ANNUAL REPORT

2007-08

PROJECT DIRECTORATE OF BIOLOGICAL CONTROL

BANGALORE, INDIA

Project Directorate of Biological Control
Bangalore 560 024.

Telephone	:	+91-80-2341 4220, 2351 1998, 2341 7930
Telegram	:	BIOSUPPRESSION, Bangalore
Fax	:	+91-80-2341 1961
E-mail	:	pdbc@indiatimes.com
Website	:	http:/www.pdbc.res.in

Published by

Project Director
PDBC, Bangalore

Compiled and edited by

B. S. Bhumannavar
R. J. Rabindra

August, 2008

Cover Design : Sunil Joshi

1				
2	3	4	5	6
7				

Front Cover : 1. *Aphis craccivora* Koch, 2. *Coccinella septempunctata* L., 3. *Oenopia sexareata* (Mulsant), 4. *Hippodamia variegata* (Goeze), 5. *Propylea japonica* (Thunberg), 6. *Anegleis cardoni* (Weise), 7. *Aphis gossypii* Glover

Back cover : *Synonycha grandis* (Thunberg)

Hindi text

Deepa Bhagat and Satendra Kumar

Note

The reference to some trade name in this report is in no way an endorsement of or discrimination against these products by the Institute.

Correct citation

Bhumannavar, B. S. and Rabindra, R. J. (eds.). 2008.
Annual Report 2007-08. Project Directorate of Biological Control,
Bangalore, India, 120 pp.

Printed at

Brilliant Printers Private Limited
72, Lottegollahalli, RMV 2nd Stage,
Bangalore-560 094.

CONTENTS

1. PREFACE

Intensive agriculture employing agrochemicals has often led to the out break of several pests and diseases of crops. Changes in climate, cropping system and agronomic practices also trigger the out break of pests and diseases. Out break of new pests like the papaya mealy bug *Paracoccus marginatus* and the cotton mealy bug *Phenococcus solenopsis* continue to cause great concern. Sustainable pest management can enhance productivity of crops and biological control is the main stay of IPM programmes. The **Project Directorate of Biological Control (PDBC)** and the **All India Coordinated Project on Biological Control of Crop Pests and Weeds (AICRP on BC)** have been tirelessly working on development of biocontrol strategies as a powerful tool in the integrated management of pests, diseases and weeds in field and horticultural crops.

The PDBC along with AICRP (BC) intensified recently its efforts in developing biocontrol modules and demonstrating their efficacy in the farmers' fields. The research and development activity during the year 2007-08 continued to focus on priority pests, diseases and weeds in agricultural and horticultural crops and significant success has been made in rice, cotton, sugarcane, pulses and oilseed besides certain fruit and vegetable crops. The successful management of the sugarcane woolly aphid *Ceratovacuna lanigera* in the states of Maharashtra, Karnataka and Tamilnadu by the deployment of the predators *Dipha aphidivora*, *Micromus igorotus* and syrphids as well as the parasitoid *Encarsia flavoscutellum* a land mark success of the PDBC, continued during the year 2007-08. The successful large scale adoption of biocontrol for rice pest management in the whole of the Adat Panchayat covering 1850 ha in Kerala is impacting the nearby Panchayats.

This annual report documents the output and outcome of the research efforts of the PDBC and AICRP. We welcome criticisms and suggestions from the readers which will be accepted with an open mind and humility.

Dr. Mangala Rai, Secretary DARE and Director General ICAR, was a source of inspiration for which the biocontrol research community is grateful. Both **Dr. S.P.Tewari**, the then Deputy Director General Crop Science and **Dr. P. L. Gautam** the present Deputy Director General of the Crop Science Division provided the much needed direction as well as encouragement and I thank them profusely. I am grateful to **Dr. T. P. Rajendran**, Assistant Director General for his guidance and help in time of need in carrying out our programmes successfully.

I wish to place on record my appreciation to all the staff of the PDBC and the AICRP centers for their sincere efforts and hard work in executing the various programmes.

I thank **Dr. B. S. Bhumannavar**, Principal Scientist, Technical and Documentation Cell for his able assistance in compiling and editing this report.

I hope this annual report would be useful to all the stake holders involved in biological control and sustainable pest management.

R.J.Rabindra
Project Director
Project Directorate of Biological Control
&
Coordinator
AICRP on Biological Control of Crop Pests and Weeds

3. EXECUTIVE SUMMARY

This report briefly highlights the salient findings of research conducted at PDBC as well as 10 SAUs and six ICAR-based centres and voluntary centres under the AICRP on biological control of crop pests, diseases and weeds during 2007-08. In order to develop biocontrol technologies for the eco-friendly management of important insect pests, diseases and weeds of different crops, an extensive research programme covering both basic and applied research was drawn. Emerging problems like the sugarcane woolly aphid, management of sucking pests on *Bt* cotton, biological control of white grubs and pests of polyhouse cultivation and integration of biological control in organic farming were included in the programme.

3.1. Project Directorate of Biological Control, Bangalore

Biosystematics

The genus *Stictobura* Crotch (Sticholotidinae: Sticholotidini), endemic to Western Ghats was revised and two new synonymies and one new combination were proposed. One apparently new species nr. *Stictobura* was recorded from Assam. Two new species belonging to *Scymnus* and *Horniolus* were described. An apparently new species of *Synona* Pope was recorded from Meghalaya. Two rare arboreal coccinellids, *Ortalia horni* Weise (Kerala) and *O. vietnamica* Hoang (Assam) were recorded and studied. *Oenopia excellens* (Crotch) was recorded from Mizoram, a new distribution record. An interactive identification key to the genera of Indian Coccinellidae is under construction.

Information on aphidophagous coccinellids was incorporated in a new website, "Aphids of Karnataka" (URL: www.aphidweb.com), giving diagnostic and biological information for 67 species of aphids. Factsheets on important aphidophagous coccinellids were included in the website with diagnostic characters and other details, besides colour photographs to facilitate easy field identification.

A trichogrammatid parasiotoid *Uscana* sp.was collected on bruchids and *Trichogramma hebbalensis* was collected on *Lampides boeticus* infesting *Crotolaria* sp.

Introduction of natural enemies

The chromoloaena gallfly, *Cecidochares connexa* has successfully established in new release sites at Thrissur (Kerala), Periapodu (Tamilnadu) and Jorhat (Assam). In Bangalore, upto six per cent of the gallfly larvae were found parasitized by *Ormyrus* sp.

Rearing and evaluation of natural enemies

Life table studies on *Micromus igorotus* using four hosts viz., *Ceratovacuna lanigera*, *Aphis craccivora*, *A. gossypii* and *P. bambusicola* indicated that the immature stage mortality ranged from 29.2 per cent (on *P. bambusicola*) to 59.0 per cent (on *C. lanigera*). Longevity of *M. igorotus* was 43 days, average fecundity per female was 1082 and sex ratio was 1: 1.5 (male:female). By using recently designed oviposition cage, it was possible to get a yield of 20,276 eggs per oviposition cage per month.

A total of 26 generations of *Cryptolaemus montrouzieri* were reared on *Sitotroga cerealella* eggs. The average cost of producing 1 cc eggs of *S. cerealella* was Rs.34.38. Life fecundity studies on *S. cerealella* using four grain media viz., wheat, paddy, barley and maize indicated that net reproductive rate was highest (28.92) on maize.

The reproductive rate of *Cardiastethus exiguus* was 24.77, finite rate of increase 1.072, doubling time 10.03 days and Weekly Multiplication rate 1.63. The progeny production in field-collected *C. exiguus* was 9.5 per female per day and continuous lab rearing however adversely reduced the progeny production.

The anthocorid survived and multiplied in the garlic ecosystem and could be recorded even a month after release. The number of anthocorids per plant ranged from 0.6 to 6.7. The damage rating was 2.3 in the treatment, while it was 2.8 in control. The yield was 2.72 kg/4 sqm in the treatment and 2.3 kg/4 sq m in control.

There was significant reduction in the incidence of *Thrips tabaci* after three releases of 15-20 nymps/plant on onion and the yield of bulbs was increased by 30.0 per cent.

The anthocorid, *Blaptostethus pallescens* when released to stored pulse, could reduce the emergence of the pulse bruchids.

Four releases of anthocorids against chilli mites @ 10 nymphs/plant at weekly interval reduced the per cent curled leaves.

Attraction of *Trichogramma* to rice cultivars and weeds

Among the four cultivars of rice studied viz. Triguna, TN1, Jaya and Vijitha, Triguna recorded the highest response for *Trichogramma japonicum* and *T. shoenobii*.

Among the weeds in rice ecosystem, *Melia dubia* and *Malvastrum coramandalicenum* recorded maximum attraction of *T. japonicum* while *Cleome viscosa* recorded the least. Among 100 analytical fractions of *Melia dubia*, fractions 22 and 23 showed highest attraction to *T. japonicum* recording 84.0 & 87.75% parasitisation respectively in ovipositional response studies. In the case of *Tephrosia purpurea*, fraction 60 showed the highest attraction to *T. japonicum* recording 84.5% parasitization in ovipositional response studies. The volatile composition of rice, and several weed species was analyzed through GCMS and the dominant compounds identified were methyl hexadecanoate, 2-di-butyl phenol, caryophyllene and phytol.

Molecular characterisation of entomophagous insects

Molecular characterisation of 12 species of *Trichogramma* revealed that base pairs the ITS-2 rDNA varied from 500bp – 900bp. Based on this size variation, three groups could be distinguished: **Group I** included *Trichogrammotoidea armigera* and *Trichogrammatoidea bactrae*; **Group II** included *Trichogramma achaeae, Trichogramma japonicum* and *Trichogramma embryophagum*; **Group III** included *Trichogramma chilonis, Trichogramma pretiosum, Trichogramma evanascens, Trichogramma mwanzai, Trichogramma pretiosum* (TF), *Trichogramma dendrolimi* and *Trichogramma brassicae*.

Wolbachia association in *Trichogramma brasiliense* and *T. pretiosum* proved that these were con-specific species. Amplification of wsp and ftsz regions revealed that *wolbachia* infection was carried through the female (transovarial) with indication of presence of bands (0.7Kb of gene). Transmission studies indicated that per cent female in parents was only 31.0% and after transmission studies of 5 generation, % female obtained was 79.4%.

Genetic variability among the different populations of *Goniozus nephantidis* (Andhra Pradesh, Karnataka and Kerala) was assessed using molecular tools. Molecular characterization of the ITS-2 region rDNA of *G.nephantidis* of Karnataka and Kerala was done. Gene sequence of ITS-2 and 18 S rRNA region was submitted to the GenBank. (EUO 16231 and EU516348).

Molecular characterization of the 16 S and 18S RNA of *Cotesia flavipes* of Karnataka and New Delhi populations was done. The gene sequence was submitted to the GenBank (EU516349).

Bio-diversity of chrysopids and coccinellids

Nine geographic populations of *Chrysoperla carnea*, three of *Mallada boninensis* and six of *Cryptolaemous montrouzieri* were maintained.

Highest percentage survival of *M. boninensis* was recorded in Salem population. Anand population of *C. carnea* showed highest predatory efficiency. Intra-specific variability in response to monocrotophos was studied and it was found that LC_{50} of Sirsa population of *C. carnea* was highest. Predatory efficiency was highest in Bangalore population of *C. montrouzieri*. Delhi population of *C. montrouzieri* recorded the highest LD_{50} for acephate.

Studies on the esterase polymorphism in different geographic populations of *C. carnea* revealed differences in the number of esterase electromorphs in different populations. It was observed that relatively more number of bands were observed in larval populations than in corresponding adults. RAPD polymorphism was also observed in nine *C. carnea* populations.

Studies on the NPV of hairy caterpillars

Surveys for the NPV of *Amsacta albistriga* yielded three new isolates. Studies on the relative efficacy of these isolates revealed that the Pavagada isolate was the most virulent with a LC_{50} of 0.89 x 10^2. It was 9.16, 7.88 and 5.40 folds more virulent than the B.R. Halli, P. Samudrum and Kadur isolates respectively against the first instar larvae.

Among the four isolates of NPV of *Spilarctia obliqua*, D.G.Halli isolate was the most virulent with a LC_{50} of 1.94 x 10^3. It was 4.19 folds more virulent than the Manipur isolate against the first instar larvae. Crude sugar (5%), molasses (5%) and Tinopal (0.2%) enhanced the larval mortality due to NPV.

Pathogens of phytophagous mites

Glycerol, yeast extract powder and dehydrated malt extract broth were found to be good adjuvants for use with *Hirsutella thompsonii* mycelia against the coconut mite, *Aceria guerreronis*. The fungal biomass in the presence of adjuvants produced more number of colonies and yielded more number of conidia per pellet.

Glycerol boosted the pathogenicity of *H. thompsonii* to *A. guerreronis* by 16.5%. In the field, the newly developed mycelial formulation of *H. thompsonii* applied after tank-mixing separately with the three selected adjuvants brought down the post-treatment population of the coconut mite significantly. Application of the mycelial formulation in combination with glycerol resulted in a tolerable mean nut damage grade of 1.96, compared with an acute score of 4.01 in control palms. In the second-round of multi-location field evaluation of *H. thompsonii* formulations (mycelial and mycelial-conidial), the mycelial formulation with glycerol could reduce the mean post-treatment population by 97.4% over control.

Isolation, characterization and toxicity of indigenous *Bacillus thuringiensis* strains

Among eight isolates of *Bt* assayed against *Plutella xylostella*, isolate B caused 100 per cent mortality after 8 days and the LC_{50} value was log 7.85 cfu/ml. The indigenous *Bt* isolate PDBC-BT1 was toxic to the rice leaf folder (*Cnaphalocrocis medinalis*), brinjal shoot borer (*Leucinodes orbonalis*) and *Amsacta albistriga*. PCR analysis showed that PDBC-BT1 harbored the CRY1 gene.

Packaging for enhancing of the shelf life of EPN

Polypropylene cover of medium gauge was suitable as packaging material for talc-based / sponge formulations of EPN. Packing with air without vacuum and 25% nitrogen + 75% air were found to be ideal with 6 and 5 months shelf-life respectively. *Steinernema carpocapsae*, *S. abbasi, S. feltiae* and *S. tami* had shelf life of 5-6 months in sponge and 1-2 months in talc. Viability of *H. indica* PDBC EN 6.12 and PDBC 4.3 (Bapatla) was maximum in talc with 6 months and 3-4 months in sponge.

Fungal antagonists

Trichoderma harzianum (Th-7) and *T. pseudokoningii* (Tp-1) showed antibiosis against *Alernaria solani* and *A. alternata* causing shrinkage and lysis of protoplasm of the hyphae. *T. harzianum* (Th-7 isolate) showed the least post treatment disease index indicating 63% reduction of leaf blight of tomato caused by *A. solani*.

Confirmation of chitinase and glucanase activities in *T. harzianum* and *T. viride* was done by PCR amplification using chitinase and glucanase specific primers. A PCR product of 815 bp was obtained in selected isolates (Th2, Th3 and Th4) with chitinase-specific primers while with glucanase-specific primers, the amplified product had a molecular weight of 399 kb in isolates Th1, Th2, Th3, Th5, Th6, Th7, Th8, Th9 and Th10.

In case of *T. viride* with the same chitinase primer, amplification could be detected only in 5 out of 10 isolates tested. In *T. viride* isolates there was variability among the isolates with respect to amplification of glucanase gene as well as in the molecular weight of the amplified product.

Addition of 6% glycerol was optimum to get the shelf life of *T. harzianum* talc formulations prolonged upto 11 months and it helped in withstanding reduction in water activity in formulation during storage.

Solid substrate fermentation-based conidia formulations were prepared after subjecting to different drying methods before packing. Drying helped in extending the shelf life of the formulation up to 12 months compared to control that had a shelf life of only 7-8 months. In the bio-efficacy studies, the products that were processed by drying were able to reduce wilt incidence in tomato to 35% compared to control where it was 74%.

Different packing materials were tested for extension of shelf life of *Trichoderma*. In LLDP 80μ, the shelf life could be extended upto 5 months with the talc formulations without any other treatments to enhance shelf life.

Endophytic bacteria

Two endophytic bacteria from cotton and one from tomato were purified. Four rhizospere isolates were purified from healthy rhizosphere of pigeonpea. Two of the isolates showed 66.6% to 80% inhibition of *Fusarium udum* Isolate 1 (Gram Positive) with highest root length (24.67cm) and shoot length (18.50cm).

Powder formulations of *Pseudomonas fluorescens* containing 2% yeast extract and 2% glycerol resulted in highest cfu count of 1.1×10^8 per gram beyond 180 days.

Software development

Database on Entomopathogenic Nematodes has been developed in HTML format containing information on taxonomy, biology, distribution, bioefficacy, virulence and host range, effect of biotic and abiotic factors, survival and storage, mass production, formulation, application and integration with IPM.

A software "Vegetable crop pests," has been developed in MS-Access with information on important pests of vegetable crops like brinjal, beans, cabbage, cowpea and the natural enemy complex, their distribution and IPM options.

3.2. AICRP on Biological Control

Bioactivity of native *Bacillus thuringiensis* isolates

Of the four isolates of *B. thuringiensis* tested, *viz*., AUG-4, AUG-5, AUG-7 and SEPT-1 against diamondback moth, Cabbage butterfly, American bollworm, tobacco caterpillar, Bihar hairy caterpillar, and Eri silkworm, isolate AUG-5 gave 100 per cent mortality of *Diacrisia obliqua* and *Pericallia ricini* followed by *Helicoverpa armigera* (96.7 %) and *Plutella xylostella* (96 %). However, these *Bt* isolates were not as effective as standard *Bt* strains against *Pieris brassicae.* Aug-5, a prospective *Bt* isolate, effectively reduced *P. xylostella* and *P. brassicae* populations on cabbage under the field conditions (IARI).

Biological control of plant diseases

Out of 30 isolates of *Trichoderma* studied, PB2, PB6 and PB24 exhibited highest per cent inhibition (>40%) against *Rhizoctonia solani*, *Sclerotium rolfsii* and *Fusarium,* respectively after 48 hours *in-vitro*. All the isolates except PB4, PB12, PB17, PB21 and PB26 reduced more than 40% hyphal growth of *Rhizoctonia*. Only isolate PB6, PB15 and PB24 reduced more than 40% hyphal growth of *Sclerotium* and *Fusarium* in dual culture. Best root growth inducing isolates were

PB2, PB4 followed by PB20 and PB30. Maximum shoot growth promotion was recorded in isolate PB16 followed by PB7 and PB18 as compared to control. Isolate PB2, 4, 11, 16, 17, 18, 20, 29 and 30 were good root as well as shoot growth promoters (GBPUA&T).

Five isolates of *Trichoderma* (PB2, 8, 9, 18 and 23) were evaluated for their ability to enhance water stress tolerance of mustard plants under glass house condition, when used as seed treatment. No wilting was seen in treatment PB9 and PB23 even after 4 days of stress. The plants treated with PB9 and PB23 wilted 6 days after stress whereas plants in control wilted 3 days after stress (GBPUA&T).

Technologies to extend the shelf life of antagonists have been developed. The population of *Trichoderma harzianum* was above 2 x 10^6 up to 12 months and population of *Pseudomonas fluorescens* was above 10^8 cfu per ml up to 17 months of storage (GBPUA&T).

Large-scale field demonstration of *Trichoderma* was conducted at farmers' fields on pea, rice and organic rice. On pea, seed treatment with *Trichoderma* resulted in significantly higher germination. Foliar spray of mixed formulation of *T. harzianum* (PDAT-43) + *P. fluorescens* (PBAP-27) @ 10g/l was given as soon as rust incidence was detected in traces. Rust incidence was lower and green pod yield higher in *T. harzianum* treated plots (GBPUA&T).

Large-scale field demonstration on management of sheath blight, blast, BLB, brown spot and stem rot in hybrid rice cv. RH-10 was done at 275 farmers' fields covering approx. 500 acres area (GBPUA&T).

Thirteen members of Tarai Farmers Association successfully adopted the package (FYM colonized with mixed formulation of *T. harzianum* + *P. fluorescens* (@ 5 to 10 tons/ha) or use of vermicompost colonized with *P. fluorescens* (@ 5 to 10 q/ha); Rock phosphate; Seed biopriming with mixed formulation of Th + PsF (@ 10g/kg seed; need abased spray of Th + PsF (@ 10 g/l) in patches infected with sheath blight) for effective disease management in organic rice with substantial increase in yields in approximately 500 acres (GBPUA&T).

