strain and highest in Rahuri strain. In a study made to compare the 2nd generation of Rahuri and Sehore strains, the latter proved to be a better performer. However the host searching ability of Rahuri and Sehore strains was found to be 46.9 and 5.6 per cent, respectively.

In evolving an endosulfan resistant strain of Trichogramma chilonis, parasitoids were exposed to 0.75 ml/l solution of endosulfan for 32 generations. After 52 generations mortality obtained was 8.0, 15.0, 18.0 and 30.0% after constant exposure for 1, 2, 4, and 5 hours. Parasitism obtained was 83.0% after 32 generations at 0.75 ml/l dosage. After this test parasitoids were shifted to 1.0 ml/l dosage. Mortality obtained in first exposure at this dosage was 90.0 and 100.0% after 1 & 2 hours of constant exposure and low parasitism of 45%. But after passing 21 generations mortality obtained was 45.0, 60.0, 80.0 and 90.0% after 1, 2, 4 and 6 hours of exposure and 80.0% parasitism. Currently this strain is showing resistance to 0.035% concentration of endosulfan after exposing for many generations. Efforts are continuing to develop endosulfan resistant strain of Telenomus remus.

Susceptibility of several natural enemies (parasitoids, predators and weed insects) viz., Trichogramma chilonis, Trichogrammatoidea eldaneae, Allorhogas pyralophagus, Adelencyrtus mayurai, T. japonicum, T. brasiliensis, T. achaeae, Cheilomenes sexmaculata, Tr. armigera, Eucelatoria bryani, Apanteles angaleti, Bracon kirkpatricki, Chelonus blackburni, Chrysoperla carnea/scelestes, Apanteles papilionis, Cryptolaemus montrouzieri, T. pretiosum, Leptomastix dactylopii, Allotropa japonica, Anagyrus dactylopii, Aphytis proclia, Encarsia perniciosi, Aphelinus sp., Cotesia (Apanteles) plutellae, Telenomus remus, Amblyseius tetranychivorus, E. inaron, Aenasius advana, Blepyrus insularis, Cephaleta brunniventris, Tetracnemoidea indica, Cyrtorhinus lividipennis, Lycosa pseudoannulata, Pareuchaetus pseudoinsulata, Neochetina eichhornia, N. bruchi and others to pesticides has been determined.

The optimum host - Planococcus citri and parasitoid Leptomastix dactylopii ratio has been found to be 75:1 for mass multiplication of L. dactylopii. The parasitoid developed on all the stages of P. lilacinus but adult females of 20 to 25 days old were found highly suitable for the breeding of L. dactylopii. Similarly the optimum host parasitoid ratio for multiplying Copidosoma koehleri and C. desantisi on potato tuber moth eggs has been worked out to be 50:1.

A study on the effect of different egg density of Helicoverpa armigera and parasitoid numbers on intensity of parasitism on cotton by Trichogramma chilonis indicated that effective suppression of H. armigera has to be achieved by regulating dosages as per egg density.

Egg clusters of Chilo partellus with varying egg numbers were used to study the performance of Trichogramma chilonis and the results indicated a 92.33 % parasitism in egg clusters having 26-30 eggs and an overall parasitism percentage of around 70 % in egg clusters having 16-55 eggs and an yield of around 35 from these egg clusters..

The Indonesian strain of Cotesia flavipes has been reared on Chilo partellus. Individually hand stung larvae produced maximum (70%) cocoons while the other two methods of exposure (larvae under a layer of diet and larvae in maize stems) produced only 60 and 55 per cent cocoons out of the larvae exposed. Cocoons were formed 12-14 days after exposure and adults emerged 4-6 days after cocoon formation. Each bunch of cocoons from a larva produced from 60-80 adults. The local strain of C. flavipes collected from parasitised C. partellus produced low parasitism percentages and only two generations could be maintained.

Studies on the effect of different egg number of Helicoverpa armigera on parasitism and adult recovery of Trichogramma brasiliensis revealed that an egg to parasitoid female ratio of 40:1 is ideal to avoid super parasitism.

Comparative studies using the indigenous and Indonesian strains of Cotesia flavipes at ratios of 1:2, 1:1 and 2:1 revealed the superiority of the indigenous strain in producing more adults per host larva parasitized and a greater proportion of females in the progeny.

Comparative studies were carried out between laboratory reared and field collected Pharoscymnus horni for biological and temperature tolerance parameters. These studies indicated that various developmental stages of field collected P. horni took less time for completion of development than laboratory reared adults (reared continuously for 300 days). Fecundity of field collected adults was 36.6 ± 5.91 in comparison to 32.2 ± 3.86 in laboratory reared adults. Longevity was also reduced in laboratory culture. Storage of adults at 15° resulted in a slight increase in mortality during storage. After storage for 15, 30, 45 and 60 days developmental period fecundity declined in general but laboratory culture was found to be more adapted to withstand storage than field collected population. Therefore, field population should be added regularly once in 10 generations to rejuvenate the laboratory cultures.

Studies conducted on the dispersal of two Trichogramma spp. on cotton revealed that T. achaeae was more efficient than T. brasiliensis against H. armigera on cotton. T. achaeae females parasitised 100 percent eggs of H. armigera on cotton upto 5 metres distance in the wind direction from the release point. In the opposite direction only 27 and 15 per cent eggs were parasitised. T. chilonis and T. achaeae gave effective suppression @ 1.5 lakh/ha and Trichogrammatoidea armigera @ 2.5 lakh/ha when released @ 375 for first two species and @ 625 per spot for Tr. armigera, respectively.

In experiments on host searching ability of various ecotypes of Trichogramma chilonis on cotton, the percent parasitism by Bio C1 strain was 83.5, 82.2, 69.2, 53.0 and 32.7% and by Bio C2 strain was 84.0, 81.7, 69.0, 49.0 and 36.0% upto 1, 2, 3, 4 and 5 metres distance. Prevailing wind played a major role as higher parasitism was recorded in the direction of wind. Parasitism by other four strains viz., Bio C3 to Bio C6 was comparatively less than Bio C1 and C2. Thus results on host searching ability of T. chilonis for Helicoverpa armigera eggs on cotton reveal that Bio C1 and Bio C2 strains are more promising for further field evaluation.

Screening of various Bacillus thuringiensis products against Trichogramma chilonis and neonate larvae of Helicoverpa armigera revealed that two B. t. products Bitoxibacillin and Lepidocide and T. chilonis are compatible and can be released/sprayed together for effective biosuppression.

Asco virus from *H. armigera* and *S. litura*, *Metesia* sp. from *S. litura* have been isolated at PDBC, Bangalore for the first time. At IARI commercial preparation of *Bacillus thuringiensis* could kill larvae, pupae and adults of *S. litura*.

Preliminary attempt to establish primary cell culture from the embryos of *S. litura* for the *in vitro* multiplication of insect baculoviruses and other obligate pathogens have shown indications of cell growth, suggesting the establishment of primary cell culture. Attempts have been made to establish primary lepidopteran insect cell culture from undifferentiated insect haemocytes. This could be successfully maintained in serum free insect cell culture medium with occasional change of medium once in 7-10 days.

Standardisation for isolation and purification of polyhedral inclusion bodies, polyhedral protein, and DNA of *Helicoverpa* nuclear polyhedrosis virus has been made and it was found to layer at 46% (W/W) sucrose gradient, and dissolved in 0.1 M sodium carbonate solution.

Successful identification of sexes of lepidopterous hosts in larval stages based on morphological characters was achieved and preliminary study on the mass multiplication of nuclear polyhedrosis virus of *S. litura* using female larvae preferentially over male larvae has given encouraging results of higher virus yield.

At PDBC, Bangalore, bacteria isolated on nutrient agar and King's medium B from sunflower leaves, crown and roots inhibited *in vitro* growth of the leaf spot and wilt pathogens - *Alternaria helianthis* and *Sclerotium rolfsii* and also the root rot pathogens *Rhizoctonia solani* and *Macrophomina phaseolina*. Antagonistic bacteria from leaves were mainly actinomycetes and pigmented Gram-positive bacteria, while those from roots and crowns were identified as *Pseudomonas fluorescens* -*putida*, *P. maltophilia*, *P. cepacia*, *Flavobacterium odoratum* and *Bacillus* sp. In soil bioassays, when used as seed inoculum in the presence of *S. rolfsii*, *P. cepacia* strain N24 increased significantly the percentage of seedling emergence. Bacteria strains which exhibited broad spectrum *in vitro* antagonistic activity were tested for colonisation of sunflower roots, when used as a seed inoculum. Good colonisers (10^4 to 10^6 bacteria/g root) were consistent in their ability to reduce disease and fungal wilt. A seedling having a primary root length of 5 cm with fewer lateral roots, necrosed cotyledons or crown and a wilted shoot indicated its diseased status. On an average, only 30% of seedlings were diseased when treated with the antagonistic strains, in the presence of the pathogen, while 60% of the seedlings were diseased in the presence of the pathogen alone. In microplots treated with strain N24, only 1 to 3% of the seedlings were wilted, while

14% of the seedlings were wilted in the presence of the pathogen alone. The results obtained show that bacterial antagonists of sclerotial fungi can be used as seed inocula to improve plant growth through disease suppression.

Major efforts for the biological control of sugarcane pests were directed to borer and scale pests. Most of the dipterous parasitoids introduced for the control of borers failed to establish. Even Diatraeophaga striatalis introduced from Indonesia and recovered from internode borer from Pugalur area of Tamil Nadu in 1980 failed to give the desired control. A braconid parasitoid A. pyralophagus has been recovered from stalk borer at Jagadhari (Haryana), Lucknow, Ladda (Punjab) and other places. At Lucknow it has also been recovered from Scirpophaga excerptalis and C. partellus. Augmentation of St. inferens has decreased the population of shoot borer in Tamil Nadu. Similarly, inundative releases of another indigenous parasitoid Isotima javensis has given fairly good control of top borer, S. excerptalis.

Spiders Hippasa greenaliae and Cyrtophora cicatrosa were very common in sugarcane ecosystem, the former appearing early When H. greeneliae were caged in sugarcane fields at Coimbatore, the population of shoot borer was reduced. Dimethoate 0.1% and endosulfan 0.1% were safe to H. greenaliae. At Coimbatore, colonisation of spiders was high in intra-row spaces than in inter-row spaces. Selective exclusion of cultural practices like weeding and detrashing enhanced the colonisation of spiders. Furrow irrigation greatly disturbed the spider population. Burning trash after cane harvest has a drastic effect on the spider population.

Field evaluation of Trichogramma chilonis against Chilo infuscatellus and Chilo sachhariphagus indicus at Mandya revealed egg parasitism of 43.3 - 86.8% in released area in comparison to 5.2 - 13.3% in control area. Initial parasitism recorded was 5.7 and 6.2%, respectively. Per cent borer incidence in released and control area ranged from 5.6 - 12.0% and 39.5 - 62.3%, respectively. Percent borer incidence in pre-release observation was 15.8 and 16.2% in released and control areas. Results thus prove that T. chilonis release @ 50,000/ha on 40 day old crop six times with a of 10 days could effectively suppress the borers on sugarcane. For the suppression of Chilo auricilius a cooperative experiment was laid out in 40 ha area at Nawanshahar, Punjab. Trichogramma chilonis (sugarcane strain) was released @ 50,000/ha, from July end to December, releases were made at 10-15 days interval. The incidence in the colonised area was 9.5 per cent and 12.6 per cent in the months of September and December, respectively, while the corresponding figures for control were 57.6 and 61.0 per cent. Further trials have confirmed these findings in Jalandhar, Gurudaspur and other areas of Punjab. The combined release of _T. chilonis_ and _A. pyralophagus_ was superior to releasing these parasitoids individually.

At Bangalore _T. chilonis_ when released @ 75,000/ha at weekly interval gave egg parasitism of maize stem borer ranging from 0.0 to 79.6% in released plot in comparison to 0.0 to 18.6% in control area. Percent borer incidence ranged from 4.0 to 15.6% in released plot and 13.0 to 82.0% in control plot, respectively.

The field efficacy of two strains of _Cotesia flavipes_. viz. indigenous strain and Indonesian strain for the control of sugarcane borers was compared at Ludhiana , Lucknow and Coimbatore and it was seen that the indigenous strain of _C. flavipes_ was better as compared to the Indonesian strain to control three species of sugarcane borers, viz. _Chilo auricilius_, _C. infuscatellus_ and _Acigona steniellus_ in Ludhiana while the differences were not discernible at Lucknow and in Coimbatore the level of incidence was not reduced through parasitoid release.

In laboratory parasitization studies at Coimbatore indigenous population of _C. flavipes_ showed higher levels of parasitization on sorghum borer than on internode borer. Laboratory investigations carried out at Lucknow on the biology of exotic strain of _C. flavipes_ on the larvae of _C. auricilius_ revealed that each female wasp produced 37.17 ± 27.85 adults and the sex ratio of the emerging progeny was 1 : 0.33 (Male : Female).

Exotic predator _Sticholotis madagassa_ from East Africa has been evaluated against scale insect _Melanaspis glomerata_ and recovered from Pravaranagar and Shakarnagar. Out of exotic parasitoids introduced only _Neococcidencyrtus_ sp. has accepted scale insect. _Fusarium subglutinanus_ was found effective in reducing the scale insect population in ratoon stubbles at Coimbatore. The use of indigineous and exotic predators along with indigenous parasitoid may be continued for the suppression of this pest.

Success has been achieved by colonisation of _Epiricania melanoleuca_ against _Pyrilla perpusilla_ in Maharashtra, Andhra Pradesh and other areas. Introduction of entomopathogenic fungus _Metarhizium anisopliae_ inoculum through inoculated pyrilla adults @ 250/ha increased the field infection from 4 per cent at the start to 98.4 per cent after 60 days during humid months at Lucknow but the results at Coimbatore were not encouraging. The effect of release of cocoons of _Epiricania melanoleuca_ for the control of _Pyrilla perpusilla_ was studied in Ludhiana and it was found that the population of pyrilla within a month was very low when compared with the control plot.

Four sprays (on 40,55,70 and 85th days after planting) of Granulosis virus (GV) of shot borer with a dosage of 10^{9} granules/ml also gives good control of this pest. Soil application of HCH along with first spray of CiGV increased the efficacy of CiGV sprays.

Basic studies on CiGV and CaGV have been accomplished. The granulosis virus of C.infuscattelus was formulated as a wettable powder by SBI,Coimbatore. Pathogenicity of formulated granulosis virus decreased more rapidly than that of unformulated virus. Formulated virus lost its virulence less rapidly when stored at 4°C compared to room temperature. Sodium carbonate at 0.25% concentration showed synergistic effect when added to granulosis virus. Filtration followed by centrifugation method is found suitable for extracting the GV from soil. The formulated virus could be stored at room temperature for 4 months.