In chickpea, significantly highest plant canopy was recorded in plots sown with seeds treated with *Trichoderma* + FYM enriched with *T. harzianum*. Seeds treated with *Trichoderma* followed by the use of either FYM or vermicompost colonized with bioagents proved to be significantly superior to farmer's practices. Significantly low incidence of wilt and *Ascochyta* blight was observed in the crop with seed treatment with *Trichoderma* + manures enriched with bioagents. Maximum grain yield was harvested from the plots having seed treatment with *Trichoderma* + FYM colonized with *T. harzianum* (AAU, Anand).

Farm Yard Manure @ 20 t/ha and Castor cake @ 2 t/ha colonized with *T. harzianum* @ 2.0 kg and 0.2 kg respectively, effectively controlled wilt disease in castor in a demonstration at farmer's field (ANGRAU).

Pathogens for the management of fruit rot

Four strains two each of (*T. harzianum* and *P. fluorescens*) were evaluated for their efficacy against fruit rot disease in papaya. Both the *Pseudomonas* strains *i.e.* strain 3 and strain 27 were found equally effective, but proved to be significantly better than both the strains of *Trichoderma*. *Trichoderma* strain 43 was found to be significantly more effective in comparison to strain 10 in suppressing the fruit rot disease (AAU, Anand).

Fruit rot in mango could be delayed by using I-4 and I-2 isolates of yeast in Chausa and Dasheri varieties of mango (PAU).

Pre-harvest spray (35 and 15 days prior to harvest) of mixed formulation of *T. harzianum* (PBAP-27) and *P. fluorescens* (PBAT–43) @10 g/l with 1% Tween 20 and post harvest dip in suspension of *P. fluorescens* was most effective in suppressing post harvest rot in mango cv. Dasheri (GBPUA&T).

Biological Control of Plant Parasitic Nematodes

Studies on the efficacy of *T. harzianum* (5 kg/ha), *Pochonia chlamydosporia* (20 kg/ha), vermicompost (1 t/ha) and neem cake (0.5 t/ha) against pigeonpea cyst nematode (*Heterodera cajani*) revealed that significantly least number of live cysts of the nematode and highest plant height was registered in plots treated with *T. harzianum* + *P. chlamydosporia* (AAU-Anand).

Application of *P. lilacinus* in combination with *P. chlamydosporia* each @ 100 g/ plant or mustard cake (2 t/ha) controlled root knot nematodes *Meloidogyne* spp. infecting pomegranate, reduced the root rust index and improved plant canopy (AAU-Anand).

In pigeonpea, combined application of *T. harzianum* @ 5 kg /ha plus *P. chlamydosporia* @ 20 kg /ha, reduced eggs / cyst population, seedling mortality and increased seed germination, plant height and yield (TNAU-Nematology).

Soil application of *T. harzianum* @ 5 kg/ha + *P. chlamydosporia* @ 20 kg/ha at sowing along with FYM and basal dose of fertilizers was found effective in reducing the reniform nematode population and number of females/ 5 g roots and increasing the yield of red gram with 1: 1.35 ICBR (MPKV, Pune).

Soil application of *P. lilacinus* @ 20 kg/ha at pruning (Bahar) along with FYM and basal dose of fertilizers was found effective in reducing the citrus nematode population and number of females/ 5 g roots and increasing the yield of citrus (MPKV, Pune).

Results of an experiment on biological control of root knot nematode, *Meloidogyne* spp. in FCV tobacco nurseries conducted at Hunsur revealed that in combination with neem cake, *P. lilacinus* significantly reduced the number of egg masses/g root and soil population of the root knot nematode. Application of *P. lilacinus* increased the root knot-free healthy transplants by 32.1 % over untreated check and was on par with *P. lilacinus* + neem cake and *P. lilacinus* + vermicompost (CTRI).

Biological suppression of crop pests

Sugarcane

Large scale validation cum demonstration of *T. chilonis* against plassey borer of sugarcane was conducted at Assam. Eleven releases of *T. chilonis* @ 50,000/ha at 10 days interval could significantly suppress the population of plassey borer in the released plot (AAU-Jorhat).

Demonstration on effectiveness of temperature-tolerant strain of *T. chilonis* developed by PDBC, Bangalore @50,000 per ha at 10 days interval during mid - April to end of June over an area of 40 ha (two locations) revealed that it was at par with chemical control and reduced the early shoot borer incidence by 52.7 per cent (PAU).

In large scale demonstration on effectiveness of *T. chilonis*, carried out over an area of 1800 ha at farmers fields in collaboration with three sugar mills of the state of Punjab, three releases of *T. chilonis* @50,000 / ha at 7-10 days interval during July to October resulted in significant reduction of stalk borer incidence by 58.5 per cent (PAU).

In field trials against the internode borer (INB) on sugarcane the INB incidence was significantly lower in *Trichogramm*a + pheromone plots compared to control plots and yield was significantly higher (SBI).

The parasitoid *Encarsia flavoscutellum* was recovered to the extent of 12.6% from the sugarcane woolly aphid (SWA) after two months of its release at Maharashtra (MPKV). In Tamilnadu, *E. flavoscutellum* self perpetuated well in the experimental plots and nearby areas of sugarcane. *Encarsia* adult activity was noticed up to 7 kms away from released spots in all directions (TNAU).

Mass production of *D. aphidivora* on SWA was carried out in shade net of 5 x 5 x 4 m size and an average 2,820 larvae/pupae were recovered per shade net within 65 days. Inoculative release of *D. aphidivora* @ 1,000 larvae and/or pupae per ha at 10 spots in sugarcane field effectively reduced SWA population, pest intensity rating and increased predator population and cane yield (MPKV, Pune).

The IPM module consisting of the use of improved variety, paired row planting, normal dose of N, intercrop with groundnut, border rows of cowpea and two releases of *D. aphidivora* @ 1,000 larvae/ha significantly suppressed SWA infestation, and increased the predator population particularly *D. aphidivora* in *Adsali* crop at Maharashtra (MPKV, Pune).

There was a significant reduction of SWA in IPM plots in comparison to farmers' practice at Tamilnadu and a cost benefit ratio of 1:2.6 was recorded. The population of coccinellid beetles, syrphids and *Encarsia* were higher in IPM plots (TNAU).

Bt Cotton

In Tamilnadu, Biocontrol based IPM (BIPM) composing of seed treatment with *T. harzianum*, maize as border row crop, providing bird perches, release of *C. carnea* against sucking pests and *Trichogrammatoidea bactrae* against the pink boll worm recorded lower population of pests compared to farmers practice. Higher yield with lower boll worm population *vis-a-vis* damage was due to the increased per cent parasitism by *Trichogramma* parasitoids coupled with more per cent parasitism by braconids, ichneumonids and tachnids. In farmers' field with *Bt* cotton, the per cent parasitism by the above mentioned parasitoids was significantly lower (TNAU).

In Maharashtra, BIPM package consisting of seed treatment with *Trichoderma*, border rows of maize, erection of 10 bird perches/ha, release of *C. carnea*, spraying of NSK 5% suspension, SlNPV and three releases of *Tr. bactrae* was found effective in the suppression of sucking pest population, boll worm (*Earias vitella*) damage and increased seed cotton yield of *Bt* cotton (MPKV, Pune).

The sucking pest complex was comparatively lower in *Bt* cotton when grown with BIPM than in Farmers Practice (FP) due to activity of natural enemies at Andhra Pradesh. With respect to management of *H. armigera, Bt* cotton fared better both in BIPM and FP. Pink boll worm population, locule and boll damage by the PBW were less in *Tr. Bactrae*-released plots when compared with that of FP and untreated control in Andhra Pradesh (ANGRAU).

At Raichur, pest population was almost similar in both BIPM and Farmers practice plots. Bt cotton + BIPM plot recorded maximum net profit of Rs 31,240/ac compared to Farmers practice plot (Rs 30,160/ac) (UAS-D, Raichur).

At Anand, Gujarat, significantly lowest population of sucking pests was recorded in BIPM module. Larval population of pink bollworm, *Pectinophora gossypiella* in green bolls of cotton was low in BIPM (comprising of seed treatment with *Trichoderma* @ 8 g/kg of seeds, border row of maize crop around the cotton field, bird perches @ 10/ha, release of *Trichogrammatoidea bactrae* @ 1.5 lakhs/ha/week, two to three releases of *C. carnea* larvae @ 14000/ha at weekly interval and spray of Neem Seed Kernel Suspension (NSKS) @ 5 %) plots and was comparable with pesticide treated plots (Farmer's practices). However, BIPM plots yielded maximum (2,169 kg/ha) seed cotton yield (AAU, Anand).

Tobacco

Satisfactory control of *Spodoptera litura* was recorded in tobacco nurseries, when water with pH 6-8 was used in SlNPV spray fluid. Spray fluid with pH below 6 or above 8 was detrimental to SlNPV under field conditions. At a dose of 1.5 x 10^{12} POB/ha SlNPV strains isolated from Rajahmundry, Jeelugumilli or Jeddangi regions of A.P. were found effective.

Bt (PDBC strain) at 1:10 and 1:100 dilutions was moderately effective causing 40-62 per cent and 28-44 per cent mortality of larvae of stemborer, *Scrobipalpa heliopa*. An expert system for identification of biological control agents of tobacco pests is being developed at CTRI. Graphical use interface was created in Visual Basic.

Pulses

On pigeonpea, lower incidence of pod borers and lesser pod damage was recorded in BIPM plots in comparison to Farmers Practices due to increased natural enemy activity in BIPM plots. Higher yields and C:B ratio were also recorded in BIPM plots.

Spray application of 1.0 and 1.5 billion *Heterorhabditis* sp /ha resulted in the suppression of pod borer complex and higher yields. During the surveys conducted for natural enemies of pigeonpea pod wasp, *Tanaostigmodes cajaninae* and pod fly, *Melanagromyza obtusa* in *Kharif* 2007-08 in pigeonpea growing belt of Tandur region of Andhra Pradesh, more than 12.0 per cent pod damage was due to pod wasp while the pod damage by pod fly ranged between 8.0 to 9.0 per cent. However, the parasitization was negligible (ANGRAU).

IPM module (comprising of moderately disease resistant variety "KBR-108", biofertilizers (*Rhizobium*), seed treatment with *Trichoderma,* Pheromone traps @ 5 traps/ha for monitoring *Helicoverpa* population and spraying of HaNPV) was demonstrated in a farmers field of chickpea (450 acres) in a participatory mode at an adopted village Karoan, Allahabad in collaboration with bioved, Allahabad. In the IPM plots, mortality due to *Fusarium* and *Rhizoctonia* fungi was reduced. There was also a significant reduction in the infestation of pod borer and wilt in IPM as compared to Non-IPM and yield was significantly higher (NCIPM).

At Andhra Pradesh, two rounds of sprays of microbials were initiated on the appearance of borers like *H. armigera* and *Adisura atkinsoni* on *Dolichos lablab*. Pest populations were found to be less in *Bt* treatment followed by HaNPV @ 1.5 $x10^{12}$ POBs /ha (ANGRAU).

Rice

Seven releases of *T. chilonis* and *T. japonicum* @ 1,00,000 /ha starting 30 days after transplanting reduced the incidence of leaf folder and stem borer in organic paddy and *Basmati* rice (PAU).

Validation of biointensive pest management comprising of application of organic manure "mukta" @ 2t/ha, seed treatment with *P. fluorescens* @ 8g/kg, application of *Beauveria bassiana* 10^{13} spores/ha, erection of bird perches 10/ha, three releases of *Trichogramma japonicum* and spray of *P. fluorescens* (10g/litre) in organic rice production was carried out at Jorhat. Incidence of dead heart, white ear head, leaf folder damage and GLH population/hill were significantly higher in the farmers' practices and yield was higher in the organic and conventional package in comparison to the farmers' practice (AAU-J).

Use of *Trichoderma*-enriched farm yard manure, seedling root dip with 2% *P. fluorescens* before transplantation, one release of *T. japonicum* and spraying with *P. fluorescens* @ 2kg/ha effectively controlled the insect pests and diseases in HSB-16 (taraori) rice in 50 ha area (NCIPM).

Validation of biointensive pest management practice in organic rice production was done at Kerala. Significantly low incidence of white ear heads and rice bug affected ear heads and higher coccinellid and spider counts were recorded in organic farming, while grain yield was significantly high in conventional farming (KAU).

DOR *Bt* @ 2.0kg/ha was at par with chemical control and proved effective for the management of rice leaf folder on rice (PAU).

Maize

Field application of *Heterorhabditis indica* @ 2 billion /ha could effectively reduce the plant damage by cut worm *Agrotis ipsilon* and led to significant increase of grain yield in maize at Jammu (SKUAS&T-J).

Castor

Maximum parasitisation of 28.7 per cent was recorded by *T. chilonis* followed by *Tr. bactrae* (22.7%) on castor capsule borer (ANGRAU).

Coconut

In large-scale demonstration of biocontrol of coconut leaf caterpillar *Opisina arenosella* conducted at Kerala, sequential release of *C. exiguus* and *G. nephantidis* resulted in excellent control of the pest (KAU).

Experiment on management of *Oryctes* with integration of biocontrol components showed maximum reduction in pest damage with integration of baculovirus, *M. anisopliae* and pheromone trap (CPCRI).

In large area demonstration of *Oryctes rhinoceros* management using *Metarhizium anisopliae* var. *major* and baculovirus, all the grubs and pupae of the beetles were found diseased in the treated pits (KAU).

Tropical Fruit Crops

Trochogramma manii sp.nov. a new species was reported on the eggs of pomegranate fruit borer, *Deudorix isocrates* (NRC, Grapes).

Community IPM through weekly releases of *T. chilonis* six times starting from end June onward in a compact belt of wild pomegranate at Udhampur proved effective in suppressing anar butterfly *Deudorix isocrates* (SKUAS&T-Jammu).

Three sprays of *M. anisopliae* @ 1x10^7 conidia/lit on tree trunk as well as on shoots during flowering gave good control of mango hoppers in Maharashtra (MPKV, Pune).

Chrysoperla sp. was recorded as a potential natural enemy of mango thrips during the last week of December, when the pest population was at its peak at Navsari. A mean of 21 mango thrips were consumed by a single larva under laboratory conditions (NAU, Navasari).

Release of *C. montrouzieri* @ 2,500 beetles/ha was found to be effective in reducing mealy bug population in custard apple at Pune. There was also an increase in the yield of marketable custard apples.

Two releases of *C. montrouzieri* @ 5,000 beetles/ha during off-season as well as two months after October pruning was found to be effective in reducing the mealy bug infestation in grape orchards (MPKV, Pune).

The efficacy of *C. montrouzieri* in controlling the grape mealybug was demonstrated in a grower's vineyard near Pune. A significant reduction in bunch infestation was observed in the treated plot in comparison to check plot. Formulations of *Verticillium lecanii* were observed to be ineffective against grape mealybug (NRC Grapes).

Temperate Fruit Crops

For rearing of *Amblyseius longispinosus* in the laboratory, *Tetranychus urticae* proved better than *Panonychus ulmi* due to its higher net reproductive rate, and intrinsic rate of development. In laboratory test against *T. urticae*, a predator: prey ratio of 1:30 eliminated the pest population within 10 days during May-June and 1:40 ratio was optimum to suppress the mite in 15-17 days during October-November. *Scolothrips sexmaculatus* was observed predating on *T. urticae* at Solan (YSPUH&F).

As a result of augmentative releases of *Encarsia perniciosi*, parasitism of San Jose scale increased from 8.9 to 22.2% in IPM managed orchard, which was significantly higher than that in farmers' field and unmanaged orchard. Hyperparasitism in field conditions affected the performance of *E. perniciosi* at Srinagar. Cost: Benefit ratio of apple production was worked out as 1:3.54 and 1:3.41 in farmers' orchards and IPM orchard respectively (SKUAS&T, Srinagar).

Beauveria bassiana, *M. anisopliae*, *V. lecanii* (each at 10^{7}conidia/ml) and *Hirsutella thompsoni* (5g/litre emulsified water) failed to suppress the woolly apple aphid at Solan (YSPUH&F).

Metarhizium anisopliae and *B. bassiana* provided effective control of apple stem borer (*Aeolesthes sarta*) under field conditions at Srinagar (SKUAS&T).

Heterorhabditis bacteriophora at 5000 IJ/10ml water provided moderate control of apple stem borer in Solan (YSPUH&F).

Neonate larvae of the apple root borer, *Dorysthenes hugelii* were sensitive to the entomopathogenic nematodes *H. bacteriophora* and *S. feltiae* at 2 X 10^9 IJ/ha and their application in the tree basin of apple trees at commencement of attack (July) can take care of the new infestation. Once the larvae had bored into the root, the drenching was found to be ineffective (YSPUH&F).

Vegetable Crops

In Jorhat, field evaluation of *Trichogramma brassicae* and *T. chilonis* @ 1,00,000/ha (6 releases) against *Plutella xylostella* revealed that *T. brassicae* was better in reducing the infestation (14.9%) than *T. chilonis* (19.2%). Maximum yield (17,370 kg/ha) was also recorded in the *T. brassicae*-released plot (AAU-Jorhat).

Trichogramma brassicae and *T. chilonis* released fields of cauliflower recorded lowest infestation of *P. xylostella* and higher yield and cost benefit ratio in comparison to farmers practice at Devarayapuram near Thondamuthur, Tamilnadu. The study also confirmed that *T. brassicae* was relatively a superior egg parasitoid over *T. chilonis* for the management of DBM in cauliflower (TNAU).

In Jammu, weekly releases of *T. brassicae* @ 1lakh/ha six times resulted in significant protection of cauliflower from damage by *P xylostella* with a C:B ratio of 1:9.75 and egg parasitism of about 46 % (SKUAS&T-Jammu).

In Bangalore, DOR *Bt* recorded the lowest *P. xylostella* population, followed by *S. carpocapsae*. The parasitoid release plot recorded a mean infestation of 0.67 larvae/ plant as against 4.20 larvae / plant in control. Release of egg parasitoid + *Bt* spray gave significant increase in yield than parasitoid alone (IIHR).

Five releases of *T. brassicae* @ 1 lakh/ ha/ release at weekly interval starting from 45 days after transplanting was found effective in reducing larval population and leaf damage due to DBM, recorded higher parasitism (52.6%) and gave maximum marketable cabbage head yield (MPKV, Pune).

Population of *P. xylostella* was effectively controlled by DOR *Bt*, *T. brassicae, S. carpocapsae* and NSP treatments in Udaipur. Benefit-cost ratio was however highest in spinosad treatment followed by DOR Bt and NSP treatments (MPUA&T).

In Srinagar, field performance of *T. brassicae* against cabbage butterfly, *P. brassicae* on cabbage was poor causing a considerable rise in pest larval density and severe damage and crop loss (SKUAS&T).

Beauveria bassiana, M. anisopliae and *B. thuringiensis* showed effective response against *P. brassicae* on knol khol at Srinagar causing 40 to 53.3% mortality (SKUAS&T).

In Jammu, a local isolate *S. carpocapsae* (JMU) @ 2 billion/hectare was more virulent against *P. brassicae* infesting cauliflower than isolates procured from outside. The nematode treatment (2 sprays at weekly interval) gave control of the pest comparable to insecticides (SKUAS&T-J).

In the laboratory testing, *T. brassicae* successfully parasitized eggs of *P. brassicae* and parasitization was high in fresh egg clusters rather than in 3-4 day old eggs. However, two field releases of the parasitoid at 50,000/ha in April 2007, did not result in any parasitization (YSPUH&F).

In Jorhat, *T. chilonis*, EPN and *Bt* were effective against the fruit borer of brinjal. Insecticides treated plot however recorded the lowest fruit damage with highest yield, which was on par with EPN-treated plots @ 2 billion/ha (AAU-Jorhat).

In Punjab, DOR Bt @ 2.0kg/ha was at par with chemical control and proved to be effective for management of fruit borer in brinjal. DOR *Bt* @ 2.0kg/ha was at par with chemical control for management of *Earias* sp. on Okra (PAU).

In Solan, two hitherto unreported species of aphelinid endoparasitoids were collected from whitefly infesting tomato, brinjal and cucumber and these have tentatively been identified as *Encarsia inaron* and *Eretmocerus delhiensis* (YSPUH&F).

Potato

In a large scale demonstration trial, inundative releases of *Copidosoma koehleri* @ 5,000 mummies/ha in four equal dosages in perforated plastic vials at weekly interval starting from 45 days after planting was found significantly effective over farmers' practice in reducing the leaf mines and tuber infestation due to PTM and increasing marketable potato yield (MPKV, Pune).

Biological control of white grubs

In potato crop, soil application of *Beauveria brongniartii* and *M. anisopiae* at 10^{14} conidia/ ha significantly reduced the white grub (mainly *Brahmina coriacea*) population and tuber damage as compared with the control but these treatments were inferior to the chemical treatment. In another field trial, where no insecticide was used, *B. brongniartii* (10^{14} conidia/ha) and *Heterorhabditis indica* (4×10^9 IJ/ha) proved better than *M. anisopliae* (10^{14} conidia/ha) and resulted in increased yield in comparison to control (YSPUH&F).

Soil application of *M. anisopliae*-enriched FYM (2×10^{10} conidia/kg) @ 20 kg/plot at the time of planting was effective in reducing white grub population as well as tuber damage with higher mycosis and recorded higher marketable potato yield at Pune (MPKV).

Biological suppression of white grubs on sugarcane using FYM enriched with *B. bassiana* was attempted at Hisar. The lowest number of grubs was recorded in plots provided with FYM containing the highest dose of *B. bassiana* i.e. 6×10^{10} conidia/kg (CCSHAU).

Polyhouse crop pests

In Vellanikkara, Kerala the major pests identified in polyhouses on Gerbera and croton plants were aphids, mealy bugs, scales, mites and thrips. Gerbera plants were found severely affected by thrips (*Frankliniella* sp.). Fungal pathogens were tested @ 10^{10} conidia/l for the control of thrips on Gerbera plants at Kerala. The lowest pest population was recorded in verticel followed by *B. bassiana* (KAU).

Three sprays of abamectin 1.9 EC @ 0.5 ml/lit was found significantly superior in suppressing mite population (*Tetranychus urticae*) on carnation and it was on par with *H. thompsonii* @ 10 g / lit. Four releases of anthocorids, *Blaptostethus pallenscens* @ 20 predators/plant at weekly interval was found effective against spider mites on carnation in polyhouse conditions (MPKV)..

Weed control

The exotic stem gallfly *Cecidochares connexa* released against *Chromalaena odorata* established in the Agro climatic condition of Assam from August 2007, more than ten galls per plant was recorded (AAU-J).

In Tamilnadu, releases of *C. connexa* at Periapodu near Anamalai resulted in significant reduction in *Chromolaena* plant height, number of panicles per plant, number of capitula per panicle and per cent seed germination in the released field compared to control. Reduced flowering, reduced internodal length, more of stem galls coupled with poor plant vigour was observed in the *Cecidochares*-released fields (TNAU).

An investigation on the differential performance of *Cyrtobagous salviniae* against *Salvinia* was conducted in Thrissur and Ernakulam districts of Kerala. The weevils were present in all the surveyed areas. Water samples were drawn from these area, analysed and documented (KAU).

The rust bioagent (*Puccinia* sp.) was specific to *C. rotundus* and did not infect any other host under the study. Among insects, only *Bactra minima* and *Rhopalosiphum nymphaeae* were observed to attack *C. rotundus* in very mild form (5-9%) and did not cause any significant damage to the weed (NRCWS).

Establishment of Mass Production Units

AAU, Jorhat Centre has established a Biocontrol Laboratory to produce selected biocontrol agents. Five *Trichogramma* species were maintained. The biocontrol agents produced in the laboratory were utilized for teaching and training of farmers, Extension Workers, enterpreneurs and also students of P.G. Research. Cultures of parasitoids were supplied to different Regional Research stations of AAU, KVKs, Agricultural Officers, Govt. of Assam for their field demonstration.

MPKV, Pune mass produced five Trichogrammatid cultures, two egg-larval parsitoids, three predator cultures and four laboratory host cultures. The cultures were supplied to other AICRP centres. *Trichogramma* spp., *Copidosoma koehleri, Cryptolaemus montrouzieri* and *Dipha aphidivora* were mass cultured and used for demonstrations and distributed to farmers.

PAU, Ludhiana mass produced *T. chilonis, T. japonicum, Chelonus blackburni* and *C. carnea.* During the period under report, 18,700 cards of *T. chilonis,* 4000 of *T. japonicum,* 20,000 adults of *C.*

blackburni and 90,000 adults/grubs of *C. carnea* were produced.

NAU, Navsari mass produced continuous culture of *Chrysoperla carnea* and used for field trials and distributed to farmers.

CCSHAU, Hissar supplied *Epiricania melanoleuca* and egg parasitoids for use against *P. perpusilla* and cane stem borers in collaboration with CBCL, Coop. sugar mills Sonipat, Biocontrol laboratory, Coop. Sugar mills, Shahbad, Maham and Jind.

Transfer of technology

1. In *Bt* cotton, Biocontrol based Pest Management (BIPM) consisting of (a) seed treatment with *Trichoderma* @ 8 g/kg of seed (b) border row of maize crop around each ha of crop (c) bird perches @ 10/ha (d) Two to three release of *Chrysoperla* larvae (2 to 3 days old) @ 14,000 per ha at weekly interval at later stage when aphid incidence appear (e) spraying of NPV for *S. litura* (1.5 x 10^{12} POB/ha) 'as and when' neonate larvae are seen (f) initial spray of Neem Seed Kernel suspension (NSKE) @ 5% (g) Two to three release of *Trichogrammatoidea bactrae* @ 1.5 lakhs/ha/week synchronizing with appearance of pink bollworm has been demonstrated and recommended for the states of Gujarat, Andhra Pradesh and Tamilnadu.

2. BIPM consisting of (a) sowing disease resistant variety (b) seed treatment with *Pseudomonas* @ 8 g/kg of seeds/ seedling dip in 2% suspension (c) bird perches @ 10/ha (d) Three to seven release of *Trichogramma japonicum* @ 1 lakh/ha at weekly interval (after observing egg masses) when either the leaf folder or stem borer occurred (e) spray *Bt* at 2 kg/ha, 2-4 sprays depending on pest occurrence (f) spray *P. fluorescens* (2.5 kg/ha) against foliar diseases and (g) need-based application of botanicals against sucking pests has been recommended for the rice pests and diseases in Kerala, Assam and Punjab. In Kerala, there was successful dissipations of the technology over 1500 ha of Kole lands in Thrissur Dt. In Punjab, the technology is being adopted in Basmati as well as organic rice cultivation.

3. Nine releases of *T. chilonis* @ 50,000/ha at 10 days interval has been recommended for the state of Assam against the plassey borer for obtaining higher yield.

4. In Tamilnadu, Maharashtra and Karnataka, our recommendation of inoculative releases of *Dipha aphidivora* @ 1,000 larvae per ha or *Micromus igorotus* @ 2500/ha at 10 spots has been widely adopted along with conservation by avoiding chemical insecticidal sprays which effectively controlled the sugarcane woolly aphid population.

5. Temperature tolerant strain of *T. chilonis* developed by PDBC, Bangalore @ 50,000 / ha controlled the early shoot borer in Punjab and resulted in higher cost:benefit ratio. In Punjab, twelve releases of *T. chilonis* could reduce the incidence of stalk borer on sugarcane and six releases of *T. japonicum* @ 50,000 /ha were effective against top borer, *Scirpophaga excerptalis*.

6. At Uttaranchal, the technology of seed treatment with *Trichoderma harzianum* isolates PBAT-39 and PBAT-38 (10g/kg seeds) was effective in suppressing anthracnose in chilli. Seed treatment alone (*T. harzianum* PBAT-39 @10g/kg) or combination with foliar application of mixed formulation of *T. harzianum* (PBAT-39 @10g/l) and *Pseudomonas fluorescens* (PBAP-27 @10 g/l) significantly reduced rust severity and increased grain yield of vegetable pea. These technologies are being adopted by the farmers.

7. In Kerala, management of *Oryctes* was possible through integration of Green muscardine fungus (GMF), *Oryctes* baculovirus (OBV) and attractant baited pheromone traps. GMF to be treated in 5 pits of 1 x 1 x 0.5 m size @ 5 pits/ha at a dose of 5 x 10^{11} spores/m2 and OBV to be released @ 12-15 infected beetles/ha and pheromone traps to be set up @ 2 traps/ha. This technology is being popularized among the farmers.

Human resource development

Dr. Deepa Bhagat attended (a) training programme on "IPM in Rice" from 03.9.2007 to 7.9.2007 at Directorate of Rice Research, Rajendranagar, Hyderabad (b) Synthesis of pheromones and other allelochemicals from 01.02.2008 to 01.03.2008 at Indian Institute of Chemical Technology, Hyderabad and (c) Encapsulation of compounds from 03.03.2008 to 16.03.2008 at Department of Pharmaceutical Sciences & Technology, N. P. Marg, Matunga, Mumbai.

Ms. M. Pratheepa attended training programme (a) E – Learning from 20.08.2007 to 25.08.2007 and (b) GIS Bases Decision Support for Sustainable Agriculture under NAIP scheduled from 01.02.2008 to 21.02.2008 at NAARM, Hyderabad.

Dr. S. K. Jalali attended a training programme on Management Development Programme on PME for Agricultural Research from 24.03.2008 to 28.03.2008 at Indian Institute of Management, Lucknow Co-implemented by NAARM, Hyderabad.

Dr. A. N. Shylesha underwent a training on Managing digital resources using open source software from 21.01.2008 to 25.01.2008 at UAS, GKVK, Bangalore.

Dr. Y. Lalitha underwent training on Molecular Biology Techniques from 21.01.2008 to 16.02.2008 at National Research Centre on Plant Biotechnology, Lal Bahadur Shastri Centre, Pusa campus, New Delhi.

Revenue generation

A revenue of Rs.10.04 lakhs was generated by the project directorate, which included consultancy, training fee, quality testing fee, sale of technical bulletins and natural enemies.

Publications

One hundred and ten research papers were published in scientific journals. Forty papers were presented during symposia/ seminars/ workshops. Ten book chapters/ scientific reviews were written and thirty five popular articles/ technical and extension bulletins were published.

4. INTRODUCTION

Brief History

The All India Co-ordinated Research Project on Biological Control of Crop Pests and Weeds was initiated in 1977 under the aegis of the Indian Council of Agricultural Research, New Delhi, with funds from the Department of Science and Technology, Government of India. Within two years the ICAR included the project under its research activities with full financial support. Recognition of the importance of biological control came during the VIII plan with the up-gradation of the centre to the present Project Directorate of Biological Control with headquarters at Bangalore. The Project Directorate started functioning on 19th October 1993. The AICRP started with 13 centres initially and has now 16 centres, all functioning under the Project Directorate.

Past achievements

Basic Research

- Eighty-nine exotic natural enemies (NEs) have been studied for utilization against alien pests, out of which 59 could be successfully multiplied in the laboratory, 51 species have been recovered from the field, four are providing partial control, five substantial control and six are providing economic benefits worth millions of rupees. Twelve are augmented in the same way as indigenous natural enemies.
- The encyrtid parasitoid, *Leptomastix dactylopii,* introduced from West Indies in 1983, has successfully established on mealybugs infesting citrus and many other crops in South India.
- Two aphelinid parasitoids of South American origin were fortuitously introduced against *Aleurodicus dispersus. Encarsia guadeloupae*, introduced from Lakshadweep has colonized in peninsular India, displacing the earlier introduced *Encarsia* sp. nr. *meritoria*.
- *Trichogramma brassicae*, an egg parasitoid, introduced from Canada was successfully quarantined and found suitable for biological control of *Plutella xylostella* on cole crops.
- *Curinus coeruleus* (origin: South America), the coccinellid predator introduced from Thailand in 1988, colonized successfully on subabul psyllid, *Heteropsylla cubana*.
- *Cyrtobagous salviniae* (Origin: Argentina) was introduced in 1982 and colonized on water fern, *Salvinia molesta*, in 1983. Weevil releases have resulted in savings of Rs.68 lakhs / annum on labour alone in Kuttanad district, Kerala.
- The weevils, *Neochetina bruchi* and *N. eichhorniae,* and the hydrophilic mite, *Orthogalumma terebrantis* (Origin: Argentina), introduced in 1982 and colonized in 1983 on stands of water hyacinth, have established in 15 states. Savings on labour alone is Rs. 1120 per ha of weed mat.
- The chrysomelid beetle, *Zygogramma bicolorata* (Origin: Mexico), introduced and colonized in 1983 on stands of parthenium, has established in all the states and Union Territories suppressing parthenium growth during rainy season.
- The stem gallfly, *Cecidochares connexa*, was introduced from Indonesia in 2002 and

successfully field released and established on *Chromolaena odorata* in Karnataka, Assam, Tamilnadu and Kerala and is suppressing the growth of *C. odorataa* and is spreading from the release spot.

- *Puccinia spegazzinii*, the rust fungus specific to *Mikania micrantha* imported from CABI, UK in 2003 was successfully quarantined in NBPGR, New Delhi and open field releases were made in Kerala and Assam where the establishment is being monitored.
- Biosystematic studies were carried out on 275 predatory coccinellids. A website on Indian Coccinellidae featuring image galleries of common species and their natural enemies has been constructed and hosted.
- A computer-aided dichotomous key to 10 common Indian species of *Chilocorus* is hosted on the internet.
- *Aphids of Karnataka*. URL: www.aphidweb.com (compendium on the aphid fauna of Karnataka covering 67 species, covering diagnostic and other information such as host plants and natural enemies with photographs and other illustrations).
- Aphids of Karnataka - Web photo album on Picasaweb (the largest of its kind with 1160 digital photographs of aphids of Karnataka). URL: http://picasaweb.google.com/home
- Biological control of sugarcane pyrilla has been achieved within the country by the redistribution of *Epiricania melanoleuca,* a parasite of *Pyrilla perpusilla.*
- Breeding techniques for 46 host insects standardized including rearing on semi-synthetic diet and cost of production has been worked out.
- Improved laboratory techniques were developed for the multiplication of 26 egg parasitoids, seven egg-larval parasitoids, 39 larval/nymphal parasitoids, 25 predators and seven species of weed insects.
- A technique for shipping *Telenomus* cards in ventilated plastic boxes fixed with polystyrene strips (with slits) has been standardized.
- *Sitotroga cerealella* eggs proved to be the most suitable for rearing *Orius tantillus* and *Corcyra cephalonica* eggs for *Blaptostethus pallescens*.
- A beef liver-based semi-synthetic diet has been evolved for *Chrysoperla carnea* to facilitate its large-scale production and use.
- Toddy palm leaf powder-based artificial diet was developed for rearing *Opisina arenosella*
- The Coccinellid predators, *Cryptolaemus montrouzieri, Cheilomenes sexmaculata* and *Chilocorus nigrita* were successfully mass-produced on semi-synthetic diets.
- A new multi-cellular acrylic larval rearing unit devised for efficient and economic mass production of *Helicoverpa armigera* and *Spodoptera litura* for commercial production of host-specific parasitoids and NPV.
- The sugarcane woolly aphid, *Ceratovacuna lanigera* was successfully controlled by the release of predators, *Micromus igorotus* and *Dipha aphidivora,* and parasitoid, *Encarsia flavoscutellum* in Karnataka, Andhra Pradesh, Maharashtra and Tamilnadu.
- A novel technique of modified atmosphere packing of *Corcyra cephalonica* eggs followed by low temperature storage at 8±1°C has been developed to extend the shelf life.
- Tritrophic interaction studies between the egg parasitoid, *Trichogramma chilonis,* bollworm *H. armigera* and cotton, chickpea, pigeonpea, sunflower and tomato genotypes have helped in identifying biocontrol-friendly genotypes.
- Suitable low temperatures for short-term storage of trichogrammatids, *Eucelatoria bryani, Carcelia illota, Allorhogas pyralophagus, Copidosoma koehleri, Hyposoter didymator, Cotesia marginiventris, Leptomastix dactylopii, Sturmiopsis inferens,* and *Pareuchaetes pseudoinsulata* have been determined.
- An endosulfan-tolerant strain of *Trichogramma chilonis* (Endogram) developed for the first time in the world. Technology transferred to private sector for large-scale production.

- Strains of *T. chilonis* tolerant to multiple-insecticides and high temperature and a strain having high host searching ability have been developed for use against lepidopterous pests.
- Pesticide tolerant strain of *T. chilonis* had higher amount of glutathion-s-transferase activity than the susceptible strain.
- Different pesticides have been screened against 37 natural enemies for identifying the relatively safe ones to be used in a biological control-based integrated approach.
- Kairomones from scale extracts of *H. armigera* and *C. cephalonica* increased the predatory potential of chrysopids.
- Acid hydrolyzed L-tryptophan increased the oviposition by *C. carnea* on cotton.
- Two fungal (*Trichoderma harzianum*-PDBC-TH 10 and *T. viride*-PDBC-TH 23), and two bacterial antagonists (*Pseudomonas fluorescens*-PDBC-AB 2, 29 & 30 and *Pseudomonas putida*-PDBC-AB 19) of plant pathogens have been released for commercial production after intensive studies.
- Bacterial antagonists, particularly *Pseudomonas cepacia* (starin N 24), suppressed successfully *Sclerotium rolfsii* in sunflower rhizosphere as seed inocula.
- New species and strains of entomopathogenic nematodes (EPN), namely, *Steinernema abbasi, S. tami, S. carpocapsae, S. bicornutum* and *Heterorhabditis indica* have been recorded.
- Suitable media for mass multiplication of EPN were identified. *S. carpocapsae* @ 1.25-5 billion/ha proved effective against the brinjal shoot and fruit borer, *Leucinodes orbonalis*. Talc-based and alginate-capsule formulations of *S. carpocapsae* and *H. indica* were effective against *S. litura* in tobacco. A sponge formulation was found suitable for transport retaining 90% viability of *Steinernema* spp. for 3-4 months and 85% viability of *Heterorhabditis* spp. for 2 months.
- An easy and rapid technique to screen antagonistic fungi against plant parasitic nematodes has been devised to identify efficient strains. The antagonistic fungus, *Paecilomyces lilacinus* was found effective against *Meloidogyne incognita* and *Rotylenchulus reniformis* in red laterite soils and *Pochonia chlamydosporia* was effective in sandy loam soil.
- Molecular identity of native isolates of *P. chlamydosporia* at PDBC was established through sequencing the β-tubulin gene (1 to 233 bases) and registered in the Genbank, NCBI, Maryland, USA.
- *Bacillus thuringiensis* isolate PDBC-BT1 caused 100% mortality of first instars of *Plutella xylostella*, *Chilo partellus* and *Sesamia inferens*. *B. thuringiensis* isolate PDBC-BNGBT 1 caused complete mortality of *Helicoverpa armigera*.
- `PDBC-INFOBASE' giving information about bioagents, their use and availability in public and private sector in the country; and 'BIOCOT", giving information about biocontrol measures for cotton pests and a CD version of the software "Helico-info" were developed.
- The software on "Vegetable crop pests," has been developed in MS-Access. It gives the users information on important pests and their natural enemy complex, distribution and IPM options of vegetable crops like brinjal, beans, cabbage, cowpea, tomato and potato.

Applied Research

- Eight releases of *T. chilonis* (@ 50,000/ha at 10 days interval) during April-June and six releases of *T. japonicum* (@ 50,000/ha at 10 days interval) during May-June have proved effective in suppressing sugarcane tissue borers.
- *Beauveria bassiana*, *B. brongniarti* and *Metarhizium anisopliae* were mass cultured and utilized effectively against sugarcane white grubs.