Hirsutella nodulosa was recorded for the first time in the world on internode borer. The pathogen was active in internode borer throughout the year infecting highest no. of larvae in October-December. Beauveria bassiana was tested against C. auricilius larvae. Second instar larvae were highly susceptible. LT_{50} values of mature larvae when infected with 4×10^{8} spores/ml was lowest at 20°C and highest at 10°C being 4.9 and 19.1 days, respectively. In vitro studies showed greater inhibitory effect of HCH and quinalphos on Beauveria bassiana.

Three formulatioins of B.t. viz., Delfin, Dipel 8L and Centari was tested against C.auricilius in Punjab and it was found that higher dosages of Delfin and Dipel 8L were significantly better than the lower dosages and at Coimbatore, Dipel was found effective against internode borer in the laboratory.

Under controlled conditions Steinernema glaseri and Heterorhabditis sp. n. caused cent percent mortality at 1.9×10^{8} Ijs/pot, both in Holotrichia serrata and Leucopholis lepidophora. Beauveria bassiana (root borer isolate) was not found pathogenic to H. serrata. Bacillus popoillae caused 70.8% mortality of L. lepidophora.

Integrated Pest Management module comprising of blanket application of oxydemeton methyl 0.03, three releases of Chrysoperla carnea @ 50,000/ha at 10 days interval and 8 releases of Trichogramma chilonis @ 1,50,000/ha/week and one application of endosulfan 0.07% proved effective against bollworm, Earias vittella in hybrid cotton-6 at Gujarat. Application of all the above treatments ;with an additional spray of HaNPV suppressed pests on cotton variety MCU-5 at Coimbatore (Tamil Nadu). The IPM module not only increased the yield but also conserved the naturally occurring biotic agents.

Through IPM strategies on cotton double the benefit could be obtained as compared to 30 rounds of insecticidal spray at Hyderabad. Similar trials at Ludhiana, Coimbatore and Anand where release of T. chilonis and C.carnea and HaNPV was compared with spray schedules could give effective control of boll worms and the IPM module recorded more yield than the spray schedule.

In Punjab, eight releases of Trichogramma chilonis @ 1,50,000/ha during August-October (at 10 days interval), two sprays of oxydemeton methyl 0.075 per cent (750 ml/ha) in 1st, second and one spray in the last week of September, one spray of cypermethrin 0.016% (200 ml/ha) in the middle of September and one spray of carbaryl 0.4% per cent (2.5 kg/ha) in the 1st week of October were found effective in the management of cotton pests and in reducing the number of insecticide sprays in cotton ecosystem to five in the entire crop period. The egg parasitism of bollworms reaches as high as 70 per cent in September-October. The white fly population was high in plots where only chemical control measures were adopted.

Laboratory studies made at Ludhiana to study the effect of two different formulations and dosages of Bacillus thuringiensis on the larvae of Earias sp. revealed that higher dosages of Delfin (2kg/ha) and Dipel 8L (2 lit./ha) gave better mortality as compared with their lower dosages (1 kg/ha).

In the parasitoid/predator release blocks, natural enemies viz., Rogas aligarhensis, Agathis sp. Bracon greeni, Cheilomenes sexmaculata, Coccinella septempunctata, Brumus suturalis, Geocoris bicolor, Orius sp., Apanteles angaleti, Chrysoperla sp., Mallada boninensis and predatory spiders were conserved. B. kirkpatricki has established in Gujarat and T. achaeae has been recovered from innundative release fields on exposed egg cards.

C. sexmaculata performed best when the population of A. gossypii on cotton was high. The early planted crop of cotton was having less aphid (A. gossypii) population partly due to the impact of natural enemies.

Seasonal studies on Bemisia tabaci and its natural enemies around Bangalore suggest that during summer months when crops are not available in the fields, lantana serves as alternate host plant and on this plant parasitoids were more active probably because regular pesticide sprays on cultivated crops eliminate natural enemies.

The situation of biological control of rice stem borer Scirpophaga incertulas is more or less similar to sugarcane borers. T. dignoides is the most effective natural parasitoid and gives control from February to March at

Cuttack. In Tamil Nadu egg parasitism by Tetrastichus schoenobii was high during February to April and September (48.5 to 76.9%) and Telenomus rowani during January, June, September and December (27.3 to 38.0%). At Jorhat the egg parasitism was quite low. Thirty adults of T. japonicum per 10 egg masses were enough to get maximum parasitism. Augmentation of T. japonicum in the fields along with supply of extra host stages maximised the parasitism levels. Inundative releases of Trichogramma japonicum at 50,000 adults/ha/week starting 50 days after sowing (for direct sown Rabi) or 30 days after transplanting (for the transplanted Kharif) were made in Gopalapur village (Titabar, Jorhat) for suppression of paddy stem borer and leaf-folder. The results of 8 releases in Rabi experiment showed that in biocontrol plots the percentage occurrence of white ear head was comparatively low (3.15%), whereas it was high (6.20%) in control. For Rabi crop similar results have been obtained in Tamil Nadu. Few more exotic parasitoids are likely to be introduced. C. lividipennis is the most promising predator of brown plant hopper. Efforts made to mass multiply this predator for field utilisation have been successful. Release of 100 mirid bugs or 50-75 eggs/m^2 at 10 days interval checked the build up of BPH population to some extent. At Coimbatore release of 70 nymphs/m^2 on 45th, 55th, and 65th DAT was found promising. The presence of any combination of spiders @ 3 nos. per hill (Lycosa pseudoannulata, Oxyopus javanus and Tetragnatha sp.) checks the population of BPH and WBPH. Rice gall midge has a very useful indigenous parasitoid Platygaster oryzae. Bracon hispae followed by Neochrysocharis chrysontomyia are the key parasitoids of Dicladispa armigera at Assam.

At Coimbatore, release of Trichogramma japonicum (5 times) was on par with release of parasitoid (4 times) followed by spraying of phosphamidon 300 ml/ha in reducing the rice stemborer dead hearts during kharif, 1993 . Higher yield could be recorded from the plots treated with spraying of phosphamidon (twice) as well as release of T. japonicum (4 times). In rabi, 1993 the results indicated that release of T. japonicum thrice followed by spraying of phosphamidon 300 ml/ha once was on par with need based spraying of phosphamidon 300 ml/ha twice in reducing the stemborer attack and recording higher yield. A similar trial on the evaluation of Trichogramma japonicum to control Scirpophaga incertulas on rice in Ludhiana showed that the releases of T. japonicum @ 50,000/ha at 10 days interval were effective while T. chilonis tried against Cnaphalocrosis medinalis @ 50,000/ha, at 10 days interval reduced the number of leaves damaged by the pest to almost half in the released plot as compared with the control plot. Release of T. japonicum @ 50,000 adults/ha at Pune was found to be the most effective and significantly superior to endosulfan (0.07%) and untreated control for the control of stem borer.

Three egg parasitoids viz., Tetrastichus schoenobi, Telenomus rowani and Trichogramma japonicum were recorded at Coimbatore parasitizing eggs of rice stem borer and the parasitism percentages were also fairly high. The larval parasitoids of rice leaf folders, Cnaphalocrosis medinalis and Marasmia patnalis were Trichogramma cnaphalocrocis, Temelucha philippinensis, Xanthopimpla flavolineata, Brachymeria sp., Charops brachypterum, Elasmus sp., and Apanteles flavipes.

Successful establishment of the parasitoid Allorhogas pyralophagus has been achieved with the recovery of this exotic parasitoid from the yellow stem borer larvae in Assam. Seasonal incidence of key natural enemies of rice hispa Dicladispa armigera in the hispa endemic areas of Assam (Sibsagar) and Kakajan revealed the activity of egg larval parasitoid Chrysonotomyia sp.,larval parasitoid Bracon hispae and egg parasitoids Trichogramma spp., and Oligosita sp.

Acephate 75 WP, chlorpyriphos 20 EC and monocrotophos 36 WSC @ 0.5 kg a.i./ha recorded equal populations of spiders Lycosa pseudoannulata and Tetragnatha javana and were on par with untreated check. Granular insecticides carbofuran 3G, phorate 10G and quinalphos 5G were found to be safer to the parasitoid Platygaster oryzae and spiders L. pseudoannulata and T. javana. Neem oil and neem seed kernel extract 5% were safer to P. oryzae, spiders and mirid bug, Cyrtorhinus lividipennis.

Studies at Coimbatore revealed that spraying of monocrotophos 100ml/ha (thrice), Bacillus thuringiensis 2.5 lit/ha (thrice), buprofezin (4 times) 1.6 kg/ha, NSKE 5% (4/5 times) as need based either alone or in alternation were found to reduce the leaf folder damage. The safety of treatments in conserving the population of predators and extent of larval parasitism was in the order of NSKE > B. thuringiensis > buprofezin > monocrotophos.

In pulses, HaNPV has given encouraging results in suppression of H. armigera on chick pea in Gujarat and other places. Forty seven per cent increase in yield has been obtained in Gujarat. The effectiveness of NPV against H. armigera in chickpea was also estimated at Hyderabad and Coimbatore and it was found that spray application @ 250 LE/ha was effective in reducing the damage on chickpea in Hyderabad and in Coimbatore.

Trials with T. chilonis and NPV for the control of H. armigera on pigeon pea were conducted in Hyderabad and Coimbatore and application of NPV @ 250 LE/ha was as effective as endosulfan (0.07%) and NPV @ 125 LE/ha + endosulfan (0.035%) in combination with T. chilonis release were found quite effective in reducing the larval population and damage by H. armigera. T. cholonis alone was ineffective.

H. armigera appeared on pigeonpea at the flowering stage of the crop. On pigeonpea, the egg parasitoid Trichogramma sp. was recorded during the flowering stage and three larval parasitoids, Campoletis chlorideae, Xanthopimpla sp. and an unidentified tachinid were recorded during pod formation stage at Hyderabad. Tachinids appear to be more abundant on pigeonpea than ichneumonids.

Two peaks of moth emergence once in 2nd week of September and the second in 4th week of September were recorded while monitoring H. armigera population through pheromone trap catches at Hyderabad and two weeks later egg population of H. armigera was observed synchronizing with the peak flowering period of pigeonpea which showed that trap catch data could help in synchronizing field release of parasitoids and spray of HaNPV. Five species of birds viz., cattle egret, rosy pastor, common myna, drongo and house sparrow predate on the large sized H. armigera larvae.

Evaluation of B.t. formulations viz., Dipel, Delfin, Biobit, BARC strain, BTK-I, BTK-II, B.T.T, and Agree at 0.5 kg/ha at Hyderabad and Coimbatore revealed that Biobit was best followed by Endosulfan 0.07% at Hyderabad, while in Coimbatore all B. t. formulations and endosulfan (0.07%) were superior to control.

Biological suppression of oilseed pests especially castor semilooper A. janata has received much attention. Success was reported by releasing exotic parasitoid T. proditor. A promising granulosis virus has also been isolated at PDBC, Bangalore; IARI, New Delhi and GAU, Anand. Evaluation of inundative releases of local Trichogramma strains is being attempted.

On mustard the predators, viz., Coccinella septempunctata and syrphid Leucopis sp. also appeared with the appearance of Lipaphis erysimi. The parasitoid Diaeretiella rapae appeared during 1st week of March on B. oleracea var. botrytis and B. juncea, whereas it appeared on 24th February on R. sativus. The predators and parasitoids disappeared with the disappearance of L. erysimi in the 2nd fortnight of March. The parasitoid, Diaeretiella rapae and the predators Coccinella septempunctata, Episyrphus alternans. E. balteatus, Metasyrphus confractor, Scaeva latemaculata and Spaeroporia indiana were recorded on mustard aphid Lipaphis erysimi at Ludhiana. A field experiment laid out in Ludhiana to study the efficacy of C. septempunctata and Cheilomenes sexmaculata released as larvae @ 1000/ha revealed that C. septempunctata was better to control the mustard aphid as compared with C. sexmaculata.

The relationship between L. erysimi and natural enemies was found to be significantly positive whereas abiotic factors, viz., temperature and relative humidity were not found to be influencing the aphid population.

The feeding capacities of predators of L. erysimi were also studied in the laboratory. The grub of C. septempunctata consumed on an average 564.91 ± 8.19 nymphs of L. erysimi during its total life whereas feeding capacity per day was found to be 47.07 ± 0.68 nymphs. During five days the males consumed 51.50 ± 0.95, 55.66 ± 1.56, 63.66 ± 1.81, 67.58 ± 1.31 and 69.66 ± 0.55 nymphs while the females consumed 57.66 ± 1.01, 67.33 ± 0.92, 71.33 ± 0.43, 73.00 ± 0.63 and 75.91 ± 0.63 nymphs. The larvae of syrphids, Episyrphus alternans, E. balteatus, Metasyrphus confrater, Ischiodon scutellaris, Scaeva latimaculata, Melanostoma orientale, Betasyrphus serarius, Metasyrphus latilunulatus and Sphaerophoria indiana consumed on an average, 495.33 ± 8.27, 527.50 ± 7.68, 864.50 ± 11.63, 724.58.58 ± 6.33, 781.75 ± 14.16, 408.16 ± 5.56, 415.83 ± 4.99 , 528.33 ± 3.9 and 359.5 ± 4.69 nymphs during their larval span. The larvae of Leucoplis sp. consumed on an average 68.40 ± 1.33 aphid nymphs during its larval span with per day feeding capacity of 6.64 ± 0.10. The feeding capacity of Cheilomenes sexmaculata grub and adult were also studied in the laboratory.

Preoviposition, egg + larval period, pupal period, oviposition period in case of D. rapae lasted 57.5 ± 2.02 min., 4.1 ± 0.17 days, 5.1 ± 0.23 days and 5.6 ± 0.26 days, respectively, while longevity of male and female was 5.2 ± 0.36 and 6.5 ± 0.22 days, respectively. An individual female parasitised 115.3 ± 6.13 aphids. The population of natural enemies remained too low to play a significant role in reducing the population of L. erysimi. There is a need for standardising augmentative releases of key predators and parasitoids.

In studies on the effect of colonisation of C. septempunctata and the insecticide treatment for control of L. erysimi the insecticide treatment proved to be superior while grubs proved to be the voracious feeders as compared with adults of C. septempunctata. The grubs of C. septempunctata when released @ 30/3 m^2 reduced the aphid population over control to above 75 per cent in a week's time.

On sunflower in Punjab chrysopids, spiders and coccinellids caused good suppression of pests and it is possible to grow kharif crop without resorting to chemical insecticide sprays.

Chrysoperla carnea was not an effective predator of safflower aphid, Uroleucon carthami.

On groundnut natural enemies of leaf-miner Aproarema modicella have been studied and a technique for mass multiplication of aphid predator Cheilomenes sexmaculata has been developed. Release of 1,50,000 C. sexmaculata has been recommended for the suppression of Aphis craccivora. Inundative release of T. chilonis in March suppresses the population of H. armigera. In April, parasitoids - B. gelechiae and Campoletis chlorideae, unidentified staphylenid and migratory bird - rosy pastor consume the major Helicoverpa population.

By artificial inoculation of healthy white grubs with Bacillus popilliae diseased grubs could be obtained and their spore powder has been produced at GAU, Anand to make inoculative application of B. popilliae in the field. Field application of milky disease B. popilliae caused 57.14% disease incidence in grubs of Holotrichia consanguinea. Entomophilic nematode Steinernema glaseri caused 72.22 per cent mortality of white grubs when used @ 1920 nematodes/30 gm of soil.

Spray application of Dipel at 0.5 and 0.75 kg/ha was highly effective and significantly reduced the population of A. janata in castor at Hyderabad. Spray application of AjNPV at 250 LE/ha, 125 LE/ha and at 125 LE + endosulfan 0.03% also significantly reduced the larval population and was on par with endosulfan (0.07%).

Synergistic effect of nuclear polyhedrosis viruses SlNPV 100 larval equivalent (LE) with tannic and boric acid 0.025% for control of S. litura in tobacco nursery and field has been achieved. For the suppression of S. litura in tobacco nurseries joint large scale demonstration trials with PDBC were successfully conducted at Dommeru, Duddukur and G. Patnam. Five sprays of SlNPV were applied and 250 LE/ha at 15 days interval. In treated nurseries 1-4% seedlings were damaged, while in distant control the damage was 33.5-42%. Similarly for the suppression of H. armigera HaNPV on FCV tobacco at 250 LE/ha was most effective followed by HaNPV at 125 LE/ha + Nicotine sulphate 0.2%. Curved leaves were found free from the NPV residues. H. armigera has oviposition preference for rustica tobacco. Large number of eggs are laid but the larvae fail to survive due to parasitisation (Trichogramma sp.), predation (Nesidiocoris tenuis) and sticking to the gummy surface of the leaf.

Rustica tobacco, Tagetes as well as chickpea have been successfully tried as border row trap corps around FCV tobacco for H. armigera. The trap crops also encouraged natural enemy activity which in turn significantly contributed in suppressing the pest population. Commercial formulations of Bacillus thuringiensis at 0.5 kg/ha have been found promising against H. armigera in seed crop of tobacco. B. t. has also shown some promise against S. litura in nurseries and fields. Periodic releases of the parasitoid T. remus and the predator Apertochrysa/Chrysoperla along with a spray of neem seed kernel suspension have also given good results. The release of Chrysoperla also help in suppressing the population of Myzus persicae. Promising natural enemies of whitefly Bemisia tabaci have been identified.

Six chrysopid larvae per tobacco plant released at the beginning of aphid infestation effectively reduced in the buildup of aphid population and was on par with phorate 10G @ 2g/plant

In a biointensive IPM demonstration trial in commercial tobacco nursery integration of parasitoids, predators, insect pathogens, antifeedant (NSKS) and ovipositional trap crop castor against S. litura was demonstrated. The cost benefit ratio for IPM was 1 : 2.74 whereas for conventional chemical control it was 1 : 1.52.

A simple sampling technique has been developed to monitor Opisina arenosella population. Techniques for mass culturing of Brachymeria nosatoi and Parena nigrolineata had been standardised. A method to estimate the intensity of natural parasitism of O. arenosella by examining the emergence slits/holes in empty pupal cases has been worked out by which 7 species of pupal parasitoids can be identified. Laboratory multiplication technique for the endoparasitoid Apanteles taragamae at Kayangulam was standarised. It was found that the second instar caterpillars of Opisina arenosella were best suited to multiply the same in large numbers.

Release of Bracon hebetor, Goniozus nephantidis, Elasmus nephantidis and Brachymeria nosatoi effected high percentage of parasitism and significant suppression of Opisina arenosella at Ambajipeta (Andhra Pradesh).

An exotic predatory bug, Platymeris laevicollis, of African origin has been used in Vittal (Karnataka) for the biological suppression of Oryctes rhinoceros. A baculovirus disease (which multiplies in the gut) infects 30 to 40 per cent beetles in Kerala. The smear test and immunoosmophoresis were found to be ideal and quick diagnostic methods for routine screening of field collected rhinoceros beetles and grubs to assess the intensity of natural incidence of baculovirus disease. The disease was introduced into Minicoy island, Lakshadweep by infecting and releasing the adult beetles. The pathogen has now established in the natural population of beetles and in breeding sites. Leaf, spathe, and spindle damage have been remarkably reduced. A mean of 60% baculovirus infection was noticed in the natural population of beetles. There was drastic decline in site occupancy of the pest. Infection with *Oryctes* baculovirus led to the reduction in their longevity by 1/3 and fecundity by 99 per cent. Re-release of baculovirus in an already infected contiguous area at Palode (Kerala), resulted in 46% reduction in *Oryctes* infestation in the oil palm plantation and higher incidence of baculovirus disease in the natural population of grubs in the breeding sites of the pest in and around the plantation. Baculovirus was introduced into Androth Island, Lakshadweep and Andamans through CARI, Port Blair. Electron microscopic examination of mid-gut tissues of the scarabaeid beetle, *Xylotrupes giden*, confirmed the occurrence of typical baculovirus, similar to one infecting rhinoceros beetle. Re-release of baculovirus of *Oryctes* at Chittilappally (Kerala) effected drastic reduction in the intensity of pest infestation and crop damage, three years after a single re-release of the viral pathogen infected adult rhinoceros beetles.

A cheap simple method for multiplying the fungal pathogen, *Metarhizium anisopliae*, has been developed. Coconut water (a biological waste from copra industry) drawn aseptically before breaking open the nuts has been successfully utilised for mass culturing of *M. anisopliae*. Similarly a selective medium for isolation of this fungus from cattle dung has been standardised.

Among the pathogens of *Leucopholis coneophora* a gregarine protozoan parasite was detected in the grubs. Pathogenicity tests revealed that LD_{50} was 9.86×10^{5} and the infected grubs succumbed to the infection within 27.62 ± 6.28 days.

The entomogenous bacterium *Bacillus popilliae* var. *holotrichiae* was pathogenic to *L. coneophora*. The indigenous scoliid parasitoid *Campsomerilla collaris* could be successfully reared on the fully grown grubs of *Leucopholis coneophora* in the laboratory. It had an incubation period of 2 days, larval period 5 days and pupal period 28-30 days.

Pseudomonas aeruginosa has been identified as a potential bacterial pathogen of *Rhynchophorus ferrugineus*. Further a bacterium, a virus and an yeast-like organism were detected from the field collected grubs of red palm weevil, *R. ferrugineus* in Kerala and these were observed to be pathogenic to the test grubs. Variation of protein, both qualitative and quantitative could be noticed in diseased and healthy grubs of R. ferrugineus when infected with a rod shaped nuclear virus.

Stephanitis typica occurred throughout the year on coconut palms in the field, but its population was high during March, June, July and October-November. The population of predator Stethoconus praefectus was high in May, June, and July and November at Nagaiakulangara and in August at Cheppad, Kerala. In other months the population of prey was high and predator low. Of the three species of alternate host plants tested, arrowroot (Maranta arundinacea) was found to be the best for multiplication of the lace bug and its mirid predator followed by potted coconut seedlings.

Among the indigenous predators of the phytophagous mite Oligonychus iseilemae the dominant mite predators were Amblyseius paraerialis, A. eucalypticus and Cunaxa sertirostris. The prey consumption, predator - prey ratio and peak period of abundance of these species in the field were studied.

Encarsia perniciosi is well established against San Jose scale on apple besides, Aphytis proclia and Chilocorus bijugus, Pharoscymnus flexibilis and Cybocephalus sp. also play an important role in the population suppression of this pest in Kashmir valley. Predators, are early arrivers in the orchard. The releases of Aphytis proclia and Encarisa perniciosi in Kashmir on apple (@ 2000 each per tree) could effectively reduce the infestation by San Jose scale. The predator, Chilocorus bijugus when released @ 20/ tree reduced the scale density in Kashmir while a single release of Chilocorus bijugus larvae @ 50 neonate grubs per tree at Solan brought about a reduction in mean population of the scales.

In Himachal Pradesh, woolly aphid failed to multiply during spring and autumn due to heavy predation by Coccinella septempunctata and Hippodamia variegata. The exotic parasitoid Aphelinus mali overwintered in mummified aphids as prepupa from November end to Feb. end (91-107 days) at Solan but from the stock brought from Kullu, adult emergence had begun by January end. Aphelinus mali which was introduced at Nauni in 1991 has uniformly spread in the apple orchard and is providing satisfactory control. A coccinellid Platynaspis saundersi acted as a good woolly apple aphid.

Biology of a chrysopid (Chrysoperla carnea) was studied for 3 generations . The chrysopids wintered in cocoon as prepupa from first week of November to early March. Imago came out of pupal cocoon by second fortnight of March. The larval duration was 18-20 days in spring and 8-13 days in

July - September. Each larva consumed 301-325 Aphis pomi. A coccinellid Platynaspis saudersi acted as a good predator of Aphis pomi and also fed on Macrosiphonella sp.

Chilocorus bijugus overwinters as adult and passes through four distinct but overlapping generations from February to October. Survival was higher for females than males. Egg laying and development of grubs began at diurnal temperature of 10-16°C. On the other hand, scale predator Pharoscymnus flexibilis overwintered as adult without laying any progeny till March. Overwintering adults of Hippodamia variegata and Oenopia sauzeti had better survival by February end (88.5 and 76%) and egg laying commenced by last week of March and mid March, respectively. C. septempunctata and Coelophora sexreata had not commenced egg laying by March end. The former had 13.6% parasitism due to Dinocampus coccinellae .

Coccinellids C. septempunctata, H. variegata, C. sexareata , O. sauzeti and Platynaspis saundersi had feeding potential of 426-450, 174-276, 324-410, 227-263 and 175-195 aphids (in case of first 4 species peach leaf curl aphid and A. pomi for the last one), respectively. Parasitisation by the braconid Dinocampus coccinellae was to the extent of 20%. Besides, two more species Scymnus posticalis on A. pomi , A. gossypii and A. fabae , and Spilocaria bissellata feeding on E. lanigerum and A. fabae were also recorded.

Entomophilic nematodes Neoaplectana bibionis and Heterorhabditis bacteriophora were effective against eggs and grubs of Brahmina coriacea while they failed to control the root borer Dorysthenes hugelii. Entomopathogenic nematode Heterorhabditis bacteriophora could be multiplied in the laboratory at Solan on Corcyra larva and when applied @ 100 infective juveniles per cm^2 surface area (10^{12}/ha), against white grubs of Brahmina coriacea (III instar) could bring down the population of the larvae in about four months. Bacillus popilliae and Metarhizium anisopliae tested at $(0.5-2) \times 10^8$ spores g soil, failed to control B. coriacea grubs.

An anthocorid bug took heavy toll of apple blossom thrip. Exorista rossica was the most common parasitoid of Lymantria obfuscata and Anastatus kashmerensis a promising egg parasitoid.

For the biological control of citrus mealybug P. citri releases of coccinellid, C. montrouzieri gives good results in mixed planted citrus orchards (citrus and coffee). Local parasitoids and predators were found very effective in the control of diaspine scale Drophonococcus chiton. In case of citrus, Tetracnomoidea indica appeared in large numbers and suppressed P. lilacinus, while C. peregrines was responsible for the control of P. citri. Releases of larvae of C. montrouzieri were found highly effective in clearing the mealybug, P. citri infesting grape bunches and release of 10 C. montrouzieri beetles per vine gave excellent control of grape mealybug within 75 days of release. The predator was highly effective against guava scale, Chloropulvinaria psidii and the pink mealybug Maconellicoccus hirsutus on guava. Release of C. montrouzieri effectively controlled Ferrisia virgata on guava in about 45 days after release. Spalgis epius and C. montrouzieri contribute significantly to the suppression of P. lilacinus in guava orchard. When the ants were controlled with dust application of malathion, P. citri on guava was effectively suppressed by L. dactylopii. The coccinellid predator Cryptolaemus montrouzieri consumed several eggs and nymphs of the mango mealybug Rastrococcus iceryoides in the laboratory and in the field the predators were able to bring down the mealybug infestation. Release of C. montrouzieri, Coccidoxenoides peregrinus and Leptomastix dactylopii were able to suppress the mealy bug populations on pomegranate.

Four demonstration trials conducted at Bangalore on guava and grape mealybugs proved the efficacy of the natural enemies in the farmer's field.

The coccinellids and syrphids effectively checked the populations of Aphis gossypii on guava, Scymnus sp. and Cheilomenes sexmaculata played the major role. L. dactylopii has also established on P. citri at its released sites in Kodagu, Bangalore, (Karnataka) and Pollachi (Tamil Nadu). The parasitoid was recovered from P. citri infesting citrus, grapes, guava, pomegranate, croton and mango.

Dichlorvos 0.10 per cent was found safe to the parasitoid. Deltamethrin 0.05% was safe to Coccidoxenoides peregrinus.

On pomegranate, the aphelinid, Encarsia inaron was able to check the whitefly. Aphis punicae natural enemies were able to bring down the aphid population within two months. The record of Aphidius sp., Aphelinus sp., and Signiphora sp. appreared to be new on pomegranate aphid, Aphis punicae at Bangalore. The whitefly Lipaleyrodes euphoribiae was regulated mainly by Encarsia sp. and an unidentified drosophilid predator on star gooseberry.

On cabbage at Bangalore, Karnataka native parasitoids Apanteles plutellae and Tetrastichus sokolowskii can effectively suppress the diamondback moth while aphids are checked by coccinellid and syrphid predators in the absence of pesticide interference. The epilachna beetle is effectively suppressed by indigenous parasitoid Pediobius foveolatus. In cauliflower and cabbage fields at Solan Pieris brassicae larvae were heavily parasitized by the solitary ichneumonid endoparasitoid Hyposoter ebeninus and by Cotesia glomeratus thus the necessity for application of any insecticide against P. brassicae was not felt.

T. brasilinesis successfully parasitised eggs of Earias vittella on okra under field conditions. T. pretiosum was able to reduce the tomato fruit borer Helicoverpa armigera infestation when released at 2,50,000/ha. Similarly inundative release of T. brasilinesis @ 50,000 per hectare 6 times at weekly interval on tomato produced the egg parasitism upto 78.4% in release area as compared to 12.3% in control area. The percent fruits bored in released area was 0.0-19.0% in comparison to 42.0 per cent in control area. Trichogramma pretiosum recorded a mean of 45.05% parasitism of tomato fruit borer Helicoverpa armigera eggs under open field conditions in Bangalore when releases were made @ 5,00,000 adults/ha while natural parasitisation of H. armigera eggs by Trichogramma spp. provided satisfactory control of the borer and the need of T. pretiosum was not felt in Solan.

Cryptolaemus montrouzieri was able to clear the population of Coccidohystrix insolita on brinjal. Burmoides suturalies, a coccinellid predator was often encountered preying on aphids of peas and chillies in Bangalore. Chrysoperla carnea was found to control the aphids on chillies when releases were made at the rate of 5 larvae per plant.