- *Encarsia flavoscutellum, Micromus igorotus* and *Dipha aphidivora* effectively controlled the sugarcane woolly aphid.
- Application of *Heterorhabditis indica* @ 2.0 billion IJs/ha resulted in minimum population of white grubs in sugarcane.
- *Trichogramma chilonis* has proved effective against maize stem borer, *Chilo partellus.*
- Biocontrol-based IPM modules consisting of use of moderately resistant variety, *T. viride* as seed treatment, release of *T. japonicum* @ 50,000/ha/week (6 releases), spray of *Pseudomonas fluorescens,* need-based insecticidal application and use of bird perches (10/ha) controlled the rice stem borer and increased the grain and net profit.
- IPM module comprising of need-based use of oxydemeton methyl (0.03%), releases of *C. carnea, T. chilonis* and spray of *Ha*NPV controlled the sucking pests and boll worms and increased the yields of seed cotton and conserved natural enemies.
- BIPM package recorded significantly lower bud and boll damage, lower population of sucking pests and higher seed yield than the package with chemical agents in Bt cotton.
- *Bt* and *Ha*NPV were important components of BIPM of pod borers in pigeonpea and chickpea resulting in increased grain yield.
- Release of *Telenomus remus* @ 100,000/ha and three sprays of *Sl*NPV @ 1.5 x 10^{12} POBs/ha along with 0.5% crude sugar as adjuvant against *S. litura* in soybean resulted in 17% higher yield than in chemical control.
- Integration of *T. remus* and NSKE for the management of *S. litura* and *C. carnea* and *Nomuraea rileyi* (@ 10^{13} spores/ha) for the management of *Helicoverpa armigera* on tobacco were effective. The cost-benefit ratio for BIPM was better (1:2.74) than that for chemical control (1:1.52).
- *Ischiodon scutellaris* @ 1000 adults/ha or 50,000 larvae/ha reduced *Lipaphis erysimi* population on mustard and gave higher yield.
- Inundative releases of parasitoids *Goniozus nephantidis* and *Brachymeria nosatoi,* against *Opisina arenosella* on coconut, coinciding the first release with the appearance of the pest, have proved effective.
- Adult release of *G. nephantidis* on trunk was as good as release on crown for the control of *O. arenosella* on coconut
- *Oryctes* baculovirus has been highly successful in reducing *Oryctes rhinoceros* populations in Kerala, Lakshadweep and Andaman Islands.
- *Cryptolaemus montrouzieri* has effectively suppressed *Planococcus citri* on citrus and grapes, *Pulvinaria psidii, Ferrisia virgata* on guava, *Maconellicoccus hirsutus* on grapes and *Rastrococcus iceryoides* on mango.
- Efficacy of *Trichogramma, Cryptolaemus, C. carnea, Ha*NPV and *Sl*NPV has been successfully demonstrated in Punjab, Andhra Pradesh, Karnataka, Maharashtra, Gujarat and Tamilnadu.
- *Aphelinus mali* and several coccinellid predators were found effective against the apple woolly aphid.
- San Jose scale parasitoids, *Encarsia perniciosi* and *Aphytis* sp., were well established in Jammu & Kashmir and Himachal Pradesh.
- *Trichogrammatoidea bactrae* and *Bt* were found effective against *Plutella xylostella*.
- Tomato fruit borer, *H. armigera* was effectively controlled by releases of *T. pretiosum* and *Ha*NPV.
- *Copidosoma koehleri* and *Bt* were found effective against potato tuber moth in country stores.

Mandate

Project Directorate of Biological Control, Bangalore
Harness the natural resources to develop and promote biological control strategies for sustainable and eco-friendly pest management in agriculture and horticulture to enhance the profitability and welfare of the farming community.

AICRP on biological control of crop pests and weeds

Promotion of biological control as a component of integrated pest and disease management in agricultural and horticultural crops for sustainable crop production.

Demonstration of usefulness of biocontrol in IPM in farmers' fields

Organisational set-up

With a view to fulfil the mandate effectively and efficiently, the Project Directorate is functioning with specialized laboratories for Biosystematics, Introduction and Quarantine, Mass Production, Pathology, Entomophagous Insect Behaviour studies, Biotechnology and a Co ordination, Documentation and Training Cell (Fig. 1).

Financial statement (2007-08) (Rs.in lakhs)

Project Directorate of Biological Control, Bangalore

Head	Plan	Non-plan	Total
Pay & allowances	00.00	160.23	160.23
TA	04.00	04.50	08.50
Other charges including equipment	68.44	50.96	119.40
Information Technology	01.00	-	01.00
Works/petty works	111.67	19.80	131.47
HRD	02.00	-	02.00
OTA	-	0.14	0.14
Total	**187.11**	**235.63**	**422.74**

AICRP Centres (ICAR share only) expenditure (2007-08)

Name of the centre	Expenditure (Rs. in lakhs)
AAU, Anand	34.50
AAU, Jorhat	20.24
ANGRAU, Hyderabad	31.50
Dr.YSPUH&F, Nauni, Solan	21.82
GBPUA&T, Pantnagar	18.63
KAU, Thrissur	29.55
MPKV, Pune	29.92
PAU, Ludhiana	29.49
SKUAS&T, Srinagar	21.46
TNAU, Coimbatore	29.36
Total	**266.47**

ICAR Institute-based centres (CPCRI, Kayangulam; CTRI, Rajahmundry; IARI, New Delhi; IIHR, Bangalore; IISR, Lucknow and SBI, Coimbatore) did not maintain separate budget accounts since the Project has been merged with Non-Plan

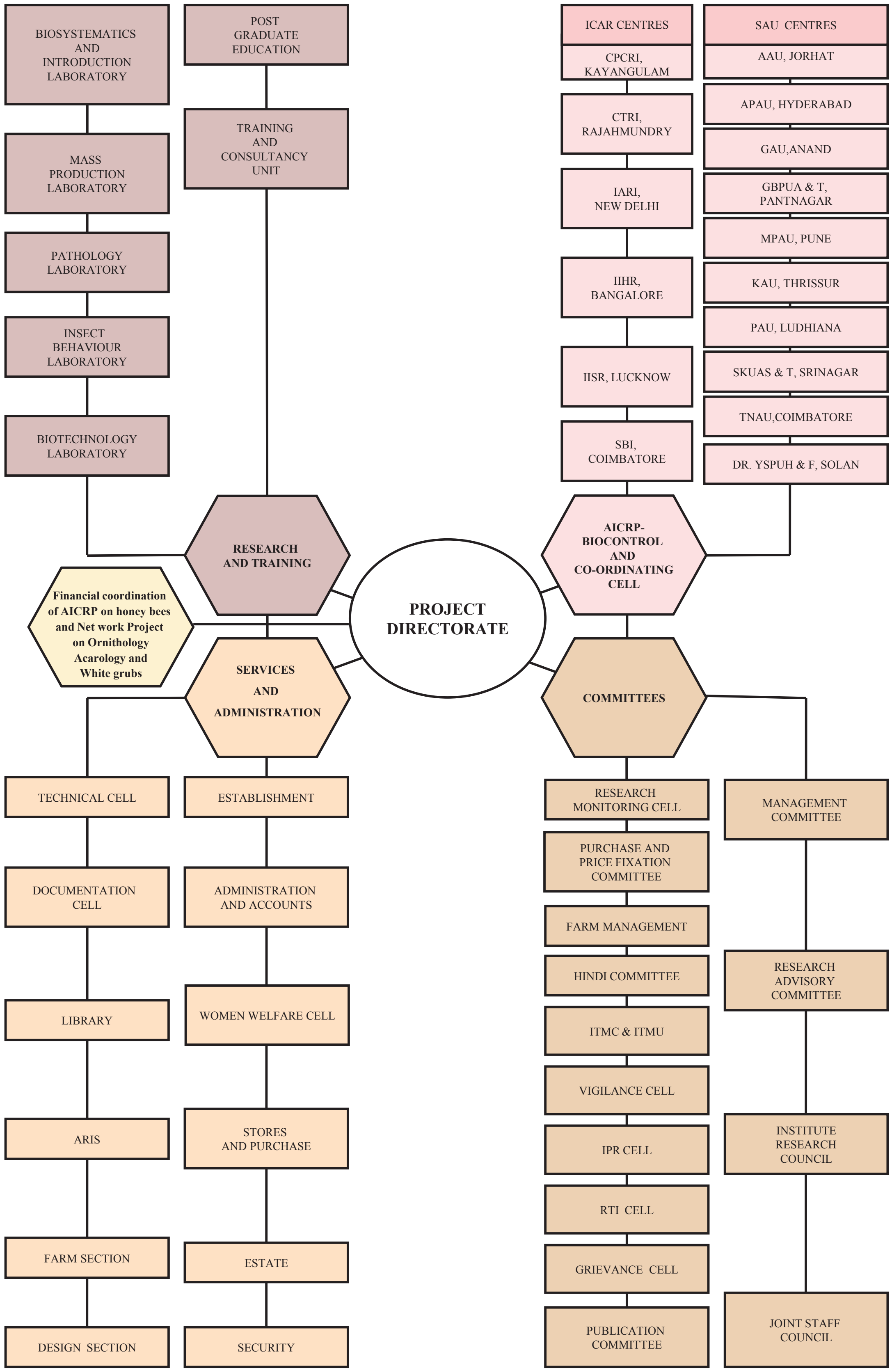


Fig. 1 The Organisational Chart of PDBC

5. RESEARCH ACHIEVEMENTS

5.1. Project Directorate of Biological Control, Bangalore

5.1.1. Biosystematics

5.1.1.1. Taxonomic studies on lesser known coccinellidae of the Indian subcontinent

(a) Taxonomic revisions and new taxa described

The genus *Stictobura* Crotch (Sticholotidinae: Sticholotidini) (Fig. 2), endemic to Western Ghats region, was revised during this period. Two new synonymies and one new combination were proposed based on the studies carried out. One apparently new species belonging to a genus near *Stictobura* was recorded from Assam. A new species of *Scymnus (Pullus)* (Fig. 3) predatory on bamboo aphid, *Pseudoregma bambusicola* Takahashi, was described from Karnataka. A new species of *Horniolus* Weise, commonly misidentified as *Scymnus latemaculatus* Motschulsky, was described from Karnataka. An apparently new species of *Synona* Pope was recorded from Meghalaya.

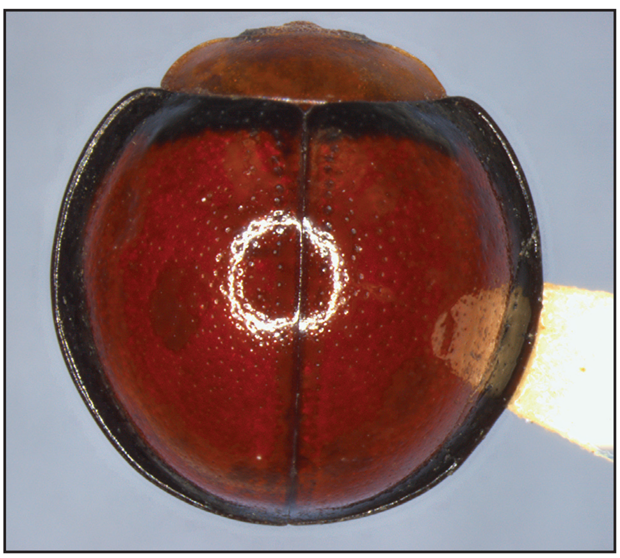


Fig. 2. New species of *Stictobura*

Fig. 3. New species of *Scymnus* on bamboo aphid

(b) Updation of checklist with nomenclatural changes and new records

Distribution and biological data for the species of the genus *Stictobura* were compiled as part of the generic revision. Two rare arboreal coccinellids, *Ortalia horni* Weise (Kerala) and *O. vietnamica* Hoang (Assam) were recorded during this period and studied. *Oenopia excellens* (Crotch) was recorded from Mizoram, a new distribution record. *Stethorus indira* Kapur was transferred to the genus *Parastethorus* based on recent work reported from elsewhere. New locality / distribution records were constantly updated in the checklist of Indian Coccinellidae. Nomenclatural changes such as new synonymies and new combinations, new faunal and distribution records mentioned before were added to update the checklist of Coccinellidae of the Indian subcontinent.

(c) Studies on coccinellids in other collections

Type specimens of *Stictobura* species from India in the collections of the Natural History Museum, London, were obtained on loan for studies. Studies on some undescribed material borrowed from the US National Museum of Natural History, Washington, D.C. are in progress.

(d) Development of interactive keys to the genera of Coccinellidae of the Indian region

Keys were constructed for the subfamilies, tribes, and genera of Sticholotidinae and Scymninae (Coccinellidae) of the Indian region and a matrix is being prepared to load the characters and character states in the software LucID for scoring. Digital photographs of common species of coccinellids have been taken for inclusion in the interactive key.

(e) Updating of website on Coccinellidae of the Indian region

The website on the Coccinellidae of the Indian subcontinent was updated periodically during the reporting period. The website gets 15-75 hits per day, with a maximum of 331 hits in one day during March 2008. Information on aphidophagous coccinellids was incorporated in a new website, "Aphids of Karnataka" (URL: www.aphidweb.com), giving diagnostic and biological information for 67 species of aphids. Factsheets on important aphidophagous coccinellids were included in the website with diagnostic characters and other details, besides colour photographs to facilitate easy field identification.

5.1.1.2. Biosystematics of *Trichogramma* and *Trichogrammatoidea*

A trichogrammatid parasiotoid *Uscana* sp. was collected from bruchids and *Trichogramma hebbalensis* from *Lampides boeticus* infesting *Crotolaria* sp.

5.1.2. Introduction and studies on natural enemies of some new exotic insect pests and weeds

The chromolaena gallfly, *Cecidochares connexa* has successfully established in new release sites at Thrissur (Kerala), Periapodu (Tamilnadu) and Jorhat (Assam). In Bangalore, upto six per cent of the gallfly larvae were found parasitized by *Ormyrus* sp. Severe infestation of mealybug, *Phenacoccus solenopsis* was recorded on *Parthenium histerophorus*

5.1.3. Biology and mass production of predators

(a) Studies on anthocorids

(i) Life table studies on *Cardiastethus exiguus*

Life table studies on *Cardiastethus exiguus* revealed that immature stages occupied 17 days. Female progeny were produced even from the first day after emergence. First mortality occurred when the adults were 34 days old, after which there was a gradual decline in survival and 100% mortality was recorded on the 111th day from adult emergence. Till the 39th day, female progeny production could be recorded, after which intermittently zero female progeny production was recorded. However, zero progeny production was recorded from 87th to 93rd day and from 96th day till mortality.

The Fertility table parameters of lab-reared *C. exiguus* were worked out. The reproductive rate (Ro) was 24.77, approximate duration of a generation (Tc) was 39.08 days, Net generation time (T) was 46.12 days, approximate rate of increase (r_c) was 0.082, precise intrinsic rate of increase (r_m) was 0.07 and finite rate of increase (λ) was 1.07. *Cardiastethus exiguus* doubled itself in 10.03 days, hypothetical F2 females was 613.55 and Weekly multiplication rate was 1.63. The progeny production in the case of field-collected adults ranged between 0 to 9.5 whereas in the case of lab-reared it was 0.3 to 0.9 per female per day.

Table 1. Fertility table parameters for *Xylocoris flavipes*

Rearing conditions	R_0	T_c	r_c	r_m	T	λ	Doubling Time (days)	Hypo. F_2 ♀s	WMR
In pairs	8.50	36.85	0.058	0.045	47.14	1.14	5.29	72.25	2.50
Mated females alone	2.31	32.03	0.026	0.026	32.07	1.06	11.89	5.34	1.49

(ii) Life table studies on *Xylocoris flavipes*

Life table studies revealed that all the fertility parameters were higher when *X. flavipes* was reared in pairs of male and female than when the mated females were reared in isolation (Table 1).

(iii) Evaluation of *Blaptostethes pallescens* against *Scirtothrips dorsalis* on capsicum

The predatory efficacy of *B. pallescens* was evaluated against *S. dorsalis* on capsicum. Twenty nymphs of *B. pallescens* were released @ 20/plant at 10 days interval. The effect of six releases was compared with three releases and control (no release). At the end of three and six releases no thrips were recorded on the released plants while 0.9, 2.3 and 0.5 thrips were recorded per terminal on control plants after 30, 40, 50 days.

(iv) Evaluation of anthocorid predators against *Thrips tabaci* on garlic

Four releases of the anthocorid, *B. pallescens* @ 20 nymphs/plant reduced the population of the thrips significantly, reduced the damage and increased the yield of garlic (Fig. 4). The anthocorid survived and multiplied in the ecosystem and could be recorded even a month after release

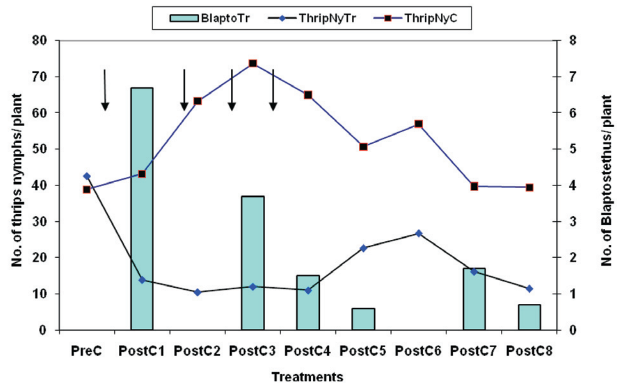


Fig 4. Thrips and anthocorid populations on garlic plants (arrows indicate the release of the predator)

v) Evaluation of anthocorid predators against *T. tabaci* on onion

Three releases of *B. pallescens* @ 20 nymphs/plant reduced the population of *T. tabaci* on onion considerably and increased the number of marketable bulbs by 24.5 % and the yield by 30.0% (Table 2).

(vi) Evaluation of anthocorids against bruchids

Results of experiments on the efficacy of *B. pallescens* against the pulse bruchids revealed that releasing @ pest:predator ratio of 1:1 either as nymphs or adults reduced the emergence of the

Table 2. Effect of anthocorid releases against *Thrips tabaci* infesting onion

Day post first release	No. of thrips/plant		No. of bulbs/100 plants		Weight per 100 bulbs (kg)	
	Treatment	Control	Treatment	Control	Treatment	Control
0	11.6	3.3	117.08	93.75	3.64	2.81
10	12.0	8.3				
20	9.0	13.0				
30	8.75	17.0				
40	4.0	3.0				
50	2.66	3.50				

bruchid, *Callosobruchus chinensis* by about 40 per cent in case of *B. pallescens* while *X. flavipes* was not effective.

(vii) Evaluation of *B. pallescens* against chilli mites

Four releases of 7 days old nymphs of *B. pallescens* @ 10 / plant at weekly interval resulted in substantial reduction in damage to leaves and increase in plant height (Table 3).

Table 3. Effect of anthocorid releases against *Polyphagotarsonemus latus*

Day post first release	% curled leaves		Plant height (in cm)	
	Control	Treatment	Control	Treatment
0	25.4	26.2	11.5	15.7
7	26.5	10.0	12.5	21.8
14	28.0	17.4	13.0	26.4
21	35.0	13.3	14.0	30.0
28	60.0	17.2	16.5	33.0

(b) Studies on *Micromus igorotus*

(i) Life table studies on *M. igorotus*

Life table studies indicated that the immature stage mortality ranged from 29.18 per cent (on *P. bambusicola*) to 59.00 per cent (on *C. lanigera*). Immature stage mortality when *A. craccivora* was used as host was 51 per cent while it was 54 per cent when *A. gossypii* was used as host. A comparison of the key mortality factors showed that total survival was affected to the maximum in the pupal stage on *A. gossypii*, *A. craccivora* and *C. lanigera* while in the egg stage on *P. bambusicola*. Pupal mortality was highest on *C. lanigera* followed by that on *A. gossypii*. Egg mortality did not vary with the host. Least larval mortality occurred when *P. bambusicola* was used as host whereas it was maximum on *C. lanigera* followed by *A. gossypii*. Irrespective of the species of aphid used for rearing, S_x value was maximum in case of third instar larva indicating least mortality in this stage. The e_x value decreased with the age when *A. gossypii*, *A. craccivora* and *P. bambusicola* were used as host giving type III survivorship curve.

(ii) Life fecundity tables for *M. igorotus*

Micromus igorotus had a maximum life span of 61 days out of which immature stages occupied 14 days on *A. craccivora*. Oviposition began on 19th day and maximum progeny per day was attained on the 11th day of oviposition. The first mortality occurred on the 4th day and fifty per cent of population survived up to 32nd day. The average number of eggs laid per female was 1082 and sex ratio was 1: 1.5 (male: female). The net reproductive rate (R_0), length of generation (T_c) and innate capacity of increase (R_c) were 66.52, 33.89 and 0.124, respectively. The population of *M. igorotus* multiplies 1.3 times per day and doubled in 2.43 days (Table 4).

Table 4. Growth rate statistics of *M. igorotus* on *A. craccivora*

Gross reproductive rate (GRR)	106.13
Net reproductive rate (Ro)	66.517
Mean length of generation (Tc)	33.89
Innate capacity for increase (Rc)	0.124
Finite rate of increase (λm)	1.33
Weekly multiplication of population	7.36
Hypothetical F2 females	4424.51
Doubling time (DT)(days)	2.43

(iii) Mass production of *M. igorotus*

It was possible to make a total of 13 harvests of eggs of *M. igorotus* in a month on alternate days by using recently designed and fabricated oviposition cage. First harvest was possible when female was seven days old and last harvest was made when female aged 42 days. It was possible to get yield of 20,276 eggs per oviposition cage per month (fig 5). A total of 1,19,671 eggs could be obtained per month if seven oviposition cages containing 20 pairs were used.

c) Studies on *Cryptolaemus montrouzieri*

(i) Effect of different grain media on yield of *Sitotroga cerealella* females

Studies indicated that even though immature mortality was lowest in maize, number females

Fig. 5. ***Micromus igorotus*** **oviposition cage**

obtained at the end were least because the number of grains per kg of maize was least (because of size of the grain) (Table 5). Studies thus indicate that it will not be economical to use maize as grain substrate for rearing *S. cerealella* as per kg cost of maize is more than other grains and as only one larva can develop per grain, it will be beneficial to use smaller grains to reduce the cost of production.