Plant feeding mites on okra and brinjal can be effectively checked by need based augmentative releases of phytoseiid mites at 10 adults per plant provided insecticides for other pests are used selectively.

An unidentified braconid parasitoid and predators were able to suppress the population of chilli aphid, Myzus persicae. At Bangalore, Myzus persicae on capsicum was kept under check by Aphelinus sp. The parasitism went upto 96.75% in April.

Three weekly sprays of Adisura atkinsoni NPV + Vairimorpha sp. at 250 larval equivalent/ha could afford reasonable control of pod borer complex on beans. Application of three rounds of virus plus nematode at an interval of 7 days significantly brought down both pod borer and blister beetle in pigeonpea. Application of three rounds of DD-136 nematode @ 1.1 x 10^3 nematodes/ml, at weekly intervals effectively checked the population of mustard sawfly, Athalia lugens proxima on radish.

Screening of diseased larvae at IIHR, Bangalore of Plutella xylostella and Crocidolomia binotalis yielded bacterial pathogen, Serratia marcesens and microsporidian, Nosema and Vairimorpha sp.. On farm trials in tomato using HaNPV on H. armigera in various locations in Karnataka gave encouraging results.

The IIHR isolate of HaNPV was effective in checking damage due to H. armigera on tomato crop. Formulation of HaNPV, at the doses of 200 and 300 L.E./ha (containing 1% jaggery and 0.05% Teepol) were effective in protecting tomato fruits against damage by H. armigera. The spray schedule consisting of 5 sprays ; three of which were given at intervals of 5 days and the remaining two at intervals of 8 days, was the most effective spray schedule.

Application of four rounds of fungus Nomuraea rileyi @ 3.2 x 10^8 conidia/ml + 0.01% Triton x-100 at weekly intervals during evening hours effectively controlled H. armigera on tomato. N. rileyi has also proved effective against S. litura on beetroot and Trichoplusia ni on cabbage.

Sporeless mutants (but having delta toxin crystal) of Bacillus thuringiensis var. kurstaki were obtained by chemical mutagenesis using nitrosoguanidine. Seven oligosporogenous (spore: cyrstal ratios ranging from 1:11 to 1:12 x 10^3) and one asporogenous mutant have been selected. This study has identified Cry IA(c) to be the most appropriate gene for cloning into the phyllosphere bacteria of cole crops. The problem of spore enrichment in the mutants during storage at 4°C was overcome by the inclusion of rifampicin in the medium. Larvae of Plutella xylostella were found to be sensitive to very low concentrations of delta toxin. The LD_{50} ranged from 0.05 - 0.22 mg/cm^2 of the leaf surface. The delta toxin preparation was effective in protecting cauliflower foliage and curds against P. xylostella. The formulation consisting of the oligosporogen mutant (P1 PU7), at a protein equivalent dose of 300 g/ha was very effective in protecting cabbage crop from P. xylostella.

Results of a trial in Bangalore to test the field efficacy of some B.t. formulations indicated that application of Dipel and Centari significantly reduced the larval population of P. xylostella as compared to endosulfan treated and control plots and the yields were also more than endosulfan treated and control plots.

The entomofungal pathogens namely Paecilomyces sp. from grubs of brinjal ash weevil on brinjal and Entomopathora sp. from hairy caterpillars of Euproctis sp. on marigold, jasmine, chrysanthemum and pomegranate, have been isolated and their pathogenicity proved positive. The egg mass of S. litura treated with the conidial suspension of Nomuraea rileyi at concentration of 1.2 x 10^7 spore/ml hatched normally. However, 95.2% of the larvae hatched from the treated eggs died of fungal infection.

This entomofungus has also been isolated from H. armigera. The pot culture experiment with Verticillium lecanii against P. xylostella (II instar) on cabbage showed that the fungus caused cent percent mortality in 4 days incubation period, when the larvae were sprayed with a fungal dose of 2.8 x 10^7 conidia/ml at 27 + 2°C and RH at 85-90%.

An entomofungus was isolated from Myzus persicae on cabbage. The fungus Erynia neoaphidis caused maximum percentage mortality of 90.3 to the II instar nymphs of B. brassicae, when they were treated with the highest concentration of 2.4 x 10^8 spores/ml within 4-5 days of incubation, at a temperature 27 + 2°C and RH at 85-90%.

For the suppression of potato tuber moth (PTM) Phthorimaea operculella the application of treatments were synchronised with the appearance of moths determined with the help of pheromone traps. The minimum infestation (8-65%) of tuber moth was noticed in the plot where 4 releases of Chelonus blackburni @ 1,50,000 adults/ha were made. This parasitoid suppressed the pest population to the extent of 44.93% as against 36.85, 34.94 and 3.16% by combine release of Chelonus blackburni + Copidosoma koehleri @ 25000 + 75000 adults/ha, Copidosoma koehleri alone @ 1.5 lakh adults/ha and endosulfan sprays, respectively.

The release of C. koehleri @ 1.5 lakh adults/ha in fields where population of PTM was simulated through adult releases, the PTM infestation was reduced by 25.25% on the basis of number of tubers infested and 41.59% on the weight basis, enchancing 7.33% per cent tuber yield over control. A granulosis virus @ 500 LE/ha has also given promising results in the suppression of PTM.

The parasitoid, Trichogramma chilonis was able to search for potato tuber moth up to a distance of 7 metre from point of release. Also it was observed that the percentage of parasitization was higher at shorter distance i.e. 62.5 to 75 % upto 3 metres which reduced to 25 % at 7 m distance.

Studies on biology of Orthogalumna terebrantis revealed that adults survived for as long as 100 days. Eggs were laid on the lower surface of young central leaves inside holes made by the females with their mouth parts. Eggs hatched in 7-8 days. The mite has established on three tanks in Bangalore and at several places in Kerala.

Studies on host specific weevils introduced for the biological suppression of aquatic weeds revealed that Neochetina bruchi completed its development in 55-70 days under glass house conditions when compared with 70-90 days in the case of N. eichhorniae. However, adults of N. eichhorniae survived for 32-207 days, laid 981 eggs (150-1254) when compared with 59-175 days survival and 681.6 eggs (303-918) in the case of N. bruchi. Adults of N. eichhoriae and N. bruchi survived 56 & 41 days in the absence of food and water. Under starvation conditions wing muscles do not develop. Density per plant and high temperature causes initiation and acceleration of wing muscle development in N. eichhorniae and N. bruchi. The egg production by females of Cyrtobagous salviniae was found to be well distributed over a period of 39 weeks although percentage of hatching was reduced from the 34th week. The total egg production per female was found to be 291.3 (147-458). The egg, larval, adult, and pupal stage lasted 7.9, 21-28, 11.3 and 172-279 days, respectively. Estimation of Cyrtobagous population using Berles funnel revealed that 67% of weevils could be collected after 2 hours using 60 watts light.

Eggs of Pareuchaetes pseudoinsulata fail to hatch at 10 and 40°C. For rearing this insect adopting 30°C for augmentative field releases during the vegetative phase and 20°C for preserving the insects during flowering stage of the weed, during which time, sufficient quantity of leaves for lab rearing may not be available is suggested.

Laboratory studies at Bangalore with Zygogramma bicolorata indicated that repeated mating reduced the viability of eggs laid by females and also their longevity. Studies on diapause showed that the beetle is capable of diapausing throughout the breeding season, with an increase in percentage with the approach of the dry season. A tachinid egg larval parasitoid Chaetexorista sp. was recorded for the first time from Z bicolorata in Bangalore and it was found to parasitise up to 22.9% of the larvae collected from the field during September, 1993.

The biological suppression of weeds has progressed well. N. eichhorniae and N. bruchi have established on water hyacinth in Karnataka, Assam, Manipur and other states. Successful biological suppression of water hyacinth ranging from 80-95% has been achieved in infested tanks in Bangalore with a total surface area of over 940 ha. Average insect population per plant ranged from 6/plant to 18.5/plant. Plants have become stunted and flower production has been reduced. The insects were observed to have migrated by flight within 30 kms from the release site to several water bodies infected by water hyacinth. Successful biocontrol of water hyacinth in 264 sq.km. area of Loktak lake, Manipur was achieved. In Kengeri tank at Bangalore where the water hyacinth roots are anchored in silt, the collapse and clearance was delayed by 4 years, because the larvae of weevils failed to get free floating roots for pupation. At Jorhat, in 21 months about 90% water surface has been cleared off by these weevils. These weevils migrated to water hyacinth areas located 25 km away from the initial released site - AAU campus. The weevils have cleared Tocklai river. The weevils have also been released in U.P., Gujarat, Punjab and several other states. N. eichhorniae has successfully colonised all the centres of release in Kerala but without any appreciable reduction in weed stand except at Ernakulam. N. bruchi failed to establish.

Orthogalumna terebrantis has established in Bangalore and at Alleppey, Moncompu and Kumarakom in Kerala. At Alleppey these mites have spread to a distance of over 2 km. In Kerala in general and at Kumarakom in particular the mites are proving better than weevils.

Cyrtobagous salviniae has established on Salvinia molesta in Kerala and Karnataka and is suppressing this weed in all the release sites. Upto 40 weevils per sq. meter of Salvinia mat have been released. In Kuttanad (Kerala) the weevil has cleared about 200 sq. miles area. In most of the paddy fields where expenditure ranging from Rs.250 to 270/- per hectare had to be incurred for removing Salvinia weed before paddy cultivation, very little or no expenditure was required after the establishment of C. salviniae. An annual saving of Rs 68 lakhs is estimated only on account of labour. The navigational canals and paddy fields in Kuttanadan and Kole lands (Kerala) as well as Vembanad lake have been cleared.

Regarding terrestrial weeds Lantana bug Teleonemia scrupulosa is suppressing this weed in some areas. But its effectiveness is reduced in Bangalore by its egg parasite, Erythmelus teleonemae which parasitise 85% eggs during May and August. Laboratory studies were carried out on the biology of E. teleonemae the solitary egg parasitoid of the lantana bug T. scrupulosa. The adults were found to survive for less than 24 hours and produce 16-24 eggs. Temperatures between 20-30^{0}C were found to be suitable for insect development. The insect was capable of parasitising host eggs that were less than 72 hours only.

Sri Lankan strain of Pareuchaetes pseudoinsulata introduced for the biological control of Chromolaena odorata has been found superior to the Trinidad strain. The insect has established in Trichur (Kerala) and Mallesara, near Thirthahalli, Shimoga District (Karnataka). It has suppressed the weed in six hectare rubber plantation in Kerala and 5 acres in Karnataka. Defoliation of C. odorata was observed in plantations and forests in Sulya taluk in

North Canara District by release of *P. pseudoinsulata*. The insect was observed to have dispersed sporadically over 1000 sq. m. area in the above region causing large scale defoliation of *C. odorata* in reserved forests as well as plantations.

Zygogramma bicolorata has established on *Parthenium* weed. The insect was found to be capable of overcoming the dry season in the field by remaining under the soil. Laboratory studies showed that just 0.2 adults per plant were able to defoliate the *Parthenium* plants in the seedlings and rosette stages, under caged conditions, within 20 and 30 days, respectively. In the case of flower initiation and flowering stages, 4 adults per plant were required to achieve the same effect in 30 days. In field dispersal of this insect is very poor which is a limiting factor for the spread and effectiveness. Although the beetle was colonised by IIHR in 1983, its impact was evident only in 1988. The beetle has caused defoliation of parthenium in and around Bangalore. The insect has spread naturally into 8 districts in Karnataka, Andhra Pradesh and Tamil Nadu. However, regrowth of the weed was noticed in many places due to heavy rains received during November and December 1991. The insect has also established at Menonpara (Kerala), and many areas of Maharashtra. In 1991 and 1992 complete defoliation of *Parthenium* and massive breeding of the insect was observed in Karnataka. Some adult beetles from the surrounding defoliated *Parthenium* were recorded feeding on sunflower leaves on certain cultivars in isolated pockets.

Studies carried out over a period of two years in two uncultivated parthenium infested horticultural fields at Bangalore showed that defoliation by *Zygogramma bicolorata* can cause up to 99.5% decline in weed density, provided the soil is left undisturbed. Forty different species of plants, formerly suppressed by the weed, were noticed to grow in the areas vacated by parthenium.

Studies on population dynamics of *Heteropsylla cubana* and *Curinus coeruleus* revealed that pest population during 1989-90 was high during July and October. During this period *C. coeruleus* population rached upto 84.7 adults per tree. Pest population was significantly low during 1990-91. Results thus indicate that with the introduction of *C. coeruleus* in and around Bangalore, population of *H. cubana* has been drastically reduced. Release of *C. coeruleus* is superior to monocrotophos sprays. Efforts have been initiated to introduce additional exotic natural enemies for the suppression of this pest.

The overall progress of the project is satisfactory. However, there is an urgent need to speed up import of important natural enemies for strengthening the biological control programmes. Identification of new biocontrol agents and methods to increase the efficiency of the existing ones have to be worked out on priority basis. Large scale field trials are necessary to demonstrate the efficacy of biotic agents. New thrusts in mass production including *in vitro* production of parasitoids, entomopathogens, entomophilic nematodes and antagonists and production of predators and some of the target hosts, parasitoids of which cannot be multiplied on laboratory hosts etc. should be our country's research priorities.

Staff Position:

Sl. No.	Name & Designation	Date of joining the current position	Date of joining the project	Date of leaving	Total man months spent on the project
(1)	(2)	(3)	(4)	(5)	(6)
	Project Directorate of Biological Control, Bangalore				
1.	Dr. S.P.Singh Officer on Special Duty	19.10.93	09.11.89	Continuing	12
2.	Dr. K. Narayanan, Principal Scientist (Ento.)	01.01.86	28.05.80	"	12
3.	Dr.N.S.Rao Senior Scientist (Ento.)	01.01.86	15.10.93	"	6
4.	Mr. S.R. Biswas, Senior Scientist (Ento.)	01.01.86	01.04.88	"	12
5.	Mr. S. Ramani Scientist SS (Ento.)	10.01.93	17.06.91	"	12
6.	Mrs.Chandish R. Ballal Scientist SS (Ento.)	06.02.92	06.02.85	On studyleave w.e.f.14-02-94	11
7.	Mr. S.K. Jalali Scientist SS (Ento.)	06.02.93	06.02.85	Continuing	12
8.	Mr. M. Narayana Rao T-4	16.03.89	16.03.89	"	12
9.	Mr. P.K. Sonkusare T-4	15.02.89	15.02.89	"	12
10.	Miss. Y. Lalitha T-II-3	01.06.91	01.06.91	"	12
11.	Mr. B.K. Choubey T-II-3	01.06.91	01.06.91	"	12
12.	Miss. S.K.Rajeshwari T-1	01.10.87	01.10.87	"	12
13.	Mr.P. Raveendran T-1	01.10.87	01.10.87	"	12

(1) (2)	(3)	(4)	(5)	(6)
14.Mr. P.Vanaraju Sr.Clerk	28.01.85	28.01.85	"	12
15.Mr.G.V.Sharma SS GR. I	01.10.87	01.10.87	"	12
16.Mr.M Muniswamy SS.GR. I	01.10.87	01.10.87	"	12
17.Mr. Ramakrishnaih SS.GR. I	17.02.92	17.02.92	"	12
18.Mr.Narayan Nair Driver	01.10.87	01.10.87	28.02.94 (retired)	11
19.Mr. Chandrappa Driver	18.02.92	18.02.92	Continuing	12
Central Plantation crops Research Institute, Kayangulam				
1.Dr.S. Sathiamma Senior Scientist (Ento.)	01.01.86	01.10.84	Continuing	12
2.Dr. V.A. Abraham Senior Scientist (Ento.)		01.04.90	30.9.93	5
3.Dr. T.K. Dangar Scientist (Micro.)	08.01.86	08.01.88	31.12.93	9
4.Sri. C.P. Ramachandran Scientist (Ento.)		01.04.89	Continuing	12
5. Mr.A.S. Sabu Tech. Asst.(T4)	26.03.93	26.03.93	"	12
6. Mr.V.Chandrasekharan Supporting staff	10.04.92	10.04.92	Continuing	12
Central Tobacco Research Institute, Rajahmundry				
1. Mr.R.S.N.Rao Senior Scientist (Ento.)		21.04.77	Continuing	12
2. Mr. G.H. Mohanachari Tech. T-I		13.11.93	"	8
3. Mr. Sara Grace SS Gr. II.		28.08.93	"	5

(1) (2)	(3)	(4)	(5)	(6)
Indian Agrilcultural Research Institute, New Delhi				
1. Dr.K.L.Srivastava Senior Scientist (Ento.)		01.10.78	"	12
2. Mr. Ravi Kumar Palta Tech. Asst.(T-4)		14.04.83	"	12
3. Mr. Manohar Singh Fieldman		30.04.86	"	12
Indian Institute of Horticultural Research, Bangalore				
1. Dr. M. Mani Senior Scientist (Ento.)	01.01.86	09.09.77	"	12
2. Mr. K.P.Jayanth Senior Scientist (Ento.)	01.01.86	24.09.77	"	12
3. Mr. A.Krishnamoorthy Scientist SG(Ento.)	01.01.86	24.09.77	"	3
4. Dr. K.S.Mohan Senior Scientist (Ento.)	01.01.86	03.01.78	"	12
5. Mr. C.Gopalakrishnan Scientist (Pl. Patho.)	21.01.85	02.11.78	"	12
6. Mrs.P.N. Ganga Visalakshy Scientist (Ento.)	28.03.87	28.03.87	"	12
7. Mr. G.L.Pattar Technical Officer (T-5)	01.07.85	05.09.77	"	12
8 Mr. D.L.Shetty Technical Asst.(T-4)	31.12.82	31.12.82	"	12
9. Mr.S.Hanumantharaya Field Technician (T-3)	01.07.89	01.05.87	"	12
10.Mr. N.Subbaiah Field Technician (T-2)	01.07.86	21.02.79	"	12
11.Mr. N. Chandra-shekhar Sub-Assistant.	22.02.79	22.02.79	"	12
12.Mr. Anjanappa Mali	12.05.77	12.05.77	"	12

(1)	(2)	(3)	(4)	(5)	(6)
Indian Institute of Sugarcane Research , Lucknow					
Main Centre:					
1.	Dr. Ashok Varma Principal Scientist (Ento.)	01-01-1986	-	"	12
2.	Dr. N.K. Tiwari Senior Scientist (Ento.)		01.04.92	"	12
4.	Dr. R. K. Tanwar Scientist (Ento.)	14.03.86	14.03.86	"	12
5.	Mr. C.L. Gupta T-II-3		11.10.74	"	12
6.	Mr. B. L. Maurya T-II-3		30.12.77	"	12
8.	Mr. Niranjan Lal T-II-3		15.10.74	"	12
Pravaranagar(MS)					
5.	Mr. R.B. Jadhav Sr. Tech. Asst. T-5		29.12.77	"	12
6.	Mr. N.M. Wadekar Fieldman T-2		29.08.78	"	12
Shakarnagar (AP):					
7.	Mr. D.C. Rajak Sr. Tech. Asst. T-4		16.02.90	"	12
8.	Mr. K.V. Rao Fieldman T-2		22.03.79	"	12
Sardarnagar (UP)					
9.	Mr. Hari Lal Sr. Tech. Asst. (T-5)		30.12.77	"	12
10.	Mr. J.C. Tewari Fieldman T-2		18.08.78	"	12

(1)	(2)	(3)	(4)	(5)	(6)
Sugarcane Breeding Institute, Coimbatore					
1.	Dr. S. Easwaramoorthy Senior Scientist (Ento.)		12.09.77	"	12
2.	Mr. J. Srikanth Scientist (Ento.)		01.01.92	"	12
3.	Mr. N.K. Kunjukrishna Kurup, Tech. Officer (T-5)		03.10.78	"	12
4.	Mr. M. Shanmugasundaram Tech. Asst. (T-4)		01.02.77	"	12
5.	Mrs. G. Santhalakshmi Tech. Asst. (T-4)		26.02.77	"	12
6.	Mr. Raghawendra Kumar T-II-3		16.07.88	"	12
Assam Agricultural University, Jorhat					
1.	Dr. A. Basit Entomologist		01.04.87	"	12
2.	Mr. M. K. Rahman Field Asst.		20.08.87	"	12
3.	Mr. A.K. Bordoloi Tech. Asst.		31.10.88	"	12
Andhra Pradesh Agricultural University, Hyderabad					
1.	Mr. A. Ganeswara Rao Entomologist		01.08.90	"	12
2.	Mrs. Ramila Saxena Asst. Entomologist		16.01.84	"	12
3.	Dr. T. Ramesh Babu Asst. Entomologist		30.11.87	"	12
4.	Mr. A. Krishnamurthy Sub-Assistaant		20.03.91	"	12
4.	Mr. R. Prasad Sub-Asst.		18.06.88	"	12
5.	Mr. E.L. John, Sub-Asst.		22.12.87	"	12

(1)	(2)	(3)	(4)	(5)	(6)
Gujarat Agricultural University, Anand					
1.	Dr.B.H. Patel Assoc.Res. Scientist (Ento.)		01.02.94	"	2
2.	Mr.J.J.Jani Assoc. Res. Scientist (Micro.)		13.07.89	"	12
3.	Mrs. Kamala Chhaiya Senior. Res. Scientist		01.03.94	"	1
4.	Mr.P.H.Godhani Sr. Res. Asstt. (Ento.)		29.05.89	"	12
5.	Mr.K.P.Parmar Agril Assistant.		03.06.86	"	12
6.	Mr. N.P. Sodhaparmar Agril. Assistant		15.02.93	"	12
7.	Mr. B.M. Patel Driver		12.05.93	"	11
Kerala Agricultural University, Trichur					
1.	Dr.P.J.Joy Professor		22.05.89	"	12
2.	Mr.M.N. Satheesan Jr. Asst.Professor		09.12.83	"	12
3.	Smt. Lyla, K. R. Assoc. Prof. (NC)		05.09.92	"	12
4.	Mr.K.V. Dinesan Tech. Asstt.		11.11.91	"	12
5.	Mr. T.R. Radhakrishnan Farm. Asstt.(Gr. I)		30.06.90	"	12
6.	Mr. P.C. Girijavallabhan Farm Assistant.(Gr. I)		05.07.91	"	12
7.	Mr. T. Varghese Farm Asst. Gr. I		08.10.93	"	5

(1)	(2)	(3)	(4)	(5)	(6)
Punjab Agricultural University, Ludhiana					
1.	Dr.G.C.Verma Sr. Entomologist		13.09.77	"	10
2.	Dr.Maninder Asst. Entomologist		29.01.87	"	12
3.	Dr.J.S. Gill Asst. Entomologist		29.04.88	On long leave	0
4.	Mr. Ram Krishan Lab. Attendant		17.06.91	Continuing	12
5.	Mr.Rajinder Singh Lab. Assistant		02.11.91	"	12
6.	Mr. Praveen Kumar		01.11.92	24.01.94	9
Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar					
1.	Dr. G.M. Zaz Associate Prof.		01.08.91	"	12
2.	Mr. Abdul Majid Bhat Assistant Professor		01.12.80	"	12
3.	Mr. R.K. Tickoo Res. Assistant		01.04.81	"	12
4.	Mr. Ab. Hamid Bhat F.C.L.A.		01.12.79	"	12
Tamil Nadu Agricultural University, Coimbatore					
1.	Dr.G.Balasubramanian Professor		18.11.88	"	12
2.	Mr. S. Balakrishnan Agrl.Supervisor		16.06.90	"	12
3.	Mr.P.K.Marimuthu Agrl. Assistant.		24.12.88	"	12
4.	Mr. M. Munuswamy Lab. Asstt.		25.02.94	"	1

(1)	(2)	(3)	(4)	(5)	(6)
Dr. Y.S.Parmar University of Horticulture & Forestry, Solan (Himachal Pradesh) Nauni					
1.	Dr.P. R Gupta Entomologist		19.09.87	"	12
2.	Mr. Anil Sood, Tech. Asstt.		17.12.90	"	12
3.	Mr. Sat Pal Verma, Tech. Asstt.		22.01.91	"	12
4.	Mr. Vidya Dhar Sharma Field Assist.nt		07.02.90	"	12
Mahatma Phule Agricultural University, Rahuri (Pune)					
1.	Dr. B.G. Awate Entomologist		05.04.90	"	12
2.	Mr. B.A. Bade Tech. Asstt.		05.05.93	"	11
3.	Mr. P.M. Kurhade Field Asstt.		05.04.90	"	12

2.3 Budget Provision

Sl No.	Name of the Centre		Amount sanctioned (Rs. in Lakhs)	Total Expenditure (Rs. in Lakhs)
1.	P.D.B.C.,	Bangalore	80.00	32.44
2.	C.P.C.R.I.,	Kayangulam	*	
3.	C.T.R.I.,	Rajahmundry	*	
4.	I.A.R.I.,	New Delhi	*	
5.	I.I.H.R.,	Bangalore	*	
6.	I.I.S.R.,	Lucknow	*	
7.	S.B.I.,	Combatore	*	
8	A.A.U.,	Jorhat	6.57	1.74
9.	A.P.A.U.,	Hyderabad	5.05	6.88
10.	G.A.U.,	Anand	8.93	8.93
11.	K.A.U.,	Trichur	7.11	5.84
12.	M.P.A.U.,	Rahuri, Pune	4.99	4.16
13.	P.A.U.,	Ludhiana	12.17	5.14
14.	S.K.U.A.S. & T.,	Srinagar	2.15	2.51
15.	T.N.A.U.,	Coimbatore	11.25	8.00
16.	Dr.Y.S.P.U. H.& F.,	Nauni, Solan	8.43	3.27
17.	G.B.P.A & T.	Pantnagar	–	–

* Since the project has been merged with Non-Plan no separate budget account has been maintained by ICAR Centres

2.4. Centres Visited by Project Director

Sl.	Name of the centre		Date of visit
1.	APAU,	Hyderabad	06.04.93 to 09.04.93 03.06.93 to 05.06.93
2.	SBI,	Coimbatore	13.05.93 and 14.05.93 26.08.93 to 28.08.93
3.	IARI,	New Delhi	16.04.93 and 17.04.93 17.05.93 to 19.05.93 13.06.93 to 16.06.93 11.07.93 to 14.07.93 13.09.93 to 18.09.93 03.11.93 to 06.11.93 09.02.94 to 12.02.94
4.	YSPUH & F.,	Hissar	16.11.93 to 21.11.93
5.	PAU,	Ludhiana	20.12.93 to 24.12.93
6	GAU,	Anand	27.03.94 to 29.03.94

The centre located at Bangalore was monitored and centres located at other places cold not be visited due to various reasons.

2.5 Report of functioning of each centre and comments on experiment conducted

2.5.1. Project Directorate of Biological Control, Bangalore

The centre has carried out most of the experiments suggested. Bitoxibacillin or Lepidocide a product of *Bacillus thuringiensis* and *Trichogramma chilonis* are compatible and can be released/sprayed together for effective biosuppression of *Helicoverpa armigera*. Arboreal egg parasitoid, *Trichogramma embryophagum* could successfully parasitize the eggs of *Opisina arenosella* eggs. The egg to parasitoid female ratio of 40:1 is ideal to avoid super parasitism in case of *Helicoverpa armigera* and *Trichogramma brasiliensis* respectively. The competitive interaction studies between *Cheilomenes sexmaculata* and *Chrysoperla carnea* in presence and absence of *Aphis gossypii* revealed that in presence of aphids there was very less competitive interaction between the species while in the absence of aphids the greater mortality of *C. carnea* was observed. The economics of production of *H. armigera* was worked out and the cost of production of one *H. armigera* pupa was found to be one rupeee. This host is used for multiplying specific parasitoids and nuclear polyhedrosis virus. Comparative studies using the indigenous and Indonesian strains of *Cotesia flavipes* at ratios of 1:2, 1:1 and 2:1 revealed the superiority of the indigenous strain in producing more adults per host larva parasitized and a greater proportion of females in the progeny. Some of the experiments like strain selection for superior traits, pesticide tolerance and introduction of exotic natural enemies will continue. Studies on the effect of temperature, humidity etc. have been conducted on several biotic agents. Attempts have been made for *in vivo* and *in vitro* multiplication of biotic agents. Large scale demonstrations have been conducted to demonstrate the efficacy of biotic agents. Funds for this activity were provided by the Department of Biotechnology.

2.5.2. Central Plantation Crops Research Institute, Kayangulam

The centre has attempted most of the experiments allocated. Laboratory multiplication technique for the endoparasitoid *Apanteles taragamae* at Kayangulam was standarised it was found that the second instar caterpillars of *Opisina arenosella* were best suited to multiply the same in large numbers. Variation of protein, both qualitative and quantitative could be noticed in diseased and healthy grubs of *R. ferrugineus* when infected with a rod shaped nuclear virus. The new pathogens identified should be tested, multiplied and evaluated for the suppression of coconut pests in the field . The effectiveness of already known biotic agents should be demonstrated to the growers in collaboration with the state Department. There is an urgent need to lay maximum emphasis for evolving large scale multiplication methods of key biotic agents viz. Apanteles taragamae , Comsomeriella collaris and Stephanitis typica . Similarly efforts should be intensified to study the natural enemies of eggs of Opisina arenosella with a view to utilize some of them for the suppression of this pest in the egg stage itself.