(ii) Estimation of cost of production of *S. cerealella* eggs

The average cost of producing 1 cc of eggs was estimated to be Rs. 34.40. The estimate was very high because of low average fecundity of adults during winter months which resulted in low total yearly output leading to higher cost of production. Use of good quality unhusked wheat and temperature control during winter months can increase the fecundity.

(iii) Life fecundity tables on *S. cerealella*

Life fecundity studies on *S. cerealella* using four grain media viz., wheat, paddy, barley and maize indicated that immature stages occupied 35 to 38 days and adult longevity ranged from 6.3 days (barley) to 7.9 days (maize). Oviposition period ranged from 4-5 days and more than 70% of the total eggs were laid on first three days of oviposition (Table 6). Average fecundity ranged from 102.9 (barley) to 138.8 (maize) eggs per female. Net reproductive rate was highest (28.9) on maize and lowest (23.36) on barley, however generation time was maximum on maize (41.1 days) and minimum on wheat (37.8). Highest R_c and λ was obtained when wheat was used as grain media (Table 6).

Table 6. Growth parameters of *Sitotroga cerealella* on different cereals

Growth parameter	Grain media			
	Barley	Paddy	Wheat	Maize
Oviposition period (days)	4	5	5	5
Per cent eggs laid on the first three days of oviposition (%)	91	88	70	88
Gross reproductive rate (GRR)	32.60	34.60	35.95	46.55
Net reproductive rate (Ro)	23.36	24.46	25.32	28.92
Mean length of generation (Tc)	40.05	39.04	37.80	41.06
Innate capacity for increase (Rc)	0.078	0.082	0.085	0.082
Finite rate of increase (λm)	1.198	1.207	1.217	1.207

Table 5. Number of females of *Sitotroga cerealella* obtained from one kg of different cereals

Grain	Number of eggs used to infest one kg of grain	Immature mortality (%)	Total number of adults	Total number of females	Per cent reduction over barley
Maize	5,900	66.2	3,907.6	1,953.8	88.1
Wheat	27,800	67.8	18,845.6	9,422.8	42.9
Paddy	36,900	69.9	25,800.5	12,900.2	21.8
Barley	47,100	70.0	32,974.7	16,487.4	

(iv) Life table studies on *S. cerealella*

Life table studies on *S. cerealella* using unhusked wheat as host indicated that the per cent mortality within generation was 66.56 per cent. Mortality to survival ratio was highest in larval stage indicating high mortality in larval stage. Survival rate within age interval was highest in pupal stage. The expectation of life for individuals of age (x) decreased with age giving type III survivorship curve (Table 7).

Table 7. Life table parameters of *Sitotroga cerealella* on unhusked wheat.

x	Eggs	Larva	Pupa	Adult	Reproducing females
lx	1250.00	1008.00	461.00	418.00	210.00
dx	242.00	547.00	42.00	208.00	
% apparent mortality (100 qx)	19.36	43.76	9.33	49.76	
% Real mortality (100 dx/n)	9.90	49.50	3.44	16.64	
% Indispensable mortality	9.90	49.50	4.30		
M/S ratio	0.24	1.19	0.10		
Log lx	3.09	3.00	2.66	2.62	
k	0.09	0.34	0.04		
Lx	1129.00	734.50	439.50		
Sx (Survival rate)	0.81	0.45	0.91		
Tx	2302.50	1174.00	439.50		
ex Ilife expentancy)	1.96	1.59	1.00		

(v) Rearing of *C. montrouzieri* on *S. cerealella* eggs

A total of 26 generations of *C. montrouzieri* were reared on *S. cerealella* eggs. Pupation was 63.4% and adult emergence from these pupae was 87.0%. Average total survival was 59.6%. Average larval and pupal periods were 15.3 and 7.0 days, respectively whereas adult longevity was 46.0 days. Average adult weight was 8.1 mg while female percentage was 41.3%.

5.1.4. Behavioural response of natural enemies to plant volatiles

5.1.4.1. Identification of volatiles.

The volatile composition of rice and several weed species was analyzed through GCMS and the dominant compounds identified were methyl hexadecanoate, 2-di—butyl phenol, caryophyllene and phytol.

5.1.4.2. Behavioural response

(a) Behavioural response of *Trichogramma japonicum* to the volatiles from the different cultivars of rice and other flora associated with rice.

Secondary plant compounds of rice varieties TN1, Jaya, Vijetha and Triguna were extracted with acetone, chloroform, methanol and hexane and identified through GCMS. The variety Triguna had 69 volatile compounds followed by TN1 (58), Vijetha (46) and Jaya (26). *Trichogramma japonicum* response (attraction) was highest to the hexane extract of 30 days old Triguna rice and lowest in acetone extract of TN1. Plant volatile profile of other flora from rice ecosystem was identified through GCMS and are tabulated in table 8.

Table 8. Number of plant volatiles identified in different flora of rice ecosystem

Plant name	Number of volatile compounds
Calotropis gigantea (flower)	28
C. gigantea (leaves)	56
Melia dubia	6
Tephrosia purpurea	4
Hyptis suaveolens (flower)	6
H. suaveolens (Leaves)	14
Panicum setegerum	13
Alternanthera ficoidea	4
Cleome viscosa	17
Asistida sp.	9
Spilanthes acmella	2
Asclepia curassavica	26
Parthenium hysterophorus	4
Mulberry leaves	13

Sugarcane appears to be most preferred crop recording *T. chilonis* parasitism of 30.5%, followed by paddy (18.9%) and cotton (18.3%). Tomato (5.3%) was least preferred host plant.

(b) Behavioural response of *T. japonicum* to the volatiles from the weed species.

Among the weeds in rice ecosystem, *Melia dubia* and *Malvastrum coramandalicenum* recorded maximum attraction of *T. japonicum* while *Cleome viscosa* recorded the least.

(c) Behavioural response of *T. japonicum* to the volatile fractions from the weed, *Melia dubia* and *Tephrosia purpurea.*

Among the 100 analytical fractions of *M. dubia*, fraction 22 and 23 showed highest attraction to *T. japonicum* recording 84.0 & 87.8% parasitisation respectively in ovipositional response studies. Fractions 25, 26 and 27 did not record any parasitisation. Out of 100 analytical fractions of *T. purpurea* fraction 38 & 60 showed highest attraction to *T. japonicum* recording 81.0 & 84.5% parasitization respectively in ovipositional response studies.

(d) Behavioural response of *Tetrastichus schoenobii* to the volatiles of rice.

Rice recorded the highest response to *T. schoenobii*, followed by extracts from *Hyptis suaveolens.* Out of four rice cultivars, Triguna recorded the highest attraction of *T. shoenobii*, though on par with TN-1, Vijitha and Jaya.

5.1.4.3. Synthesis of stable kairomones for *Chrsoperla carnea* and *Spodoptera litura*

The analog of linalool was synthesized by transesterification reaction. The synthesized compounds 3,7-dimethyl-octa-1,6-dien-3-yl-octanoate, 3,7-dimethyl-octa-1,6-dien-3-yl-acetate and 3, 7-dimethyl-octa-1,6-dien-3-yl-4-hydroxybenzoate was bioassayed with *C. carnea* and *S. litura* male and female using standard Electroantennogram methods. The analogue 3, 7-dimethyl-octa-1,6-dien-3-yl-4-hydroxybenzoate elicited the highest response in *C. carnea* female whereas least response to the compound was observed in male *S. litura*.

Three linalool epoxides were synthesized by epoxidation reaction. The compounds 6-methyl-2-(oxiran-2-yl) hept-5-en-2-ol, 5-(3,3-dimethyl oxiran-2-yl)-3-methylpent-1-ene-3-ol and 4-(3,3-dimethyl oxiran-2-yl)-2-(oxiran-2-yl)butan-2-ol obtained were bioassayed for response in *C. carnea* and *S. litura* male and female, under standard Electroantennogram methods. The highest response for compound 4-(3,3-dimethyl oxiran-2-yl)-2-(oxiran-2-yl)butan-2-ol was observed in *S. litura* female.

5.1.5. Biological and molecular characterization of inter and intra specific variation in Trichogrammatids

(a) ITS-2 PCR and sequencing

The size of the ITS-2 rDNA PCR products varied from 500bp – 900bp in the twelve Trichogrammatid species used in the study. Based on this size variation, three groups could be distinguished: **Group I** included *Tr. armigera* and *Tr. bactrae* with the size of 800bp to 900bp; **Group II** included *T. achaeae, T. japonicum* and *T. embryophagum* (570 to 600bp) and **Group III** included *T. chilonis, T. pretiosum, T. evanascens, T. mwanzai, T. pretiosum* (TF), *T. dendrolimi* and *T. brassicae* (500 to 550bp). These groups could be easily recognized after electrophoresis on agrose gel. Complete ITS-2 sequences of different species have been deposited with NCBI Genbank.

(b) Restriction Enzyme analysis

Restriction digestion of all samples of *Trichogramma* DNA gave reproducible profiles. *Eco*R1 showed no sites for *T. achaeae, T. japonicum, T. pretiosum* (TF) and *T. pretiosum* (Fig. 6, Fig.7). *Sac*I showed no sites for *T. embryophagum*. *Mse*I showed no sites for *T. chilonis, T. mwanzai, T. pretiosum* (TF) and *T. pretiosum* (Fig. 8). *Sac*I showed no sites for *T. embryophagum* (Fig. 6). Restriction digestion with *Mva*I resulted in a 75bp fragment in all except *T. pretiosum* where two fragments of about 50bp and 75 bp were observed (Fig. 7). *Tr. armigera* and *Tr. bactrae* belonging

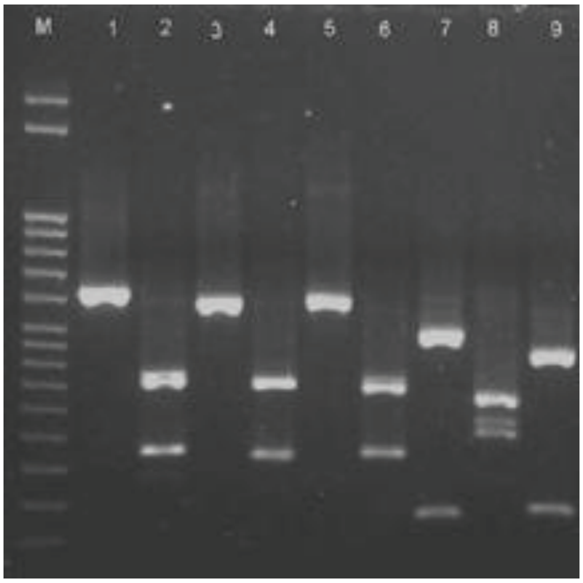


Fig. 6. PCR amplified ITS-2 region from different trichogrammatids belonging to Group II digested with EcoRI (lanes1-3), SacI (lanes4-6) and XhoI(lanes7-9) (Lanes: M, 50bp DNA ladder; 1. *T. achaeae;* 2. *T. embryophagum;* 3. *T. japonicum;* 4. *T. achaeae;* 5. *T. embryophagum;* 6. *T. japonicum;* 7. *T. acheae;* 8. *T. embryophagum;* 9. *T. japonicum*)

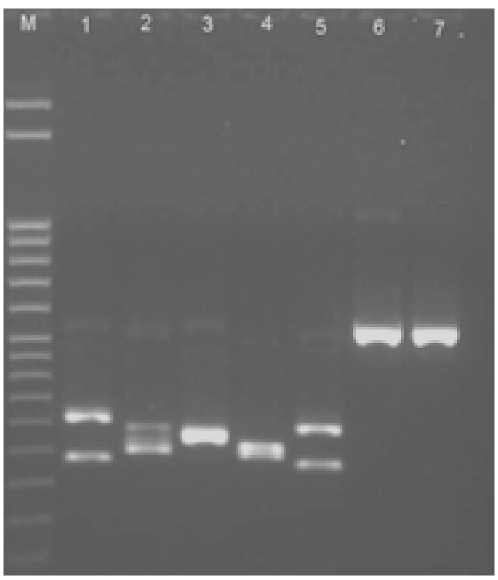


Fig. 7. PCR amplified ITS-2 plus flanking regions of 5.8s and 28s rDNA from different trichogrammatids belonging to Group III digested with EcoR1 (Lanes: M, 50bp DNA ladder; 1. *T. chilonis;* 2. *T. dendrolimi;* 3. *T. evanescens;* 4. *T mwanzai;* 5. *T. brassicae;* 6. *T. pretiosum* (TF); 7. *T. pretiosum*

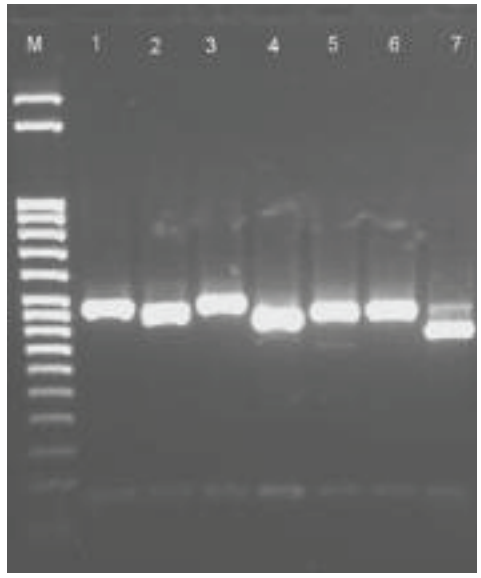


Fig. 8. PCR amplified ITS-2 plus flanking regions of 5.8s and 28s rDNA from different trichogrammatids belonging to G roup III digested with Mva1 (Lanes: M, 50bp DNA ladder; 1. *T. chilonis;* 2. *T. dendrolimi;* 3. *T. evanescens;* 4. *T. mwanzai;* 5. *T. brassicae;* 6. *T. pretiosum* (TF); 7. *T. pretiosum*

to genera *Trichogrammatoidea* could be easily differentiated after amplification of ITS-2 region. Restriction digestion with *Eco*RI enzyme enabled differention of ten species, while restriction digestion with *Mse*I enabled differentiation of six species; *Sac*I was useful to differentiate *T.embryophagum*. *Mva*I enzyme proved useful to differentiate *T. pretiosum* (TF) from *T. pretiosum.* Based on restriction patterns, a dichotomous key was constructed for easy differentiation of these twelve trichogrammatids.

(c) Study with wolbachia symbiont

Female progeny produced from crosses *T. brasiliense* (female) x *T. pretiosum* (male) and *T. brasiliense* (male) x *T. pretiosum* (female) proved to be two different forms (thelytokous and arrhenotokous) of one species *T. pretiosum*. Amplification of wsp and ftsz regions reveal that *Wolbachia* infection was carried through the female (transovarial) with indication of presence of bands (0.7Kb) in the *T. brasiliense* parent and female progeny coming from the *T. brasiliense* (female) x *T. pretiosum* (male). Amplification was absent in the male progeny of *T. brasiliense* (female) x *T. pretiosum* (male), *T. pretiosum* parent and female and male progeny of *T. brasiliense* (male) x *T. pretiosum* (female). Intensity of the banding pattern was varying with the primers.

Studies on horizontal transmission between wolbachia giver (*T. brasiliense*) and taker (*T. achaeae*) indicated that females in parents was only 31.0% and after 5 generations, females obtained was 79.4%. The mean per cent females in parent population was 32.6, however, in transmission population, it was higher (46.4%), indicating the possibility of wolbachia getting transmitted.

(d) Association of other microor-ganisms with field-collected Trichogramma-tids

The experiment with trichogrammatids collected from the castor ecosystem showed the presence of yeast and bacteria associated with the field population but not in the laboratory population. When laboratory population of *T. chilonis*, *T. achaeae* and *T. japonicum* were fed with yeast extracted from the field population, females obtained increased after 10 generations by 15 – 30%.

5.1.6. Selection of superior strains of *C. carnea* and *C. montrouzieri* from different agro-ecosystems and their molecular characterization.

(a) Quality attributes of different chrysopid populations

Variations in survival rate were observed in different populations of *C. carnea*. The survival of *C. carnea* populations was 90 % (Delhi), 84 % (Punjab), 70.5 % (Coimbatore), Varanasi (80 %), Anand (84 %) and Shimla (65 %). Highest percentage survival of *Mallada boninensis* was recorded in Salem population (90) followed by Nagpur (80) and Aurangabad (40) populations. *Apertochrysa* sp. collected from cotton fields at Darwad was reared on *Corcyra* eggs and the percentage pupation and adult survival were 84 % and 78%, respectively.

(b) Predatory efficiency of different populations of *C. carnea* against *A. craccivora*

Maximum number of aphids was consumed by *C. carnea* collected from Anand, followed by Coimbatore, Sirsa and Varanasi, Nagpur and Ludhiana (Fig.9.). Highest percentage survival of *C. carnea* larvae was recorded in Punjab (52%), followed by Nagpur (51%) and Coimbatore (46.5 %) population against imidochloprid.

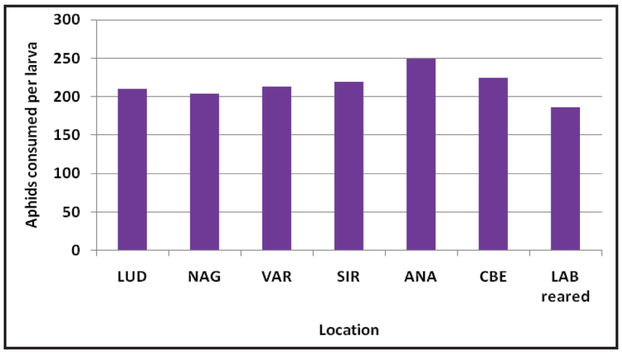


Fig. 9. Predatory efficiency of different populations of *C. carnea*

(c) Susceptibility of *C. carnea* populations to monocrotophos

The LC_{50} of monocrotophos was highest in *C. carnea* collected from Sirsa (15.6ml/lit) followed by Coimbatore (12.4ml/lit) and Anand (5.6ml/lit).

(d) Predatory efficiency of different populations of *C. montrouzieri* against *M. hirsutus*

In a study on predatory efficiency of different populations of *C. montrouzieri* collected from Shimoga, Coimbatore, Bangalore and PDBC, maximum mealy bugs was consumed by Bangalore (46.8) followed by Shimoga (43.7), Coimbatore (39.0) and PDBC (37.0) populations.

(e) Susceptibility of *C. montrouzieri* populations to acephate

Among various populations, LD_{50} of acephate was highest in *C. montrouzieri* collected from Delhi (0.75 ml/lit) followed by Coimbatore (0.36 ml/lit) and Shimoga. (0.21 ml/lit) and PDBC (0.2 ml/lit).

Deltamethrin caused 100 % mortality of PDBC and Delhi populations of *C. montrouzieri,* but only 65 % in Coimbatore and 52 % in Shimoga populations. Cypermethrin caused 100 % mortality in Shimoga, Delhi, PDBC and Coimbatore populations.

(f) Esterase and RAPD polymorphisms in *C. carnea*

Esterase polymorphism in different geographical populations of *C. carnea* was studied and there was difference in number of esterase electromorphs in different populations (5 esterase electromorphs in Varanasi, Punjab and Sirsa; 4 from Coimbatore; 3 from Gujarat, Delhi and PDBC and Shimla population showed only two esterase bands). It was observed that relatively more number of bands was observed in larval populations than corresponding adults. RAPD polymorphisms in *C. carnea* was studied in nine populations and there was variation among the populations.

5.1.7. Selection of Superior strains of certain parasitoids and their characterization

(a) Biological attributes of different populations of *Goniozus nephantidis*

The biological parameters of the Kerala and Karnataka populations of *Goniozus nephantidis* were studied at 32±1° C and 26±1° C for over six and twelve generations, respectively. No marked difference was observed in the various biological parameters among the populations. Enhanced attributes were observed at 32° C than at 26° C for Karnataka population indicating temperature above 30° C is more congenial for the development of the parasitoid (Table 9).

The population from Tamilnadu was superior in the biological attributes such as pupation (76.9%), adult emergence (94%) and adult longevity (48 days) compared to the Andhra Pradesh population which recorded 61.2%, 90.9% and 39 days, respectively. The number of larvae parasitized and the fecundity did not differ among the populations.