2.5.3. Sugarcane Breeding Institute, Coimbatore.

The centre has conducted most of the experiments allocated. It was seen that the indigenous strain of C. flavipes was better as compared to the Indonesian strain to control sugarcane borer, Chilo partellus. In laboratory parasitization studies at Coimbatore, indigenous population of C. flavipes showed higher levels of parasitization on sorghum borer than on internode borer. Three formulations of B. t. viz. Delfin, Dipel 8L, Centari and Biobit were tested against sugarcane shoot borer. It was found that higher dosages of Delfin and Dipel 8L were significantly better than the lower dosages at Coimbatore.

2.5.4. Central Tobacco Research Institute, Rajahmundry

Six chrysopid larvae per tobacco plant released at the beginning of aphid infestation effectively reduced the build up of aphid population and was on par with phorate 10 G @ 2g/plant. In a biointensive IPM demonstration trial in commercial tobacco nursery integration of parasitoids, predators, insect pathogens, antifeedant (NSKS) and ovipositional trap crop castor against Spodoptera litura was demonstrated. The Cost Benefit ratio for IPM was 1:2.74 whereas for conventional chemical control it was 1:1.52.

2.5.5. Indian Agricultural Research Institute, New Delhi

The centre continued to maintain several varieties of Bacillus thuringiensis. Some commercial formulations have been evaluated against S. litura.

2.5.6. Indian Institute of Horticultural Research, Bangalore

The centre could lay out most of the trials allocated. The record of Aphidius sp., Aphelinus sp., and Signiphora sp., appeared to be new on pomegranate aphid, Aphis punicae at Bangalore. Release of C. montrouzieri, Coccidoxenoides peregrinus and Leptomastix dactylopii were able to suppress the mealy bug populations on pomegranate. Four demonstration trials conducted at Bangalore on guava and grape mealybugs proved the efficacy of the natural enemies in the farmer's field. Burmoides suturalies, a coccinellid predator was often encountered preying on aphids of peas and chillies in Bangalore. *Chrysoperla carnea* was found to control the aphids on chillies when releases were made at the rate of 5 larvae per plant. Application of five rounds of fungus *N. rileyi* @ 3.2x10^{8} conidia/ml+ Triton x-d100 (0.01%) at weekly intervals during evening hours significantly brought down the larval population of *H. armigera* in tomato as compared to control. Application of Dipel and Centari significantly reduced the larval population of *P. xylostella*. Forty different species of plants, formerly suppressed by *Parthenium* were noticed to grow in the areas where releases of *Zygogramma bicolorata* were made.

2.5.7. Indian Institute of Sugarcane Research, Lucknow

The centre has carried out most of the experiments allocated. The differences were not discernible at Lucknow between indigenous strain of *C. flavipes* and Indonesian strain to control three species of sugarcane borers, viz. *Chilo auricilius*, *C. infuscatellus* and *Acigona steniellus*. Laboratory investigations carried out on the biology of exotic strain of *C. flavipes* on the larvae of *C. auricilius* revealed that each female wasp produced 37.17 ± 27.85 adults and the sex ratio of the emerging progeny was 1: 0.33 (Male : Female).

2.5.8. Assam Agricultural University, Jorhat

Successful establishment of the parasitoid *Allorhogas pyrelophagus* has been achieved with the recovery of this exotic parasitoid from the yellow stem borer larvae. Seasonal incidence of key natural enemies of rice hispa *Dicladispa armigera* in the hispa endemic areas (Sibsagar and Kakajan) revealed the activity of egg larval parasitoid *Chrysonotomyia* sp., larval parasitoid *Bracon hispae* and egg parasitoids *Trichogramma* spp., and *Oligosita* sp. Successful control of water hyacinth has been achieved by the field release of *Neochetina eichhorniae* and *N. bruchi*.

2.5.9. Andhra Pradesh Agricultural University, Hyderabad

The centre could conduct most of the experiments allocated. Through IPM strategies on cotton double the benefit could be obtained as compared to 30 rounds of insecticidal spray. Application of NPV @ 250 LE/ha was as effective as endosulfan (0.07%) and NPV @ 125 LE/ha + endosulfan (0.035%) in combination with *T. chilonis* release were found quite effective in reducing the larval population and damage by *H. armigera*. *T. chilonis* alone was ineffective. Spray application of NPV @ 250 LE/ha was effective in reducing the damage in chickpea. Biobit (0.5kg/ha) was best followed by Endosulfan (0.07 %) 0.5 kg/ha against the control of gram caterpillar. Two peaks of moth emergence once in 2nd week of

September and the second in 4th week of September were recorded for _H. armigera_ population through pheromone trap catches. Spray application of Dipel at 0.5 and 0.75 kg/ha was highly effective and significantly reduced the population of _A. janata_ in castor at Hyderabad. Spray application of AjNPV at 250LE/ha, 125 LE/ha and at 125 LE + endosulfan 0.03% also significantly reduced the larval population and was on par with endosulfan (0.07%).

2.5.10. _Gujarat Agricultural University, Anand_

Release of _T. chilonis_ and _C. carnea_ and Ha NPV was compared with spray schedules could give effective control of boll worms and the IPM module recorded more yield than the spray schedule in cotton. Successful control of water hyacinth has been achieved by the field release of _Neochetina eichhorniae_ and _N. bruchi_.

2.5.11. _Punjab Agricultural University, Ludhiana_

The centre has conducted all the trials as per the technical programme. The effect of release of cocoons of _Epiricania melanoleuca_ for the control of _Pyrilla perpusilla_ was studied in Ludhiana and it was found that the population of pyrilla within a month was very low. Three formulations of _B. t._ viz. Delfin, Dipel 8L and Centari were tested against _C. auricilius_ and it was found that higher dosages of Delfin and Dipel 8L were significantly better. It was seen that the indigenous strain of _C. flavipes_ was better as compared to the Indonesian strain to control three species of sugarcane borers, viz. _Chilo auricilius_, _C. infuscatellus_ and _Acigona steniellus_. _Bacillus thuringiensis_ on the larvae of _Earias_ sp. revealed that. Higher dosages of Delfin (2kg/ha) and Dipel 8L(2 lit./ha) gave higher mortality of _Earias_ sp. Release of _T. chilonis_ and _C. carnea_ and Ha NPV compared with spray schedules could give effective control of boll worms and the IPM module recorded more yield than the spray schedule in cotton. The parasitoid, _Diaeretiella rapae_ and the predators _Coccinella septempunctata_, _Episyrphus alternans_. _E. balteatus_, _Metasyrphus confractor_, _Scaeva latemaculata_ and _Spaeroporia indiana_ were recorded on mustard aphid _Lipaphis erysimi_ at Ludhiana. A field experiment laid out in Ludhiana to study the efficacy of _C. septempunctata_ and _Cheilomenes sexmaculata_ released as larvae @ 1000/ha revealed that _C. septempunctata_ was better to control the mustard aphid as compared with _C. sexmaculata_. _Trichogramma japonicum_ to control _Scirpophaga incertulas_ on rice in Ludhiana showed that the releases of _T. japonicum_ @ 50,000/ha at 10 days interval were effective while _T. chilonis_ tried against _Cnaphalocrosis medinalis_ @ 50,000/ha, at 10 days interval reduced the number of leaves damaged by the pest to almost half in the released plot as compared with the control plot. Release of *T. japonicum* @ 50,000 adults/ha at Pune was found to be the most effective and significantly superior to chemical control endosulfan (0.07%) and untreated control for the control of stem borer.

2.5.12. Kerala Agricultural University, Trichur.

This centre has reported the results of most of the trials conducted on weeds. *Cyrtobagous salviniae* continues to give effective suppression of salvinia in Kerala.

2.5.13. MPAU, College of Agriculture, Pune

The centre has conducted most of the experiments allocated. The parasitoid, *Trichogramma chilonis* was able to search for potato tuber moth up to a distance of 7 metre from point of release. Also it was observed that the percentage of parasitization was higher at shorter distance i.e. 62.5 to 75 % up to 3 metres which reduced to 25 % at 7 m distance.

2.5.14. Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar

The centre has reported results of most of the experiments. The centre should intensify and collect more information on the natural enemies of temperate vegetables. The releases of *Aphytis proclia* and *Encarisa pernicosi* in Kashmir on apple (@ 2000 each per tree) effectively reduced the infestation by San Jose scale. *Chilocorus bijugus* @ 20/tree reduced the scale density.

2.5.15. Tamil Nadu Agricultural University, Coimbatore

The centre has successfully conducted most of the experiments allocated. Release of *T. chilonis* and *C. carnea* and Ha NPV compared with spray schedules could give effective control of boll worms and the IPM module recorded more yield than the spray schedule in cotton. Application of NPV @ 250 LE/ha was as effective as endosulfan (0.07%) and NPV @ 125 LE/ha + endosulfan (0.035%) in combination with *T. chilonis* release were found quite effective in reducing the larval population and damage by *H. armigera*. *T. chilonis* alone was ineffective. NPV (250 LE/ha) was effective against *H. armigera* in chickpea. All *B. t.* formulations and endosulfan (0.07%) were found effective against gram caterpillar. Release of *Trichogramma japonicum* (5 times) reduced the rice stemborer incidence during kharif and in rabi, release of *T. japonicum* thrice followed by spraying of phosphamidon 300 ml/ha gave satisfactory control with increased yield. Three egg parasitoids viz., *Tetrastichus schoenobi*, *Telenomus rowani* and *Trichogramma japonicum* were found parasitizing eggs of rice stem borer. The larval parasitoids of rice leaf folders, *Cnaphalocrocis medinalis* and *Marasmia patnalis* were

Trichogramma cnaphalocrocis, Temelucha philippinensis, Xanthopimpla flavolineata, Brachymeria sp., Charops brachypterum, Elasmus sp., and Apanteles flavipes.

2.5.16. Dr.Y.S.Parmar University of Horticulture and Forestry, Nauni, Solan

Single release of Chilocorus bijugus larvae @ 50 neonate grubs per tree on apple brought about a reduction in mean population of the scales. Aphelinus mali which was introduced at Nauni in 1991 has uniformly spread in the apple orchard and is providing satisfactory control of the woolly apple aphid. Entomopathogenic nematode Heterorhabditis bacteriophora successfully multiplied in the laboratory on Corcyra larva and @ 100 infective juveniles per cm^2 surface area (10^{12} /ha), against white grubs of Brahmina coriacea (III instar) brought down the population of the larvae in about four months.

2.6. Problems encountered during the year

2.6.1. Project Directorate of Biological Control, Bangalore

More technical including supporting staff are to be required to be recruited at the earliest to handle the cultures.

2.6.2. Gujarat Agricultural University, Anand

Funds are to be released at the earliest to purchase the scientific equipments approved to the centre.

2.6.3. Kerala Agricultural University, Trichur

Suitable natural enemy is to be imported at an early date for the control of Mikania weed.

2.6.4. Punjab Agricultural University, Ludhiana

The vehicle approved in VIII plan for the centre to be purcahsed at the earliest to facilitate the survey and experimental work.

2.6.5. Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar

Staff approved for the centre are to be recruited on priority and funds to be released timely to purchase the equipments.

2.6.6. Tamil Nadu Agricultural University, Coimbatore

Approval is still awaited for the conversion of technical staff to scientific at least one, and the delay in fact is causing inconveience in survey work.

2.6.7. Dr. Y.S.Parmar University of Horticulture & Forestry, Solan (Himachal Pradesh) Nauni

Vehicle as approved in the VIII plan is to be provided on priority. Also some consideration need to be given for the escalation charges on scientific equipments as the projections were made as early as 1990s.

METEOROLOGICAL DATA FOR THE YEAR 1992 - 93

(i) Project Directorate of Biological Control, Bangalore

Month	Temperature (o°) Min.	Temperature (o°) Max.	Relative Humidity (%) Morning	Relative Humidity (%) Evening	Total rainfall (cm)
April	21.5	34.5	82	33	9.4
May	21.8	34.6	78	30	42.8
June	20.5	30.7	81	36	138.8
July	20.0	29.2	90	54	83.2
August	19.7	28.7	88	58	148.4
September	19.2	28.6	91	60	263.7
October	19.2	27.8	93	66	196.2
November	17.8	26.6	90	62	19.5
December	15.8	24.8	92	60	77.8
January	14.6	27.0	92	43	0.4
February	17.4	29.5	90	38	11.3
March	17.5	32.9	82	23	0.0

(ii) Assam Agricultural University, Jorhat.

Month	Temperature (o°) Min.	Temperature (o°) Max.	Relative humidity (%) Morning	Relative humidity (%) Evening	Total rainfall (cm)
April	18.7	29.0	89	51	104.8
May	22.4	28.3	88	74	363.8
June	24.4	30.8	89	75	378.2
July	25.2	32.3	86	73	303.4
August	25.7	32.1	88	75	308.5
September	24.7	31.1	89	75	167.0
October	24.6	29.8	89	78	181.8
November	16.2	27.5	90	65	1.5
December	10.9	23.1	91	55	0.2
January	8.9	23.5	93	57	25.2
February	11.6	20.4	89	61	20.6
March	14.9	24.1	86	63	121.3

(iii) Kerala Agricultural University, Vellanikkra

Month	Temperature (o°)		Relative humidity (%)		Total rainfall (cm)	sun shine hours
	Min.	Max.	7.20	14.40		
April	25.0	34.5	83	55	32.1	273.1
May	24.8	34.4	86	61	131.1	202.4
June	23.9	30.1	94	77	700.3	100.0
July	22.9	28.5	93	80	661.6	75.9
August	23.4	29.6	95	78	276.7	147.4
September	23.1	30.6	93	68	85.3	191.3
October	22.4	30.7	91	74	519.0	148.5
November	23.6	31.5	82	64	74.6	172.7
December	23.1	31.6	76	55	18.0	233.4
January	22.6	32.9	74	42	19.4	253.0
February	23.1	34.8	79	38	1.7	244.9
March	23.7	36.2	79	38	21.0	259.4

(iv) Central Tobacco Research Institute, Rajahamandry

Month	Temperature (o°)		Relative humidity (%)		Total rainfall (cm)	Number of rainy days
	Min.	Max.	7.20	14.40		
April	36.80	24.70	91	54	-	-
May	37.80	27.10	89	49	55.70	5
June	38.50	27.70	81	52	17.40	2
July	33.20	25.30	93	87	173.30	10
August	32.60	25.50	88	71	78.90	8
September	31.90	24.80	90	73	137.60	13
October	32.10	23.50	88	67	137.60	11
November	31.00	19.30	87	49	18.70	2
December	29.30	15.70	87	47	2.80	1
January	30.30	16.10	93	51	-	-
February	30.90	19.20	93	60	22.0	2
March	34.20	21.50	90	55	-	-

(v) Andhra Pradesh Agricultural University, Hyderabad

Month	Temperature (o°) Min.	Temperature (o°) Max.	Relative humidity (%) 7.20	Relative humidity (%) 14.40	Total rainfall (cm)	sun shine hours
April	22.9	38.0	57.7	24.6	15.0	10.0
May	25.8	40.7	58.5	25.0	31.0	10.3
June	25.1	36.2	69.3	37.6	36.0	8.6
July	23.2	32.1	77.0	47.1	102.3	5.7
August	22.3	30.0	81.8	54.1	142.6	5.1
September	21.8	30.3	82.0	55.0	144.0	6.9
October	20.9	30.8	82.2	53.0	77.5	8.3
November	15.0	30.1	75.7	39.8	0.0	9.6
December	11.3	27.0	79.9	38.1	27.9	8.3
January	13.9	29.3	78.5	32.4	6.2	9.4
February	17.3	32.2	76.0	33.2	5.6	10.2
March	20.2	37.4	65.1	23.3	0.0	10.9

(vi) Tamil Nadu Agricultural University, Coimbatore

Month	Temperature (o°) Min.	Temperature (o°) Max.	Relative humidity (%) 7.20	Relative humidity (%) 14.40	Total rainfall (cm)	sun shine hours
April	23.1	34.3	82	35	10.0	9.1
May	23.8	35.8	82	42	55.6	7.7
June	23.8	32.8	75	47	21.9	6.6
July	23.2	31.1	71	49	30.5	4.3
August	22.8	31.9	78	49	28.9	5.9
September	21.0	32.5	85	44	24.3	5.3
October	22.3	30.5	89	58	154.5	4.8
November	21.1	28.5	89	64	248.7	5.0
December	19.5	27.7	88	58	29.1	4.1
January	13.6	29.2	89	50	72.7	7.7
February	20.5	31.8	87	44	29.0	8.0
March	20.4	35.1	81	32	6.0	8.5

(vii) Dr.YSPUH & F , Nauni, Solan

Month	Temperature (o°) Min.	Temperature (o°) Max.	Relative humidity (%) 7.20	Relative humidity (%) 14.40	Total rainfall (cm)	sun shine hours
April	11.3	27.7	62.0	27.0	5.2	9.3
May	16.3	32.7	55.8	29.6	24.5	9.5
June	19.5	31.5	73.3	53.5	130.0	8.5
July	19.5	27.5	90.3	74.9	305.8	5.1
August	19.5	29.1	88.8	67.7	45.0	7.7
September	17.5	26.5	94.7	73.8	183.4	5.9
October	10.1	26.4	71.0	32.0	-	10.2
November	7.3	23.9	77.3	39.1	9.3	8.6
December	3.6	20.8	79.7	37.6	-	8.2
January	4.0	17.8	76.3	41.6	43.6	6.0
February	4.3	17.5	83.3	47.4	106.2	7.0
March	11.1	24.9	66.5	35.7	4.6	8.4

(viii) Punjab Agricultural University, Ludhiana

Month	Temperature (o°) Min.	Temperature (o°) Max.	Relative humidity (%) 7.20	Relative humidity (%) 14.40	Total rainfall (cm)	sun shine hours
April	16.9	34.5	67	23	16.1	10.5
May	24.1	39.4	51	24	15.8	11.1
June	26.7	38.1	65	43	21.2	11.0
July	26.0	33.0	83	67	553.0	7.5
August	26.9	35.5	83	60	65.2	10.7
September	23.3	31.7	92	66	117.7	7.9
October	15.6	32.5	88	29	0.0	10.3
November	11.8	27.2	89	34	0.0	8.6
December	6.0	22.0	96	40	0.0	8.1
January	7.6	18.9	96	56	48.3	6.3
February	8.1	20.5	91	52	35.0	8.7
March	12.9	27.9	86	40	0.0	9.6

(ix) SKUAS & T., Srinagar

Month	Temperature (o°) Min.	Max.	Relative humidity (%)	Total rainfall (cm)	Number of rainy days
April	-2.2	4.1	75	15.8	9
May	1.3	10.8	69	11.6	5
June	2.3	10.5	69	46.1	13
July	5.4	16.4	58	11.3	3
August	11.7	23.5	54	25.6	8
September	13.7	27.2	63	10.0	2
October	17.5	28.0	70	36.5	9
November	17.5	27.8	73	41.1	5
December	16.4	29.3	66	4.6	6
January	11.7	27.2	65	2.2	4
February	3.6	21.1	61	0.0	0
March	2.2	13.2	71	4.3	5

VISITORS

Project Directorate of Biological Control, Bangalore

26-03-1994	Dr.Saleem Ahmed, Senior Fellow, East West Centre, 1777 East West Road, Honolulu, Hawaii
26-03-1994	Dr.V.P.Sharma, Director, Malaria Research Centre, New Delhi
21-06-1994	Dr.S.K.Pal, Plant Protection Officer, ICRISAT Patancheru, Hyderabad
30-06-1993	Dr.Srinath, Joint Director, Dept. of Plant Protection and Quarantine, Faridabad
02-07-1993	Dr.K.G.Pillai, Dr.A.P.K.Reddy and Dr. K.Krishnaiah, Directorate of Rice Research, Hyderabad
29-07-1993	Dr.T.C.Jain, World Bank, New Delhi Dr.K.N.Singh, ADG (NARP), ICAR, New Delhi
29-07-1993	Dr.H.C.Dass, Director, NRC for Citrus, Nagpur
03-09-1993	Dr.Nandini Katre, California (USA)
09-09-1993	GBPUA & T, Pantnagar
09-09-1993	Dr.(Mrs.) Livinder Kaur, PAU, Ludhiana
09-09-1993	Dr.J.S.Naresh, HAU, Hissar
10-09-1993	Dr.Chokhey Singh, Chairman and V.M.Sahani, Member, QRT team for Cotton Research
24-09-1993	Dr.Panjab Singh, Director, IGFRI, Jhansi
11-10-1993	Dr.D.S.Ajri, M.P.K.V., Rahuri Dr.A.K.Raodeo, MKU, Parbhani Dr.C.P.S.Yadav, Project Co ordinator Dr.O.P.Dubey, ICAR, New Delhi
21-10-1993	Dr.S.N.Puri, MAU, Parbhani
21-10-1993	Dr.M.C.Sharma, Director (Tech.), Biotech International Ltd. New Delhi
22-10-1993	Shri.Jannat Husain, Commissioner and Director of Agriculture, Govt. of Andhra Pradesh, Hyderabad

30-10-1993	Dr.John LaSalle, International Institute of Entomology, London, UK Dr.Brain Sutton, International Institute of Mycology, London, UK
02-11-1993	Lycee Agricole de St. Paul La Reunion France
21-01-1994	Shri N.Parthasarathy, Financial Advisor, ICAR, New Delhi
27-01-1994	Dr.R.Naidu, Director of Research, Coffee Board, Balehonnur

Sugarcane Breeding Institute, Coimbatore

8-4-1994	Ms.Patricia Van Eijnthoven Waageningen Argicultural University. The Netherlands.

Kerala Agricultural University, Vellanikkara

27-07-1993	Dr.Sanjeev Agarwal and Dr.G.R.Chaudhary from the college of Agriculture, Jobner, Jaipur
28-03-1994	Dr.U.C. Abdurahiman, Professor of Zoology, Calicut University
28-03-1994	Dr.S.P.Singh, Officer on Special Duty, Project Directorate of Biological Control, Bangalore

Tamil Nadu Agricultural University, Coimbatore

03-04-1993	Dr. E.Raghavan Rao, IRDAES, Retired Additional Director of Agriculture, Hyderabad
13-04-1993	Dr.E.A.Siddiq, Project Director, Directorate of Rice Research, Hyderabad
23-04-1993	Dr.Kartar Singh, Senior Project Officer, British Council Division, New Delhi
03-09-1993	Dr.K.B.Saxana, Senior Research Breeder, ICRISAT, Patancheru, Andhra Pradesh
23-09-1993	Dr.A.Seetharam, Project Coordinator (MIllets), ICAR-GKVK, Bangalore
23-09-1993	Dr.M.Madawana, Geniticist, UAS, Bangalore
30-10-1993	Dr.Sant S. Veramani Plant Breeder, IRRI, Manila, The Phillippines
10-12-1993	Dr. A.Ramachandra Reddy, Head/Biotechnology Division, Hyderabad

30-12-1993	Dr. Sitaraman, Bio Technology Coordinator, Pune
27-12-1993	Dr. Manju Sharma, Advisor, DBT, New Delhi
11-03-1994	Dr.Indraul Das Gupta, Tata Energy Research Institute , New Delhi
15-03-1994	Dr. Toshio Murashige ,Rock Feller Foundation 3401, Dindeut, USA

Mahatma Phule Agricultural University, Pune

Dr.Umeshchandra Sarangi, Director of Agriculture Maharashtra State, Pune

Dr. M.R.Harwalkar, Scientist, BARC, Bombay

Dr. H.D.Rananavare, Scientist,BARC, Bombay

Dr. D.N. Yadav, Officer in charge, AICRP on Biocontrol. G.A.U., Anand, Gujrat

Indian Institute of Sugarcane Research, Lucknow

01-06-1993	Mr. G.C.Srivastava, Secretary, ICAR, Krishi Bhawan, New Delhi
10-11-1993	Delegates attending 131th ICAR Regional Committee No.IV meeting
18-01-1994	Mr. Abdetraheem Zamacil, Member of People's assembly and Head of Board of Directors of the General Cooperative Society for sugarcane production, Egypt
	Mr. Fazez Abl Elwafa, Member of people's assembly and Member of the General Cooperative Society for Sugarcane Production, Egypt
09-02-1994	Press party journalists from ICAR led by Sh. S.K.Sharma,Chief P.R.O.,ICAR, Krishi Bhawan, New Delhi
16-02-1994	Sh. D.K.Mittal, IAS, Secretary, Govt. of Uttar Pradesh. Sh.Ashok Priyadarshi, IAS, Cane and Sugar Commissioner, Govt.of Uttar Pradesh. Dr. G.P.Singh, Director, U.P.Council of Sugarcane Research, Shahrahanpur. Sh.B.P.Misra, Additional Cane Commissioner Uttar Pradesh.
21-03-1994	Dr. Balram Jakhar, Hon'ble Minister of Agriculture, Govt. of India, New Delhi

Gujarat Agricultural University, Anand

03-03-1993	Sh.K.P.Patel, Regional Farmer Training Centre, Ahmedabad
10-03-1993	Sh.I.S.Patel Regional Farmer Training Centre, Ahmedabad
17-03-1993	Sh. J.P.Shukla, Asstt. Director Agri. Raipur
06-04-1993	Sh.A.H.Shah, Retd.Principal, NMCA, GAU, Navsari
07-04-1993	Sh.Laljibhai Aghera, Chairman, GLDC Balvantrai Bhavan, Gandhinagar
26-04-1993	Dr.A.P.Sawalo, Dept. of Entomology, Agril.Univ.,Orissa
07-05-1993	Sh.Kalyansing K.Rana At & Po: Sigam, Ta:Jambusar,Dist.Bharuch
05-06-1993	Hon. Minister Sh.Harinarayan Sinha, Agriculture MInister, Bihar stae
23-06-1993	Dr. M.V.Singh, Project Coordinator (Micronutrient), Indian Institute of Soil Sci., Bhopal
19-08-1993	Sima H. Vyas, Agronomy,Dept.,GAU, Junagadh
26-08-1993	Sh.M.K. Virendrasinh, Lake Villa, Dhrangadhra
24-11-1993	Dr.M.G.Landa, Additional Commissioner, Ministry of Agri.G.O.I., New Delhi.
19-01-1994	Dr.Dolly kumar, Deptt.of Zoology, M.S. Univ., Baroda
19-01-1994	Sh. D.S. Patel, Member, Board of Management, GAU
25-03-1994	Mrs. Barve, S.V.T. college, Bombay

MISCELLANEOUS INFORMATION

Awards / Honours

NIL

Post Graduate Studies

Indian Institute of Horticultural Research, Bangalore

Dr.K.P.Jayanth delivered a lecture to the post graduated students of UAS, Bangalore on Biological Control of weeds and also conducted viva-voce examination to the Honours students of St.Joseph's college, Bangalore. Dr.M.Mani was a member of Student Advisory Committee of Ph.D.Student of UAS, Bangalore and also was an external examiner of GAU, Anand for Ph.D.student.

Assam Agricultural University , Jorhat

Offered a Biocontrol course to the Post graduate students of AAU by Dr.A.Basit. Acting as a Major Adviser for PG Research

Gujarat Agricultural University, Anand

Three students were awarded Ph.D. degrees under the guidence of Dr.D.N.Yadav

Kerala Agricultural University, Trichur

The scientific staff attached to the scheme offered classes for B.Sc. (Ag.) and M.Sc.(Ag.) students.Dr.P.J.Joy offered training cum teaching classes for post graduate students of Maharajas College, Ernakulam

Punjab Agricultural University, Ludhiana

Dr.G.C.Varma guided one M.Sc student and Dr.G.C.Varma and Dr.Maninder thought post graduate course on Biological Control of Crop Pests at PAU.

Tamil Nadu Agricultural University, Coimbatore

Dr.G.Balasubramanian guided M.Sc student

Staff Members in outside Committees

Project Directorate of Biological Control, Bangalore

Dr.S.P.Singh is a member of Scientific Panel for ICAR in Crop Sciences. Member of Editorial Board of 'Indian Hirticulture'

Central Plantation crops Research Institute, Kayangulam

Dr.S.Sathiamma Chaired a Technical Session in 6th Research Council Meeting at NRC on Cashew at Puttur.

Indian Institute of Horticultural Research, Bangalore

Dr.K.P.Jayanth acted as a member in the "Fact finding Committee on Parthenium and participated in the meeting at PDBC, Bangalore. Dr.M.Mani acted as Technical Committee member on Grape field Day at IIHR, Bangalore and also a member in the editorial committee of Journal of Biological Control.

Sugarcane Breeding Institute, Coimbatore

Dr.S.Easwaramoorthy acting as Associate Editor, Indian Society for Biocontrol advancement

Gujarat Agricultural University, Anand

Dr.D.N.Yadav was a member in the Task Force for Biological Control set up kept by DBT, New Delhi and a Member of QRT team of CICR, Nagpur

Kerala Agricultural University, Trichur

Dr.P.J.Joy served as resource person for TV Workshop, Earnakulam District

Retirement/Promotion/Transfer/Resignations

Project Directorate of Biological Control, Bangalore

Mr.Narayan Nair, Driver retaired from service at PDBC, Bangalore

Andhra Pradesh Agricultural University, Hyderabad

Dr.Ramesh Babu, Asst. Entomologist is promoted and transferred as Assoc. Prof. in Pesticide Residue Scheme at Hyderabad

Participation in Seminar/Meeting/Symposium/Training Programmes

Project Directorate of Biological Control, Bangalore

Dr.S.P.Singh attended National conference on Integrated Pest Management at Madras : Attended the 1st meeting of AICRP on Rapseed-Mustard at Gwalior; Attended the Group Discussion on IPM Strategies in Oilseed crops at PAU, Ludhiana. Dr.K.Narayanan and Mr.S.Ramani the V National Symposium on Advances in Biological Control of Insect Pests held at Muzaffarnagar.