(b) Biological attributes of different populations of *Cotesia flavipes*

The number of cocoons formed, extent of parasitisation, adult emergence and the male to female sex ratio varied significantly among the Bangalore, Chitradurga and Malur populations. The population from Malur recorded the maximum in each of the parameter mentioned, respectively. There was no marked difference in the adult longevity and the total development period among the populations (Table 10).

Population from New Delhi recorded greater parasitisation (70%) than the Andhra Pradesh population (50%), however the number of cocoons formed (51) and adult emergence (36) and male to female sex ratio (1:2.6) were higher in the Andhra Pradesh population, compared to the population from New Delhi which recorded 28 and 23, 1:1.5 respectively.

Table 9. Biological attributes of Karnataka population of *Goniozus nephantidis* at 32° C and 26° C

Biological parameters	26 +1°C	32+ 1°C	CD (P>0.05%)
Fecundity (No. of eggs/female)	49.64 + 0.866	54.6 + 0.752	2.12 **
Parasitising efficiency (%) (No. of larvae parasitised /female)	6.83 + 0.804	8.54 + 0.739	2.27 **
Percentage pupation (cocoons formed)	78.77 + 0.77	86.5 + 0.621	4.47 **
Percent adult emergence	72.4 + 0.630	85.8 + 0.749	5.82 **
Adult longevity	49.52 + 2.70	54.61 + 2.92	4.12 **
Sex ratio (Male : Female)	1: 2.35	1:2.55	NS
Total Developmental period (days)	13.78	11.72	NS

Mean of 12 generations

Table 10. Comparative biology of different populations of *Cotesia flavipes* on *Chilo partellus*.

Parameters	Population			CD (p<0.05%)	S.EM
	Malur	Bangalore	Chitradurga		
Egg + larval period	14.20	13.75	13.37	NS	0.662
Larval parasitsation (%)	47.42	32.17	29.10	9.53 **	3.144
No. of cocoons formed	141.37	80.25	105.00	40.41 **	13.32
Pupal period	6.12	6.5	5.37	NS	0.382
Adult emergence (%)	76.49	57.22	72.46	3.32 *	4.81
Adult longevity (days)	6.62	5.41	6.24	NS	0.422
Total development period (days)	20.32	20.25	18.74	NS	0.53
Sex ratio (Male: Female)	1:7.7	1:6.08	1:2.06	2.01 *	0.34

Mean of 5 replications; * Significant

(c) Molecular characterization of *G. nephantidis*

The partial products of the rDNA region of the ITS2 amplified by PCR resulted in a product of approximately 800 bp size which was similar for all the *G. nephantidis* populations. The PCR fragments generated using the pair of primers ITS2F & ITS2R were 544-728 base pairs in length. A phylogeny of *G. nephantidis* was presented based on ITS2 region of rDNA by multiple alignment of sequences using the software package CLUSTAL W 1.7. The populations studied showed length polymorphism in the region of the genome. DNA sequence analysis of the ITS2 region was more informative and showed a intraspecies divergence. Partial ITS2 sequence of the Bangalore population was submitted to Genbank with accession number EU 016231.

None of the populations of *G. nephantidis* shared a similarity more than 86% indicating some level of genetic differences between the populations.

(d) Molecular characterization of *Cotesia flavipes*

The PCR analysis of *C. flavipes* DNA of populations from Bangalore, Hyderabad and Delhi was carried out using region-specific primers. PCR fragment size generated by amplifying 16S and 18S regions in *C. flavipes* were 600 and 550 bp respectively. A 555 bp length of *C. flavipes* was submitted to Genbank with accession number EU 516349.

RAPD was successfully used to discriminate between the three populations of *C. flavipes* obtained from Karnataka, Hyderabad and Delhi and to compare the genetic variations. Cluster analysis by NTSYS showed that Bangalore and Hyderabad populations were 81% similar to that of Delhi which is 14% similar to the other two populations clearly differentiating the populations geographically.

5.1.8. Studies on insect pathogens

5.1.8.1. Nuclear polyhedrosis virus of hairy caterpillars

(a) *Amsacta albistriga*

Studies on the relative efficacy of four isolates of AmalNPV revealed that the Pavagada isolate was the most virulent with a LC_{50} of 0.89 x 10^2. It was 9.16, 7.88 and 5.40 folds more virulent than the B.R. Halli, P. Samudrum and Kadur isolates respectively against the first instar larvae (Fig. 10).

Similarly LT_{50} values were also calculated for all the four isolates using a concentration of 1 x 10^6 POB/ml of AmalNPV. It was found that the least time required was by the Pavagada isolate (89.69hrs) against first instar. This was followed by P. Samudrum, B.R. Halli and Kadur isolates which had LT_{50} values of 96.35, 106.38 and 90.36 hrs., respectively (Table 11). The activity

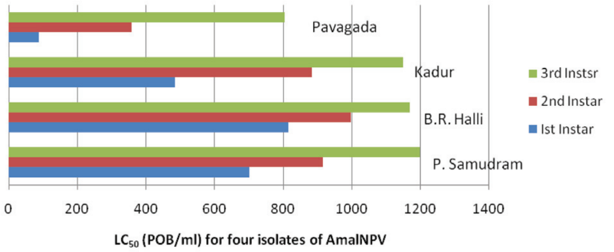


Fig. 10. **Comparative virulence of four isolates of AmalNPV against *A. albistriga* larvae**

Table 11: LT_{50} of four isolates of AmalNPV against *A. albistriga* larvae

Instar	LT_{50} in hours of AmalNPV			
	P. Samudrum	B.R.Halli	Kadur	Pavagada
I	96.35	106.38	90.36	89.69
II	114.26	116.38	109.25	98.32
III	141.57	136.68	143.68	131.25

of the four isolates of AmalNPV in decreasing order of virulence was Pavagada > Kadur > P.Samudrum>B.R.Halli for the first instar.

It was also noticed that the late instar larvae of *A. albistriga* collected from B.R. Hallli were parasitized by two species of Tachinidae (43.6%) and *Apanteles* sp. (28.6%).

b) *Spilarctia obliqua*

Probit analysis revealed that the D.G.Halli isolate was the most virulent with a LC_{50} of 1.94 x 10^3. It was 4.19, 2.65 and 1.20 folds more virulent than the Manipur, T. Vara and H.Kote isolates respectively against the first instar larvae (Fig. 11).

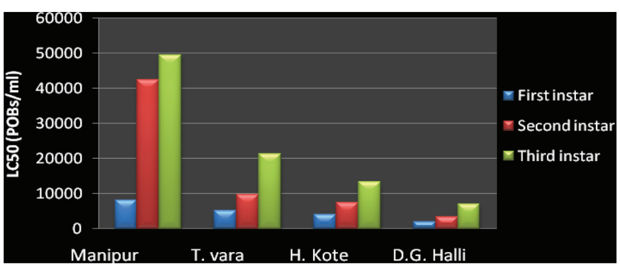


Fig. 11. LC_{50} values of four isolates of SoNPV against *Spilarctia obliqua* **larvae**

Similarly LT_{50} values were also calculated for all the four isolates using a concentration of 1 x 10^6 POB/ml of SoNPV. It was found that the least time required was by the D.G. Halli isolate (4.56 days) against first instar. This was followed by H. Kote, T.Vara, and Manipur isolates which had LT_{50} values of 5.01, 5.94 and 8.34 days, respectively (Table 12). The activity of the four isolates of SoNPV in decreasing order of virulence was D.G.Halli> H.Kote > T.Vara > Manipur for the first instar.

Table 12. LT_{50} of four isolates of SoNPV against first to sixth instars of *S. obliqua* larvae

Instar	LT50 in days of SoNPV			
	Manipur	T.Vara	H.Kote	DG.Halli
I	8.34	5.94	5.01	4.56
II	9.86	6.10	6.12	5.11
III	10.11	7.82	7.26	6.23

(c) Effect of simulated sunlight on the virulence of SoNPV

Exposure of SoNPV to simulated sunlight resulted in its activity against *S. obliqua* larvae being reduced significantly, the higher doses being more detrimental (Fig. 12). The highest dose of 750 w/m^2 for 60 min reduced the mortality from 96.3 to 39.0 per cent and when the time was enhanced to 240 min, the mortality fell to 4.5 per cent. These results indicate the importance of protecting the virus from the sun light while applying in the field.

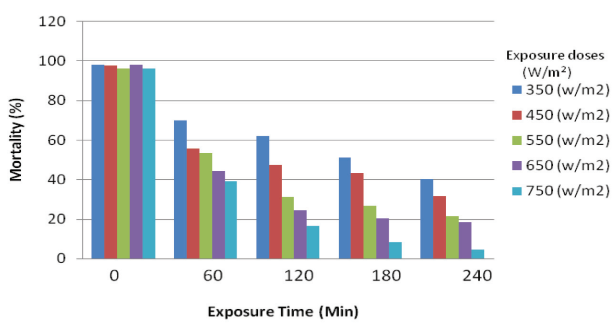


Fig. 12. **Mortality (%) due to exposure to graded doses and times of simulated sunlight in second instar larvae of *S. obliqua***

(d) Effect of various adjuvants on the efficacy of SoNPV.

The SoNPV mixed with different adjuvants was exposed to simulated sunlight (550 W/m^2) for

60 min and bioassayed against the second instar larvae of *S. obliqua*. The mortality data showed that the adjuvants were able to protect the virus in varying degrees; crude sugar, molasses and Tinopal being the most effective (Table 13).

Table 13. Efficacy of different adjuvants for SoNPV against second instar larvae of *S. obliqua*

Treatments	Larval mortality (%)
SoNPV + crude sugar (5%)	92.33^{b}
SoNPV + Tinopal (0.2%)	89.19^{b}
SoNPV + starch (1%)	49.50^{d}
SoNPV + molasses (5%)	91.66^{b}
SoNPV + CSKE (10%)	84.66^{c}
SoNPV alone	31.66^{e}
Non-irradiated SoNPV	96.74^{a}

Means followed by similar letters are not statistically different (p=0.05)

5.1.8.2. *Bacillus thuringiensis*

(a) Isolation of indigenous *Bt* strains

A total of eight isolates were obtained from soil samples collected from Chikamagalur, Sirsi, Balehonnur, Madikeri and Western Ghats. All the isolates showed cuboidal or spherical crystals. Based on the LC_{50} values isolate B was the most toxic. The isolate B produced 100 per cent mortality of *P. xylostella* larvae after 8 days with the first dilution and 73.3 to 80 per cent with the next three dilutions. The LC_{50} value was log 7.85 cfu/ml.

(b) Evaluation of PDBC-BT1 against rice leaf folder, brinjal shoot borer and *Amsacta albistriga*

All three dilutions of indigenous Bt isolate PDBC-BT1 exhibited 100% mortality of *Cnaphalocrocis medinalis* 72h after treatment. The first dilution of the above isolate inflicted 100% mortality of Leucinodes orbonalis whereas the other two dilutions showed 44 to 55% mortality. No mortality of *Amsacta albistriga* was recorded up to 120 h after treatment. However 172 h after treatment 91% mortality was recorded for the first dilution tested. The next dilution showed 66.6%.

(c) Characterization of indigenous *Bt*

SDS-PAGE analysis was done for the samples PDBC-BT1, BNGT1 and HD-1 with the standard molecular weight protein marker at 75 volts in 10% gel. All the samples contained proteins with molecular weights of 30, 25 and 17 kDa. A protein with 60-kDa molecular weight was observed in PDBC-BT1 and BNGT1, protein with 20-kDa molecular weight was obtained in PDBC-BT1 and HD-1. The HD-1 strain also showed 36 and 13 kDa protein bands, which were not found in other lines. BNGT1 was unique showing other bands corresponding to 60, 30, 25 and 17 kDa.

(d) PCR studies

Isolates 1 and 2 showed primer PCR products of 230 bp and isolate 5 PCR products of 300 bp. These 3 isolates could be related to cry 4 genes. In another PCR analysis, the universal CRY1 gene was probed with the corresponding universal primers. In preliminary PCR run the indigenous isolates PDBC-BT1 and PDBC-BT2 showed bands corresponding to 558 bp which is positive for CRY1 gene. However no bands were visible for the other isolates which could indicate that no CRY1 gene was detected in the other isolates.

5.1.8.3. Studies on entomopathogenic nematodes (EPN)

(a) Influence of different soil types on EPN efficiency

The typical sandy soil from Punjab and Pondicherry with 88 and 90% sand and 2-3% clay fraction was highly suitable to *Heterorhabditis bacteriophora* and caused absolute mortality of *Galleria* larvae at 24 and 36h post exposure at higher and lower dosages respectively. In the sandy clay loamy soil with 57% sand and 27 % clay and 60% sand and 31% clay and the other fractions in minor proportions, *Steinernema abbasi, S. tami* and *S. feltiae* produced mortality of *Galleria* up to 100% at 24 hours. In sandy clay soil with 60% sand and 30% clay, the response of steinernematids and *H. bacteriophora* was the same, with maximum mortality of 80% at 36h exposure and absolute mortality at 48h after exposure whereas in the sandy clay loamy soil of Thrissur where the sand fraction is less with higher clay fraction, mortality ranged from 0-40% at 24h exposure and higher dose was more suitable with 60-80% at 36h exposure.

(b) Persistence of EPN in different soil types

Among the nematode species and soil types studied, *S. carpocapsae* persistence was maximum (180 days) in 4 soil types *viz.* sandy clay loam of Bapatla and Attur (Bangalore) and Silt of Kanpur and silty clay of Indore whereas *H. indica* PDBC-EN 13.31 persisted for 180 days only in sandy clay loam of Bapatla and silty clay of Indore. Though sandy soils were suitable in terms of activity/ pathogenicity for both the species, persistence was found to be the least in this soil type. In general it was observed that the soil types with higher silt fraction and higher moisture holding capacity favored the persistence.

(c) Effect of carrier on EPN formulations

One month after storage, the survival of *H. indica* (strain 4.3) was 100% in talc + china clay + bentonite, talc + china clay + red china clay and 98% in talc + china clay(I) combinations. Maximum survival after three month storage (88%) was observed in talc + china clay + red china clay; talc + china clay + bentonite and talc + china clay combinations. At 120 days of storage, talc + china clay + red china clay recorded 74% survival followed by china clay + talc with 68% survival. Viability of *S. abbasi* in the above formulations was lower compared to *H. indica*. Sixty days after storage in red china clay, *H. Indica* yielded 2.8 lakhs Ijs/cadaver, while *H. bacteriophora* yielded 2.45 lakh Ijs/cadaver

(d) Shelf life of EPN dispensed in sponge

Steinernema carpocapsae had the highest shelf-life of 6 months in sponge followed by *S. tami* (175 days)*, S. feltiae* (140days) and *S. abbasi* (135days). Shelf-life of *H. indica* isolates was found to be 90-110days in sponge, whereas in talc the shelf-life ranged from 160-180 days (Table 14). This study clearly indicates the difference in suitability of formulations for *Steinernema* spp. and *H. indica*.

Table 14. Shelf-life of IJs of *Steinernema* spp. and *H. indica* in talc and sponge-based formulations

EPN species	Shelf life (days)	
	talc	sponge
S. carpocapsae	55	180
S. abbasi	45	160
S. feltiae	42	160
S. tami	50	160
H. indica isolates PDBC-EN 6. 12	180	110
H. indica PDBC-EN 4.3	165	90

e) Formulation for transport

Shelf-life of nematodes in sponge-based formulations varied depending on sponge density and dosage. Irrespective of nematode species/ isolates the viability and shelf-life was maximum in high density sponge (Table 15).

Table 15. Survival of EPN in sponge

Nematode species/ Sponge type	% survival months after storage					
	1	2	3	4	5	6
S. feltiae						
HD	100	95	90	83	77	68
MD	100	90	85	78	70	65
LD	88	79	68	50	41	28
S. tami						
HD	100	98	95	89	84	80
MD	100	95	88	84	79	72
LD	88	89	82	65	54	40
H. indica PDBC-EN 4.3 (Bapatla)						
HD	100	89	85	68	57	40
MD	100	86	78	62	45	33
LD	78	45	32	18	0	0

LD-Low density; MD- Medium density; HD- High density

(f) Comparative efficacy of different packing methods for EPN

In 100% vacuum packing, maximum survival of IJs was only 52% against the 98% survival in the 75% vacuum & 75% nitrogen packing and normal air packing. Survival was reduced significantly when stored for 60 & 90 days under the same conditions (12% in 100% vacuum and 22% in 100% nitrogen packing). Irrespective of formulations tested, normal air packing and 75% nitrogen were found more suitable than vacuum packing (Table 16).

Table 16. Survival of *H. indica* PDBC-EN 4.3. in formulations in different types of environment

Formulation	Packing method				
	100% vacuum	100% N2	75% vacuum	75% N2	Normal air packing
talc+china clay	11	24	67	74	80
talc + china clay + red china clay	12	22	68	76	88
talc + china clay + bentonite	9	20	65	70	74

(g) Bioefficacy of EPN against white grubs

Efficacy of talc-based formulation of *H. indica* PDBC-EN 6.2 and PDBC-EN 13.3 was tested at two dosages against arecanut root grub in farmer's plantation in Shimoga district during monsoon season. Among the two nematode isolates tested, *H. indica* PDBC-EN 6.2 gave maximum reduction in grub population (60%). Moreover, in all the four treatments, higher dosage, 2 x10^5 IJs gave maximum reduction with both isolates of *H. indica*.

Two isolates of *H. indica* (PDBC-EN 13.31 and PDBC-EN 6.12) as talc-based formulation recorded significant reduction in root grub population in sugarcane in Chamrajanagara district (Karnataka).

5.1.9. Enhancing the efficacy of *Hirsutella thompsonii*

(a) Comparison of different isolates of *H. thompsonii*

The Kerala isolate [MF(Ag)66] of *H. thompsonii*, used in the most recent multilocation field trials grew at the rate of 1.82 mm/day on PDA(P) while the standard Tamilnadu isolate [MF(Ag)5] showed a lower growth rate of 1.25 mm/day. The Kerala isolate produced more number of conidia (334.44 x 10^4/6-mm mycelial disc) as compared with the Tamilnadu isolate, which was able to generate only 279.44 x 10^4 conidia/6-mm mycelial disc at the 18-mm colony diameter at the end of 30 days incubation. The percentage of germination, however, was better in Tamilnadu isolate.

(b) Effect of different adjuvants on the growth of *H. thompsonii*

The number of fungal colonies formed on the filter paper by the *H. thompsonii* isolate MR(Ag)66 in the presence of adjuvants varied significantly. Highest number of colonies (19.3) emerged from the biomass treated with glycerol, which was followed by MEB and YEP treatments. The lowest number of colonies (2.3) was formed by gelatine- and nutrient broth-treated pellets. Hyphal development and extension occurred in less than 24 h only in glycerol treatment. In other treatments, it took anywhere between 24 and 48 h, except in the case of gelatine and nutrient broth, both of which took longer.

(c) Effect of simulated sunlight on the sporulation of *H. thompsonii*

Simulated sunlight was found to be slightly detrimental to conidia production by *H. thompsonii* [isolate MF(Ag)66]. The best conidiation was observed under alternating light-dark condition in all the treated-exposed and untreated-exposed treatments, YEP performing the best. In total darkness, glycerol, YEP and MEB aided extension of mycelium and formation of spores. However, total darkness was not as good as alternating light-dark regime. Heavy humidity was built-up inside the petri dishes because of the closed atmosphere provided and that resulted in slow and sparse sporulation (Table 17).

(d) Pathogenicity of adjuvant-treated *H. thompsonii* [Isolate MF(Ag)66] pellets

The adjuvants were found to increase the pathogenicity of *H. thompsonii* significantly against the coconut mite (Fig.13). Glycerol-treated pellets were the most effective in terms of the mortality caused, a 16.5% increase over control pellets, other two adjuvants were also equally effective.

Table 17. Effect of sunlight and adjuvants on the sporulation of *H. thompsonii* pellets

Treatment	No. of conidia/ pellet (x 104) (± SE)		
	Simulated sunlight	**Alternating light-dark**	**Totally dark**
Glycerol	3.07 ± 0.18a	4.74 ± 0.18a	3.98 ± 0.26a
Yeast extract powder	3.09 ± 0.14a	5.06 ± 0.17a	3.91 ± 0.19a
Malt extract broth	3.13 ± 0.16a	4.48 ± 0.16a	3.65 ± 0.18a
Control	2.42 ± 0.20b	4.00 ± 0.42b	3.19 ± 0.18b

Means in each column followed by the same letter did not differ significantly at P< 0.05, Bonferroni test.

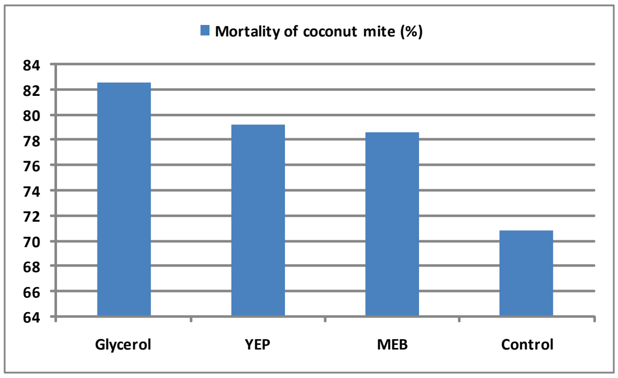


Fig. 13: Pathogenicity of *H. thompsonii* treated with three selected adjuvants against the coconut mite

(e) Field evaluation of new formulations of *H. thompsonii*

Two field trials were conducted to evaluate the efficacy of new formulations of *H. thompsonii* at Huskuru, Bangalore Rural district of Karnataka. Data from the first trial during 2007, showed that all the formulations could reduce the mite population significantly. Pre-harvest scores of nut damage also showed that *H. thompsonii* formulations were as effective against the pest as triazophos (Table 18).

In the second field trial conducted during 2008, the mycelial formulation with glycerol could reduce the mean post-treatment population by 97.4% over control (Table 19). The mycelial-conidial formulation plus glycerol was the next best with a decline of 96.9% in live mite numbers.

5.1.10. Studies on antagonistic organisms for plant disease management

5.1.10.1. Fungal antagonists

(a) Identification of *Trichoderma* isolates with enhanced biocontrol potential

(i) Amplification of chi18-2 chitinase of chitinase family–18

PCR amplification with *chit 18-2* specific primer was used and amplification was observed with the isolates Tv–8, Tv–12, Tv–18 and Tv–20.

(ii) Amplification of chi18-13 chitinase of chitinase family–18 in *T. viride* isolates

With *chit 18-13* specific primer, amplification was observed with the cultures Tv 2, Tv 4, Tv 5, Tv 8, Tv 13 and Tv 20 (Fig. 14).

(iii) Detection of chitinase gene in *T. harzianum* isolates by PCR in *T. harzianum* isolates

With *chit 18-13* specific primer, amplification

Table 18. Efficacy of new formulations of *H. thompsonii* [MF(Ag)66 ex Kerala] against *Aceria guerreronis* on coconut at Huskuru, Bangalore Rural district, Karnataka (2007 trial)

Mean	Tagged bunch 1 (2nd bunch)	Tagged bunch 2 (3rd bunch)	Mean
H. thompsonii (1%) + adjuvant 1 (0.5%)	1.9 ± 0.19 a	2.0 ± 0.22 a	2.0 ± 0.19 a
H. thompsonii (1%) + adjuvant 2 (0.5%)	2.3 ± 0.26 a	2.0 ± 0.15 a	2.1 ± 0.18 a
H. thompsonii (1%)+ adjuvant 3 (0.5%)	2.1 ± 0.22 a	2.2 ± 0.20 a	2.2 ± 0.17 a
Triazophos (Trifos 40) (0.2%)	2.0 ± 0.18 a	2.0 ± 0.20 a	2.0 ± 0.13 a
Control	4.0 ± 0.09 b	4.1 ± 0.14 b	4.0 ± 0.11 b

Table 19. Efficacy of new formulations of *H. thompsonii* [MF(Ag)66 ex Kerala] against *Aceria guerreronis* on coconut at Huskuru, Bangalore Rural district, Karnataka (2008 trial)

Treatment	Live mites (no./mm^2)	
	Pre-treatment	Post-treatment
H. thompsonii (Mycelia) (1%) + glycerol (0.5%)	9.45	0.20
H. thompsonii (Mycelia) (1%)	9.67	0.48
H. thompsonii (Mycelia + conidia) (1%) + glycerol (0.5%)	9.36	0.24
H. thompsonii (Mycelia + conidia) (1%)	10.07	0.82
Triazophos (0.2%)	8.03	2.22
Control	7.53	7.78

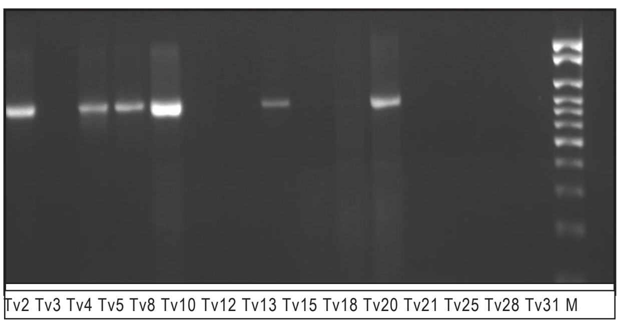


Fig. 14. PCR amplified product in *T. viride* isolates with primer specific to chitinase gene chit 18-13

was observed in Th2, Th3 and Th4 and ITCC cultures. A PCR product of 815 bp was obtained as expected.

(iv) Detection of glucanase gene in *T. harzianum* isolates by PCR

The primers EngF1 (5' GCTGGT TCC GCG TTG GCT GTG C – 3') as forward primer and Eng R (5' TCG TCA GCA TTA AGT CAA CAC CAA GTG g – 3') as reverse primer could amplify the glucanase coding region. The size of the amplified product was 399 bp. The amplified product had a molecular weight of 399 kb. The gene amplification was noticed in the isolates Th, Th2, Th3, Th5, Th6, Th7, Th8, Th9 and Th10. The amplification was not found in the isolates Th4 and Th11.

(v) Glucanase assays in *T. viride* isolates

The isolates Tv-13 and Tv-16 showed the highest activity having released the highest amount of glucose of 228 µg and 220 µg respectively, and least value was observed for Tv-4. Endo 1-4 glucanase production was also assayed.

(vi) Detection of glucanase gene in *T. viride* isolates by PCR

DNA amplification with glucanase-specific primers could be observed in the isolates Tv-3, Tv4, Tv5, Tv8, Tv10 and Tv11. The product size varied between 200 bp–300 bp. Isolates Tv12, Tv13, Tv14 and Tv16 showed amplification near 500bp which may be due to the presence of glucanase isozymes of different molecular mass, whereas Tv2,15 showed no amplification. *Trichoderma viride* isolates 13 and 16, which are found to have the amplification at 500 bp showed the highest production of both 1-3 glucanase and 1-4 glucanase.

(b) Biological control of *Alternaria* leaf blight of tomato.

(i) Antibiosis test for production of diffusible inhibitory metabolites against *A. solani* and *A. alternata* by antagonistic fungi

Among the sixteen isolates of *T. viride* tested, six isolates *viz*., Tv-4, 5, 8, 10, 11 and 13 produced diffusible metabolites inhibitory to *A. solani* (32.7-70.2% inhibition) and *A. alternata* (21.8-63.8% inhibition). Maximum inhibition was observed with Tv-5 and Tv-13 isolates. The metabolites produced by eight isolates of *T. harzianum* (Th-1, 2, 3, 4, 6, 7, 8 and Th-V1) were found to cause 41.9-82.4% inhibition of *A. solani* and 36.8-72.3% inhibition of *A. alternata.* Th-7 isolate of *T. harzianum* showed maximum inhibitory effect on *A. solani* / *A. alternata*. Among the six isolates of *T. virens* tested, Tvs-KSD isolate showed 66.2 and 60.3% inhibition of *A. solani* / *A. alternata* respectively and other isolates did not show any inhibitory effect. Among the other species of *Trichoderma* tested*, T. pseudokoningii* was also found to be highly inhibitory to *A. solani* / *A. alternata.* The metabolites produced by *T. koningii* and *T. hamatum* showed less inhibitory effect on *A. solani* / *A. alternata*. The metabolites of *Chaetomium globosum* showed 65.4 and 62.2% inhibition of *A. solani*/ *A. alternata* respectively. Light microscopic studies on the hyphal interactions between *A. solani* and *T. harzianum* showed shrinkage and lyses of protoplasm of *A. solani* hyphae indicating antibiosis interaction of *T. harzianum* with *A. solani*.

(ii) Antibiosis test for production of volatile inhibitory metabolites by antagonistic fungi against *A. solani* and *A. alternata*

Inhibitions in the growth of *A. solani* and *A. alternata* were not observed in the plates which were exposed to the 50 test fungi for a period up to 7 days. This indicates, either non production of volatile compounds by the test fungi or ineffectiveness of the volatile compounds on *A. solani* and *A. alternata*, even if produced.

(iii) Effect of antagonists from phylloplane of tomato on *Alternaria* spp.

Among the six isolates of phylloplane bacteria tested against *A. solani* and *A. alternata*, B-23 (Madanapalli) showed 68.2 and 59.3 per cent inhibition of *A. solani* and *A. alternata* respectively (Fig. 15). Other isolates showed less inhibition.

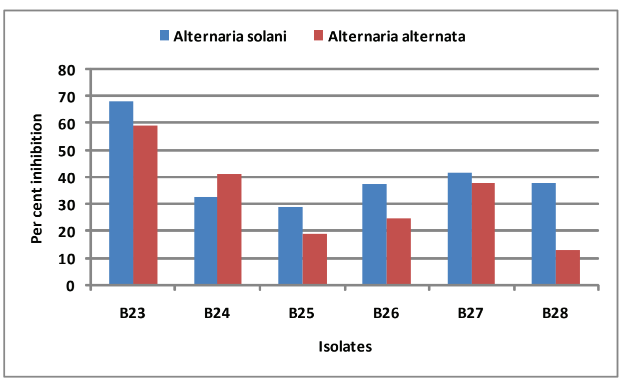


Fig. 15. Inhibition of growth of *Alternaria* sp. by different bacterial antagonists.

(iv) Evaluation of fungal antagonists against *A. solani* in tomato seedlings (Pot culture studies)

Pot culture experiment was conducted to evaluate nine promising isolates of *Trichoderma* sp. and one of *Chaetomium globosum* against leaf blight pathogen of tomato *A. solani* under glasshouse conditions. The highest post treatment disease index (PDI) of 49.2 was observed in the control plants and the lowest PDI was observed in fungicidal spray (10.2). Among the ten fungal antagonists tested, the lowest PDI of 18.4 was observed with *T. harzianum* (Th-7 isolate) which when compared with the PDI of control plants showed 62.6% reduction. *Trichoderma viride* (TV-115 isolate), *T. pseudokoningii* (Tpk) and *T. harzianum* (Th-8 isolate) showed next lowest PDI (Table 20). *T. virens* (KSD isolate), *C. globosum* (Cg) and *T. harzianum* (Th-2 isolate) showed higher PDI of 41.4, 37.2 and 36.2 respectively.

Table-20. Efficacy of antagonists on *A. solani* infection in tomato seedlings

Treatment	Post treatment disease index after days	
	30	60
Tv-5	21.5	41.4
Tv-13	25.6	48.2
Tv-115	16.1	36.4
Th-2	30.3	54.2
Th-4	23.2	40.7
Th-7	12.6	33.9
Th-8	17.8	37.6
Tvs-KSD	35.6	60.4
Tpk	17.2	35.9
Cg	31.4	56.6
Mancozeb	9.7	16.3
SW Control	30.6	73.7

(c) Development of formulations of *Trichoderma* sp. and entomofungal pathogens with prolonged shelf life

(i) Effect of addition of glycerol in production medium on the shelf life of *T. harzianum*

Addition of 6% glycerol was optimum to get the shelf life prolonged upto 11 months and it helped in withstanding reduction in water activity in formulation during storage (Fig. 16).

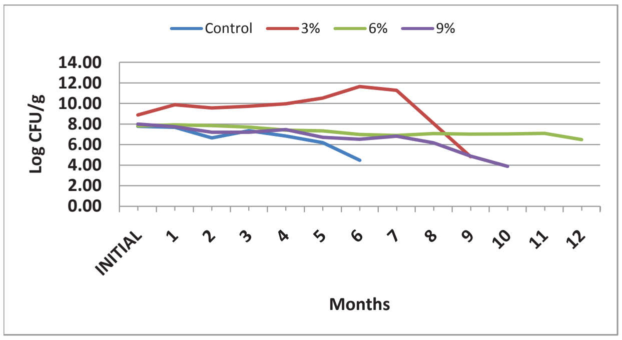


Fig. 16. Effect of addition of glycerol in production medium on the shelf life of talc formulation of *T. harzianum*

(ii) Effect of combination of chitin and glycerol with heat shock on the shelf life of *T. harzianum*

Twelve combinations were made with treatments that were found to be effective in preliminary trials in enhancing the shelf life viz. addition of colloidal chitin in production medium, addition of glycerol at 3 or 6% and heat shock. Some of these combinations increased the initial population of *T. harzianum* in the formulations. In all these combinations propagules could be recovered at >10^8CFUs g^{-1} even after 6th months of storage.

(iii) Solid substrate fermentation-based talc formulations

Solid substrate fermentation-based conidia formulations were studied for shelf life. Different drying methods were used before packing. Drying helped in extending the shelf life of the formulation upto 12 months compared to control that had a shelf life of only 7-8 months. In the bioefficacy studies also, the products that were processed with drying were able to reduce wilt incidence in tomato more efficiently (Fig.17).

(iv) Effect of quantity of formulation in packing

Varying quantities of formulations were packed in LLDP polythene bags. The CFUs recovery was reduced to less than 2 x 10^6 by 5th month when the quantity used for packing was less than 500g.

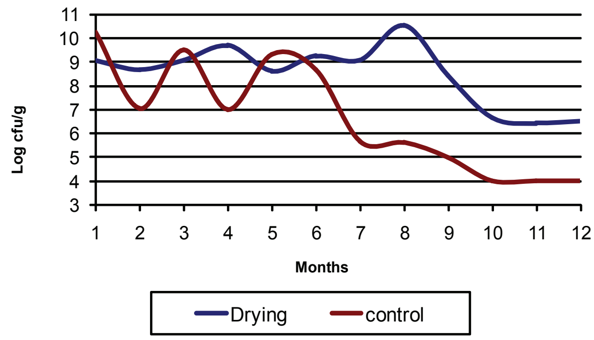


Fig. 17. Effect of post production drying on shelf life of *T. harzianum* produced in Solid Substrate Fermentation.

In case of packing with 1kg formulation, the shelf life could be extended by additional one month.

(v) Effect of different packing materials on the shelf life of *T. harzianum* talc formulations

Different packing materials were used and the most vulnerable ones were foam type, BST (75 µ), polyproylene and HMHDP (25 µ). Shelf life of 3 months only could be achieved with these packing materials. In aluminium foil covers, the shelf life could be extended upto 4 months while in LLDP 80 µ, the shelf life could be extended upto 5 months with the talc formulations without any other treatments to enhance shelf life.

(vi) Shelf life of talc formulations of entomofungal pathogens

No significant differences were observed in the cfu counts of *M. anisopliae* during six months of storage in the three packing methods at three moisture levels tested. The initial cfu counts of *B. bassiana* observed in invert emulsion were 3.4 x10^{10}/ ml and decreased to the level of 5.4x10^6/ml after five months of storage.

5.1.11. Studies on plant growth promoting endophytic bacteria

Two endophytic bacteria from cotton and one endophyte from tomato were purified. Four rhizospere isolates were purified from healthy rhizosphere of pigeonpea. One was gram positive and the other was gram negative. The isolates were tested for inhibition of *Fusarium udum* the redgram pathogen. Two of the isolates showed

66.6 to 80% inhibition. Growth promotion studies were conducted to ascertain their effect on pigeonpea plant growth. All treatments gave 100% germination. Highest root length of 24.67cm was observed with plants treated with Isolate 1 (Gram Positive) and the lowest was in control (18.67cm). Highest shoot length of 18.50cm was exhibited by isolate 1 and 2 and lowest was again in control (12.33cm). The vigour index of 4317 was shown by the Gram Positive isolate 1.

(i) Shelf life of powder based formulations of Gram positive and Gram negative bacteria.

Addition of peptone/tryptone, $CaCO_3$ and carboxy methyl cellulose enhanced the CFU count of *Pseudomonas fluorescens* talc formulations.

At 30 days of storage highest cfu count of $1.32x10^{10}$ was seen in treatments with 1% peptone + 1% $CaCO_3$ + 0.1% carboxymethylcellulose and the lowest of $2x10^8$ was in talc formulation without amendments. But at 60 days, highest cfu of $2.5x10^{10}$ per g was observed with treatments having talc + 2% tryptone + 2% glycerol + 1% $CaCO_3$ + 0.1% carboxymethylcellulose. This treatment also gave highest cfu count at 90 days indicating that it could give better shelf life. The cfu count mostly stabilized in most of the amended treatments after 90 days of storage.

Similar studies with *Bacillus* sp. indicated a gradual increase in the cfu count for 60 days. At 30 days highest cfu count of log 9.98 per gm was in treatments with Talc + 2% peptone + 1% $CaCO_3$ + 0.1% carboxymethylcellulose and the population remained stable up to 90 days. The lowest of log 7.48 cfu/g was again in talc without amendments. However at 90 days talc + 2% yeast extract + 2% glycerol + 1% $CaCO_3$ + 0.1% carboxymethylcellulose gave highest cfu count of log 9.97 per gm indicating that it could give better shelf life.

5.1.12. Development of software

Database on EPN like introduction, taxonomy, biology, distribution, bioefficacy, virulence & host range, effect of biotic factors, effect of abiotic factors, survival & storage, mass production, formulation, application and integration with IPM has been established in HTML format and it is easy to browse the information. This database helps the researchers and students to get the information about the EPN in a CD.

A software has been developed on “Natural enemies of vegetable crop pests” in MS-Access which helps the users to know about the important pests of vegetable crops like brinjal, beans, cabbage, cowpea, tomato and potato, their natural enemy complex and distribution map.

5.2. AICRP ON BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS

5.2.1. Isolation, characterisation and evaluation of potential *Bt* isolates

IARI

Four potential *Bt* isolates viz., AUG-4, AUG-5, AUG-7 and SEPT-1 were tested against the diamondback moth, *Plutella xylostella*, Cabbage butter fly, *Pieris brassicae,* American bollworm, *Helicoverpa armigera,* tobacco caterpiller, *Spodoptera litura,* Bihar hairy caterpillar, *Diacrisia obliqua* and Eri silkworm, *Philosamia ricini* to check for its broad spectrum insecticidal activity.

The isolate Aug-5 gave 100 per cent mortality of *D. obliqua* and *P. ricini* followed by *H. armigera* (96.7 %) and *P. xylostella* (93.3%). In case of *S. litura* 96.7% mortality was observed at 5 ppm (Table 21). However these *Bt* isolates were not as effective as the standard *Bt* strains against *P. brassicae*

Results of a field experiment conducted at IARI, New Delhi on cauliflower var. *botrytis* during rabi, 2007 revealed that application of *Bt aizawi* or *Bt* isolate Aug-5 were as effective as fipronil in controlling *P. sylostella* and *P. brassicae* both under natural and protected conditions (Table 22).

5.2.2. Influence of host plants on the parasitization behavior of *T. chilonis*

SBI

Choice of plants for parasitization was studied on sugarcane at the age of 150, 180 and 210 days

Table 21. Efficacy of *Bt* isolates against some lepidopteran crop pests

Treatments	Mortality (%)					
	P. xylostella	*H.armigera*	*S. litura*	*P. brassicae*	*D. obliqua*	*P. ricini*
	72h	96h	96h	24h	96h	96h
B. t. var. *kurstaki* HD-1	66.7	96.7	53.3	96.7	100	100
B. t. var. *kurstaki* HD-73	86.7	100.0	53.3	73.3	83.3	100
B. t. var. *tolworthy*	40.0	81.0	80.0	56.7	73.3	96.6
B. t. var. *kurstaki* Aug-4	73.3	90.0	-	-	100	100
B. t. var. *kurstaki* Aug-5	93.3	96.7	96.7	66.7	100	100
B. t. var. *kurstaki* Aug-7	83.3	90.0	-	50.0	90	93.3
B. t. var. *kurstaki* Sep-1	53.3	96.7	40.0	46.7	100	73.3

Table 22. Efficacy of *Bt isolates* against *P. xylostella* and *P. brassicae* on cauliflower

Treatment	Dose g ai/ha	Larvae/ plant		
		P. xylostella		*P. brassicae*
		Natural condition	Protected condition	Natural condition
B. t. aizawi	1000	1.17[a]	3.00[a]	5.80
B. t. isolate (Aug-5)	800	6.20[b]	3.00[a]	4.73
Fipronil 5 SC	75	6.19[ab]	3.91[a]	5.10
Control		13.60[c]	8.45[c]	4.19

Figures followed by the same letter in table are not significantly different from each other by DMRT (P=0.05)

and compared with flowering /maturity stage of cotton, tomato, soybean, finger millet, sorghum and maize with sentinel cards of *Corcyra* eggs. Results indicated that the monocots fared better than the dicots with increased parasitization of *T. chilonis*.