Central Plantation crops Research Institute, Kayangulam

Dr.S.Sathiamma attended the 3rd Biocontrol Workers Group Meeting at Bangalore and also XI Biennial AICRP on Cashew at UAS Bangalore

Central Tobacco Research Institute, Rajahmundry

Mr.R.S.N.Rao attended the V National Symposium on Advances in Biological Control of Insect Pests held at Muzaffarnagar and Mr.R.S.Rao and Mr.U.Sreedhar participated in the 3rd Biocontrol workers Group Meeting at Bangalore

Indian Institute of Horticultural Research, Bangalore

Dr.K.P.Jayanth and Mrs.P.N.Ganga Visalakshy participated in "Golden Jubilee Symposium on Horticultural Research - Changing Scenario" at Bangalore and also attended the 3rd Biocontrol workers Group Meeting at Bangalore. Dr K.P.Jayanth participated in the meeting on " Revival of Hebbal Lake - Experts Meet" at Bangalore. Dr.M.Mani attended the 5th National Symposium on Aphodiology at Bangalore and also in National Seminar on Optimization of Production and Productivity of acid lime held at Periyakulam

Sugarcane Breeding Institute, Coimbatore

Mr.J.Srikanth attended the 3rd Biocontrol Workers Group Meeting at Bangalore

Assam Agricultural University , Jorhat

Dr.A.Basit participated in 3rd Biocontrol workers Group Meeting at Bangalore

Andhra Pradesh Agricultural University, Hyderabad

Dr.A.Ganeswara Rao attended the International Symposium on pollination in Tropics held at Bangalore and also attended the 3rd Biocontrol workers Group Meeting at the same place.

Gujarat Agricultural University, Anand

Dr.D.N.Yadav attended the 3rd Biocontrol workers Group Meeting at Bangalore and also attended the 2rd International Workshop & Training course on Insect Pathogens and their use in the management of soil dwelling pests at New Zealand

Kerala Agricultural University, Trichur

Dr.P.J.Joy attended the 3rd Biocontrol workers Group Meeting at Bangalore

Punjab Agricultural University, Ludhiana

Dr.G.C.Varma and Dr.Maninder attended the 3rd Biocontrol workers Group Meeting at Bangalore. Dr.G.C.Varma attended the V National Symposium on Advances in Biological Control of Insect Pests held at Muzaffarnagar

Tamil Nadu Agricultural University, Coimbatore

Dr.G.Balasubramanian attended the 5th National Symposium on "Advances in Biological Control of Pests" held at Muzaffarnagar and also attended the 3rd Biocontrol workers Group Meeting at Bangalore.

Dr. Y.S.Parmar University of Horticulture & Forestry, Solan (Himachal Pradesh) Nauni

Dr.P.R.Gupta attended the 3rd Biocontrol workers Group Meeting at Bangalore.

Scientific / Technical achievements during the year

Project Directorate of Biological Control, Bangalore

1. Ballal, C.R. and Kumar, P. (1993). Host - parasitoid interaction between *Chilo partellus* and *Allorhogas pyralophagus* Marsh. J. Biol. Control 7 (2):72 - 74.

2. Ballal, C.R. and Ramani, S. (1994). Studies on four geographical strains of *Campoletis chlorideae* Uchida (Hymenoptera :Ichneumonidae). Presented in the Fifth National symposium on " Advances in Biological Control of insect pests " held at MuzaffarNagar between October 2 to 4 1993.

3. Jalali, S.K. and Singh, S.P. 1993. Effect of different pesticides on mortality and parasitizing efficiency of san jose scale parasitoid *Aphytis* sp. (*proclia* group). In golden jubilee symposium Hort. Research - Changing scenario Bangalore May, 24- 28, 1993. p 266-267.

4. Jalali, S.K. and Singh, S.P. 1993. Susceptibility of various stages of *Trichogrammatoidea armigera* Nagaraja to some pesticides and effect of residues on survival and parasitizing ability. Biocontrol Sci. Technol., 3 : 21-27

5. Jalali, S.K. and Singh, S.P. 1993. Superior strain selection of the egg parasitoids *Trichogramma chilonis* Ishii - Biological parameters. J. Biol. Control 7 : 57-60

6. Narayanan, K. 1993. "Establishment of haemocyte primary culture of *S. litura* for *in vitro* multiplication of nuclear polyhedrosis virus " paper presented at fifth National Symposium on Advances in biological control of insect pests. 2-4 October, 1993, Muzaffarnagar Abstract page 30.

7. Narayanan, K. 1993. *In vitro* attempt to infect *Spodoptera frugiperda* (SF-9) cells with baculovirus (Nuclear polyhedrosis virus) of *Spodoptera litura* (Lepidoptera : Noctuidae). Paper presented at International Symposium on virus cell interactions : Cellular and molecular responses 22-24th poteuta, 1993. Bangalore Abstract pp.34.

8. Narayanan, K.(1994) Role of biotechnology in effective utilization of insect pathogens in integrated pest management programme in India (Accepted) Review article for a chapter in the book an IPM on particular Edited by Adviser , Plant Protection Directorate, Govt. of India.

9. Ramani, S. and Ballal, C. R. (1994) Influence of change of host on handling time and its variation in Chelonus blackburni (Hym : Braconidae). Accepted for publication in the Proceedings of the Fifth National Symposium on " Advances in Biological Control of insect pests" held at MuzaffarNagar between October 2 to 4, 1993.

10.Singh, S. P., Ballal, C.R. and Jalali, S.K.(1992) New initiatives for biological control of DBM in India. IOBC Plutella Newsletter 1992 (November) : 6-7.

11.Singh, S.P. and Jalali, S.K.1993.Results on host searching ability of various Trichogramma chilonis strains. Trichogramma News. No. 7: 28

12.Singh, S.P. and Jalali, S.K.1993. Evaluation of Trichogrammatids against Plutella xylostella. Trichogramma News, No.7: 28

13.Singh, S.P. and Jalali, S.K.1994. Trichogrammatids. Directorate of Biological Control (ICAR), Bangalore. Tech. Bull. No. 7 :1-95 + 11.

Central Tobacco Research Institute, Rajahmundry

1. Rao, R.S.N. and Chari, M.S. 1993. Natural enemies of Arthropod pests of Tobacco " IPM systems in Agriculture "Published by the Directorate of Plant Protection and Quarantine, New Delhi.

2. Chari, M.S., Rao, R.S.N., Mushini, S.N. and U.Sridhar 1993. Tobacco ecosystem and its interaction with polyphagous pest Spodoptera litura and its natural enemies. Presented at V National Symposium on advances in biological control of insect pests. Oct. 1993. Muzaffar Nagar, U.P.

Sugarcane Breeding Institute, Coimbatore

1. Easwarmoorthy, S. and Santhalakshmi, G. 1993. Occurrence of Beauveria bassiana on sugarcane root borer Emmalocera depressella Swinhoe. J. Biol. Control. 7(1):47-48.

Indian Institute of Horticultural Research, Bangalore

1. Ganga Visalakshy, P.N. 1993. Toxic and behavioral effects of commonly used mosquito larvicides on the water hyacinth weevils, *Neochetina eichhorniae* and *N. bruchi*. Entomon, 18: 11-14.

2. Ganga Visalakshy, P.N. and Jayanth, K.P. 1993. Potential biocontrol agents of some horticultural weeds in India. Paper Presented in "Golden Jubilee Symposium on Horticultural Research - Changing Scenario", May 24-28, 1993, Bangalore.

3. Gopalakrishnan, C. and Mohan, K.S. 1993. Epizootics of *Erynia neoaphidis* (Zygomycetes : Entomophthorales) in field population of *Brevicoryne brassicae* (Homoptera : Aphididae) on cabbage. Entomon, 18(1&2):21-24.

4. Gopalakrishnan, C. and Mohan, K.S. 1993. Field efficacy of the fungus *Nomuraea rileyi* (Farlow) Samson against *Helicoverpa armigera* on tomato. Abstract, pp. 271-272. Golden Jubilee Symposium, Horticulural research - Changing Scenario, May 244-28, 1993, Bangalore.

5. Jayanth, K.P. 1993. Ecological impact of insects introduced for biological control of weeds - conflicting interests. Current Science, 65:901-905.

6. Jayanth, K.P. and Ganga Visalakshy, P.N. 1992. Suppression of the lantana bug *Teleonemia scrupulosa* by *Erythmelus teleonemiae* in Bangalore, India. FAO Plant Protection Bulletin, 40, 164.

7. Jayanth, K.P. and Ganga Visalakshy, P.N. 1993. Utility of the Mexican beetle *Zygogramma bicolorata* in managing parthenium weed infesting horticultural fields. Paper Presented in "Golden Jubilee Symposium on Horticultural Research - Changing Scenario", May 24-28, 1993, Bangalore.

8. Jayanth, K.P. and Ganga Visalakshy, P.N. 1993. Weeding out with weevils. Deccan Herald (Spectrum Supplement), Bangalore 46 (218): page I, August 7.

9. Jayanth, K.P. and Ganga Visalakshy, P.N. 1993. Establishment and dispersal of *Pareuchaetes pseudoinsulata* along the western Ghats in Karnataka, India. Paper presented at the "Third International Workshop on *Chromolaena* at the "Third International Workshop on *Chromolaena odorata*" at Abidjan, Cote d Ivoire, 15-19 November.

10. Jayanth, K.P. and Geetha Bali, 1992. Estimation of number of generations of the Mexican beetle, Zygogramma bicolorata Pallister by measurement of thermal units. Journal of Entomological Research, 16: 273-276.

11. Jayanth, K.P. and Geetha Bali, 1993. Factors affecting diapause in the Mexican beetle Zygogramma bicolorata in Bangalore, India. Bulletin of Entomological Research, 83:383-388.

12. Jayanth, K.P. and Geetha Bali, 1993. Effect of some commonly used weedicides on the parthenium beetle Zygogramma bicolorata Pallister (Coleoptera : Chrysomelidae). Journal of Biological Control. 7:53-56.

13. Jayanth, K.P. and Geetha Bali, 1993. Temperate tolerance of Zygogramma bicolorata (Coleoptera: Chrysomelidae) introduced for biological control of Parthenium hysterophorus (Asteraceae) in India. Journal of Entomological Research 17:27-34.

14. Jayanth, K.P. and Geetha Bali, 1993. Age-specific fecundity and intrinsic rate of natural increase in the Mexican beetle Zygogramma bicolorata at Bangalore, India. Journal of Biological Control, 7:115-117.

15. Jayanth, K.P. and Geetha Bali, 1993. Biological studies on Zygogramma bicolorata Pallister (Coleoptera :Chrysopidae), a potential biocontrol agent of Parthenium hysterophorus L. (Asteraceae). Journal of Biological Control , 7:93-98.

16. Jayanth, K.P. and Singh, S.P. 1993. Biological control of Aquatic weeds. Indian Farming. 42(11):25-30.

17. Jayanth, K.P., Sukhada Mohandas, Asokan, R. and Ganga Visalakshy, P.N. 1993. Parthenium pollen induced feeding by Zygogramma bicolorata (Coleoptera : Chrysopidae) on sunflower. Bulletin of Entomological Research, 83: 595-598.

18. Krishnamoorthy, P.N., Srinivasan, K. , Mohan, K.S., Mani, M. and Gopalakrishnan, C. 1993. Integrated Management of Helicoverpa armigera on tomato, Abstract, pp. 258-259. Golden jubilee Symposium, Horticultural Research - changing scenario, May 24-28, 1993, Bangalore

19. Mani, M. 1992. Bacrocera correcta on grapevine in India. FAO Plant Prot. Bull., 41: 162-163.

20. Mani, M. 1992. Influence of constant temperature on the developmental rate, progeny production, sex ratio and adult longevity of the grape mealybug parasitoid Anagyrus dactylopii (How.) (Hym., Encyrtidae). Insect Sci. Applic., 3:697-703.

21. Mani, M. 1993. Studies on mealybugs and their natural enemies in borer orchards. J. Biol. Control, 7: 75-80.

22. Mani, M. 1993. Biological suppression of the oriental mealybug Planococcus lilacinus an acid lime. Paper presented in National Seminar on optimization of Production and Productivity of acid lime at Periyakulam, Tamil Nadu, Oct. 3, Spodoptera litura.

23. Mani, M. 1994. Recovery of the indigenous Coccidexenoides peregrinus and the exotic Leptomastix dactylopii on Planococcus citri in lemon and acid lime orchards. Biocontrol Sci. & Tech., 4: 49-52.

24. Mani, M. and Krishnamoorthy, A. 1993. Bionomics and management of the striped mealybug, Ferrisia virgata (Ckll.) - A review . Agric. Review, 14:22-4.

25. Mani, M. and Krishnamoorthy, A. 1994. Selectivity of pesticides to the parasitoid Aphelinus sp. of the green peach aphid, Myzus persicae infesting sweet pepper, Paper presented in the Fifth National Symposium on Aphidiology at UAS, Bangalore, Jan. 27-30, 1994.

26. Mohan, K.S. and Gopalakrishnan, C.1993. Toxicity of the prototoxins of cloned CRY IA genes of Bacillus thuringiensis to important insect pests of vegetable crops. Abstract , pp. 246. Golden Jubilee Symposium, Horticulural research - Changing Scenario, May 24-28, 1993, Bangalore.

Central Plantation Crops research Institute, Kayangulam

1. Danger, T.K. and Banerjee, A.1993. Natural infection of red palm weevil by microbial pathogens. In Nair, M.K. et al. advances in coconut Research and Development. Central plantation Crops Research Institute, Kasaragod. P. 531-533.

2. Pillai, G.B. and Nair, K.R. 1993. A check list of parasitoids and predators of Opisina arenosella wlk. on coconut. Indian Cocon. J. 23 (9):2-9.

3. Pillai, G.B. and Nair, K.R. 1993. Studies on the chalcidid pupal parasitoids of the coconut caterpillar opisina arenosella walker in Kerala, India. Entomon 17:183-192.

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ACRONYMS

ICAR	:	Indian Council of Agricultural Research
PDBC	:	Project Directorate of Biological Control
CPCRI	:	Central Plantation Crops Research Institute
CTRI	:	Central Tobacco Research Institute
CICR	:	Central Institute of Cotton Research
IARI	:	Indian Agrilcultural Research Institute
IIHR	:	Indian Institute of Horticultural Research
IISR	:	Indian Institute of Sugarcane Research
NCIPM	:	National Centre for Integrated Pest Management
SBI	:	Sugarcane Breeding Institute
BARC	:	Baba Atomic Research Centre
AICRP	:	All India Coordinated Research Project
AAU	:	Assam Agricultural University
APAU	:	Andhra Pradesh Agricultural University
GAU	:	Gujarat Agricultural University
KAU	:	Kerala Agricultural University
MPKV	:	Mahatma Phule Krishi Vidyapeeth
PAU	:	Punjab Agricultural University
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 Horticulture & Forestry
GBPUAS & T	:	Gobind Vallabh Pant University of Agricultural Sciences & Technology