5.2.3. Kairomonal effect of host pheromone on *T. chilonis*

SBI

The kairomonal influence of the pheromone of internode borer (INB) on *T. chilonis* was studied in two experiments. The data on the incidence of INB and cane yield showed that there was no impact of pheromone on the efficacy of *T. chilonis*.

5.2.4. Biological control of plant diseases using antagonistic organisms

(i) Evaluation of new isolates of *Trichoderma*

GBPUAT

Antagonistic activity of 30 isolates of *Trichoderma* from rhizosphere of different plant species from different altitudes (plains to 7000 feet altitude) was evaluated against *R. solani*, *S. rolfsii* and *Fusarium* sp. by dual culture method. Out of these 30 isolates, PB2, PB6 and PB24 exhibited highest per cent inhibition (>40%) against *R. solani*, *S. rolfsii* and *Fusarium* sp., respectively after 48 hours *in-vitro*. All the isolates except PB4, PB12, PB17, PB21 and PB26 reduced more than 40% hyphal growth of *Rhizoctonia* whereas only the isolates PB6, PB15 and PB24 reduced more than 40% hyphal growth of *Sclerotium* and *Fusarium* in dual culture.

All the 30 isolates of *Trichoderma* were also evaluated for growth promotion activity in mustard crop under glass house condition. All the isolates, except PB9 and PB21, increased the root length. Best root growth-inducing isolates were PB2, PB4 followed by PB20 and PB30 whereas maximum shoot growth promotion was recorded in case of isolate PB16 followed by PB7 and PB18. Isolates PB2, 4, 11, 16, 17, 18, 20, 29 and 30 were good root as well as shoot growth promoters. Five isolates (PB2, 8, 9, 18 and 23) from all categories of growth promotion were evaluated for their ability to enhance water stress tolerance of mustard plants under glass house condition, when used as seed treatment. The isolates PB9 and PB23 could induce some tolerance to water stress.

(ii) Shelf-life of oil-based formulation of *Trichoderma* and *Pseudomonas*

GBPUAT

Formulations of *T. harzianum* and *P. fluore-*

scens were developed in mineral oil (D-C Tron Plus). Shelf life of these formulations was studied at room temperature at monthly interval. For *Trichoderma*, TSM and for *Pseudomonas* King's 'B' Medium (KB) were used for estimating the population at monthly intervals for upto 18 months. After 24h of incubation at 26±2°C, the incubated plates were examined and population was recorded as cfu /g of formulation.

The population of *T. harzianum* was above 2 x 10^6 up to 12 months and population of *P. fluorescens* was above 10^8 cfu per ml up to 17 months of storage (Fig. 18).

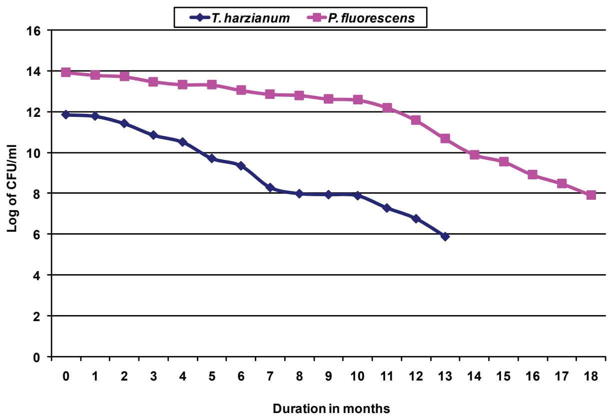


Fig. 18. Shelf life of oil-based formulations of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-27

(iii) Large scale field demonstration of biocontrol technologies in plant disease management.

a) Organic pea: GBPUAT

Seed treatment with ISR strain of *T. harzianum* PBAT-39 followed by one spray with mixed formulation of *T. harzianum* PBAT-43 (TH-43) and *P. fluorescens* PBAP-27 (PsF) was demonstrated at 8 farmers' fields under organic pea cultivation. One spray of *B. bassiana* was given to both treated and control plots. Seed treatment with *Trichoderma* resulted in significantly higher germination. Foliar spray of mixed formulation of TH-43 + PsF-27 was given as soon as rust incidence was detected. Although overall rust incidence was low in all the fields, it was invariably lower in *Trichoderma*-treated plots. Significantly higher green pod yield was recorded in bioagent-treated plots in all the fields (Fig. 19).

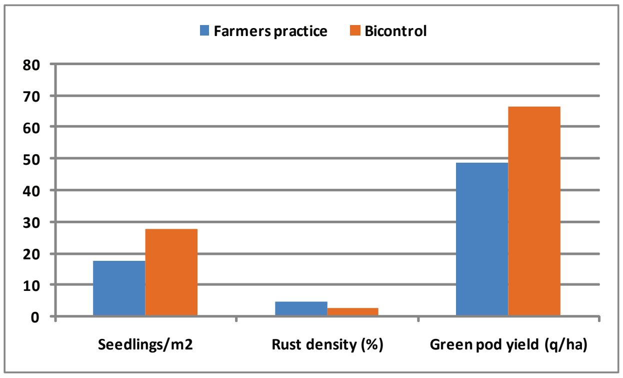


Fig. 19. Large-scale demonstration of biocontrol agents on vegetable pea (Arkel) at farmers'fields under organic cultivation

b) Rice: GBPUAT

In large scale demonstration, sheath blight, blast, BLB, brown spot and stem rot in hybrid rice were effectively managed in 500 acres in farmers field by timely transplanting by last week of June, seed biopriming with mixed formulation of *T. harzianum* PBAT-43 and *P. fluorescens* PBAP-27 (@10 g/kg) and root dip of seedlings in 10g/l suspension and judicious use of nitrogenous fertilizer as per need of the crop (based on leaf colour; usually <120 kg/ha) and need-based spray of carbendazim or propiconazole once. Yield varied between 5000 to 8250 kg/ha with an average of 6000 kg/ha.

Large-scale evaluation of biocontrol agents was done in 500 acres of organic rice (var. Pusa basmati-1) belonging to 13 Tarai Farmers by using following treatments:

1. FYM colonized with mixed formulation of *T. harzianum* (TH) + *P. fluorescens* (PsF) (@ 5 to 10 tons/ha) or use of vermicompost colonized with *P. fluorescens* (@ 5 to 10 q/ha). Rock phosphate was added
2. Seed biopriming with mixed formulation of TH + PsF @ 10g/kg seed
3. Need-based spray of TH+PsF (@ 10 g/l) in patches infected with sheath blight

This package suppressed most of the diseases under field condition. Average yield of organically cultivated Pusa Basmati-1 during 2007 was 4500 kg/ha. During 2007 none of the farmers' was required to spray bioagents. Incidence of sheath blight was negligible in most of the plots. In a few plots it appeared but at the time of maturity and had little effect on yield.

c) Chickpea: AAU (Anand)

A field experiment was conducted to evaluate the effectiveness of antagonistic bioagents against various diseases and pests of chickpea (var. GG-2). The treatments consisted of:

T1: a. Seed treatment with *T.harzianum* and *P. fluorescens*

b. Use of FYM colonized with *T. harzianum* and *P. fluorescens* at 5 t/ha

T2: a. Seed treatment with *T. harzianum* and *P. fluorescens*

b. Use of vermicompost colonized with *P. fluorescens* at 1.5 t/ha

T3: Farmer's practices (Control)

Significantly higher plant canopy perimeter was recorded in plots sown with seeds treated with *T. harzianum* + FYM enriched with *T. harzianum* than the other two treatments. Seeds treated with *T. harzianum* + vermicompost colonized with *P. fluorescens* stood second in rank. Untreated plots (Farmer's practices) showed minimum (68.2 cm) plant canopy perimeter. Similar trend of treatment effect was also noticed in case of plant height.

Significantly least (5.6%) wilted plants due to *Fusarium* were found in plots of *Trichoderma* seed treatment + application of FYM enriched with *T. harzianum.* Seed treatment with *Trichoderma* + vermicompost colonized with *P. fluorescens* was also found to be superior to farmer's practices. Similarly, both the treatments having the use of Biocontrol agents exhibited significantly low (7.6 to 8.4%) incidence of *Ascochyta* blight disease over the treatment of farmer's practice (15.8%).

Significantly higher grain yield was harvested from the plots of seed treatment with *Trichoderma* + FYM colonized with *T. harzianum* than seed treatment with *Trichoderma*+ vermicompost colonized with *P. fluorescens* and check (Table 23). *Rhizoctonia* root rot and *Macrophomina* root rot diseases were not observed in any of the plots.

d) Castor: AAU, Anand

A demonstration was conducted on castor (var. Sagarmoti) during Kharif, 2007 at farmers' field at village Antroli (Ta.Kapadvanj, Dist: Kheda, Gujarat). The treatments consisted of (T1) Castor cake @ 1.5 tons/ha + *Trichoderma* @ 2 kg/ha; (T2): FYM @ 12.5 tons/ha + *Trichoderma* @ 2 kg/ha and (T3) control (Untreated control).

The results revealed least wilted plants (4.2%) in plots treated with castor cake colonized with *T. harzianum* followed by FYM enriched with *T. harzianum*. Yield was higher in plots treated with castor cake + *T. harzianum* than in FYM + *T. harzianum* (Fig. 20).

(iv) Management of fruit rot in mango, papaya and guava

PAU

Two isolates of yeast I 2 and I 4 obtained from PDBC Bangalore along with P1 isolate were eval-

Table 23. Evaluation of Biocontrol agents on plant growth parameters, pod borer damage and disease incidence in chickpea.

Treatments	Germination (%)	Plant Canopy perimeter (cm)	Plant height (cm	Pod borer damage (%)	Disease incidence (%)		Yield (kg/ha)
					Wilt	Blight	
FYM*	76.1b	80.5 a	40.7 a	2.1 b	5.6 c	7.6 b	1,250 a
Vermicopost*	78.2 a	77.3 a	37.8 b	2.5 b	7.0 b	8.4 b	1,130 b
Control	77.0 ab	69.2 a	34.2 c	4.7 a	11.6	15.8a	965c

*FYM and vermicompost enriched with *T. harzianum* and *P. fluorescens*

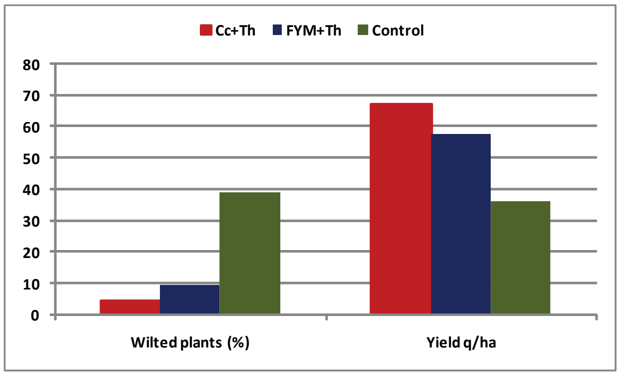


Fig. 20. Influence of organic manures enriched with *Trichoderma* on wilt disease and yield in castor

uated for their efficacy against post harvest pathogen *Colletotrichum gleosporioides* on mango.

In mango Chausa, fruit surface area rotten in isolate I 4 (8.1%) was significantly lower than in all other treatments except Isolate I 2. After 6th day, rotting was more than 28.7 per cent and reached to 100 per cent after 10th day in all the treatments, but there was no significant difference among them.

In mango Dasheri, fruit surface area rotten after 2nd day was minimum (3.6%) in isolate I 2 and was at a par with isolate I 4. Similar trend was observed after 4th day. After 6th day fruit surface area damaged difference was non significant. Per cent fruit surface area rotten increased at a much faster rate in control and was significantly higher (83.1%) than in both the isolates. However, after 10 days, 100 per cent rotting occurred in all the treatments..

AAU (Anand)

An experiment was conducted to evaluate the efficacy of *T. harzianum* (strain 10), *T. harzianum* (strain 42), *P. fluorescens* (strain 3) and *P. fluorescens* (strain 27) against papaya fruit rot caused by *C. gloesporioides*, *Penicillium, Rhizopus, Mycosphaerella and Fusarium*. The data revealed that *P. fluorescens* (strain 27 and 3) recorded significantly lower fruit incidence of 5.1 and 6.6 per cent followed by *T. harzianum* (strain 43) (15.7%) and strain 10 (18.2%). As high as 59.4 per cent fruits got infected in untreated control. .

GBPUA&T

Pseudomonas fluorescens PBAP-27 and *T. harzianum* PBAT-43 were applied alone and in mixed formulation as spray (@ 10g/l with 1% Tween 20), 35 and 15 days prior to harvesting. After harvesting, fruits were dipped into suspension of biocontrol agents (@ 10g/l with 1% Tween 20), packed in cardboard boxes and stored at room temperature ranging between 28 to 39° C. Pre-harvest spray of mixed formulation of *T. harzianum* and *P. fluorescens* and post harvest dip in suspension of *P. fluorescens* was most effective in suppressing post harvest rotting in Dasheri mango (Fig. 21). Only post harvest dipping in suspension of biocontrol agents did not reduce the fruit rot significantly.

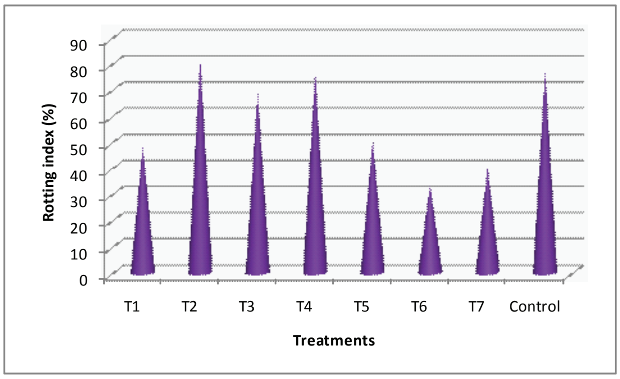


Fig. 21. Efficacy of antagonists in the management of post-harvest rotin Dasheri mango

5.2.5. Biological control of plant parasitic nematodes

(i) Biological control of pigeonpea cyst nematodes *(Heterodera cajani)* and disease complex in redgram

AAU (Anand)

An experiment was conducted on pigeonpea variety BDN2 on the biological control of plant parasitic cyst nematodes. One kg of talc formulation of fungus was mixed with 100kg of well decomposed and dry FYM. Water was sprinkled on the mixture just to make it wet, covered with tarpaulin and left for 15 days with intermittent mixing. Presence of green colour due to the conidial growth on FYM was observed. This was used for the soil application. Agronomical and plant protection measures were followed as recommended for normal crop.

Plots treated with a combination of *T. harzianum* and *P. chlamydosporia* registered maximum (1.19 m) plant height followed by the treatment of *T. harzianum* (1.14 m) and *P. chlamydosporia* (1.13 m) applied individually. Combined application of *T. harzianum* + *P. chlamydosporia* exhibited significantly higher number of unhealthy (parasitised/diseased) cysts in comparison to the rest of the treatments evaluated. Individual application of *T. harzianum* and *P. chlamydosporia* was equally effective and found statistically at par with each other but significantly inferior to combined application of *T. harzianum* + *P. chlamydosporia*. Significantly higher yield was recorded in plots treated with combination of *T. harzianum* and *P. chlamydosporia*. Plots treated with either *T. harzianum* or *P. chlamydosporia* performed equally in terms of grain yield (Table 24).

TNAU

Results of a field experiment on pigeonpea variety CORG 7 to evaluate the efficacy of antagonistic fungi against the plant parasitic cyst nematodes revealed that combined application of *T. harzianum* @ 5 kg/ha plus *P. chlamydosporia* @ 20 kg/ ha reduced the seedling mortality and increased the seed germination, plant height and yield. Application of either *T. harzianum* or *P. chlamydosporia* was not as effective as its combination. However, application of carbofuran @ 2 kg a.i./ha was significantly better than the biocontrol agents (Table 25).

MPKV, Rahuri

Results of the experiment conducted to evaluate the antagonistic fungi against the reniform nematode *Rotylenchulus reniformis* in red gram (var. Vipula) in *Kharif* 2007 at Rahuri revealed that combined application of *T. harzianum* @ 5 kg/ha and *P. chlamydosporia* @ 20 kg/ha was the most effective in reducing the reniform nematode

Table 24. Effect of biocontrol agents and organic manures on *Heterodera cajani* in pigeonpea

Treatment	Plant Height (m)	Cyst Population (*H. cajani*/ 250 cc soil)	Eggs/ juveniles/cyst	Parasitised/ diseased/ unhealthy cysts	Grain Yield (kg/ha)
T. harzianum @ 5.0 kg/ha talc formulation (108 spores/g)	1.1	25 b	18	23 a	1074.00 ab
P. chlamydosporia @ 20kg/ha talc formulation (108 spores/g)	1.1	25 b	18	23 a	1105.00 a
T. harzianum +					
P. chlamydosporia	1.2	25 b	17	27 a	1245.00 a
Carbofuran @ 2.0 kg a.i./ha (100 g/m^2)	1.10	25 b	18	18 ab	906.00 bcd
Vermicompost (VC) @ 1 t/ha (50 g/m^2)	0.8	25 b	18	18 ab	910.00 bc
Neem cake (NC) @ ½ t/ha	0.8	25 b	18	18 ab	914.00 bc
VC+ Carbosulfan seed treatment @ 3% (W/W)	0.8	25 b	18	18 ab	912.00 bc
NC+ Carbosulfan seed treatment @ 3% (W/W)	0.9	25 b	19	19 ab	911.60 bc
Carbosulfan seed treatment @ 3% (W/W)	0.8	24 b	19	19 ab	908.00 bc
Control	0.7	89 a	21	11 b	752.80 e

Figures followed by the same letter in table are not significantly different from each other by DMRT (P=0.05)

Table 25. Efficacy of antagonists against the cyst nematode in pigeonpea (CORG 7)

Treatment	Seed germination (%)	Seedling mortality (%)	Plant height (cm) 30 DAS	Grain yield (kg/ha)
T. harzianum @ 5 kg/ha talc formulation (10^8 spores/g) (T1)	90.0[d]	17.2[d]	25.9[b]	1487[b]
P. chlamydosporia 20 kg /ha talc formulation (10^8 spores / g) (T2)	92.0[c]	13.6[c]	24.3[b]	1531[b]
T1+T2	94.0[b]	11.5[b]	25.1[b]	1639[a]
Carbofuran 2 kg ai/ha	95.0[a]	3.1[a]	28.6[a]	1674[a]
Control	90.0[d]	24.3[c]	17.2[c]	933[c]

Figures followed by the same letter in a column are not significantly different from each other by DMRT (P=0.05)

population (number of females) and increased the yield of pigeonpea (Table 26).

Table 26. Efficacy of bioagents against the reniform nematode in pigeonpea

Treatment	Nematode population/ 200 cm3 soil	No. of females/ 5 g roots	Yield (kg/ha)
T. harzianum	204.0 [a]	20.6 [a]	1,650 [c]
P. chlamydosporia	188.0 [a]	18.2 [a]	1,800 [b]
T. harzianum + *P. chlamydosporia*	168.0 [a]	16.4 [a]	1,940 [a]
Carbofuran 3G	200.0 [a]	19.6 [a]	1,760 [b]
Untreated control	440.0 [b]	26.4 [b]	1,450 [d]

Figures followed by the same letter in a column are not significantly different from each other by DMRT (P=0.05)

(ii) Biological control of plant parasitic nematodes on vegetables and tobacco

a) Tomato: AAU (Jorhat)

A field study was carried out to evaluate *P. lilacinus* and *P. chlamydosporia* @ 20kg/ha each against the root knot nematode, *Meloidogyne incognita* in Tomato (Cv. Pusa Ruby) with Carbofuran @ 2kg ai/ha as check. The average initial juvenile nematode population of per 250 cc soil was 262.0 in the field.

The results revealed a significant difference in the plants treated with *P. lilacinus* which exhibited good impact on egg mass parasitization compared to *P. chlamydosporia* after 45 DAP of crop, but at harvest both the treatments were found to be at par in their efficacy (Table 27). .

b) Pomegranate: AAU (Anand)

A field experiment was conducted in pomegranate (var. Sinduri) orchard to evaluate the biocontrol agents against cyst nematode. Plant height and plant canopy measured before impose of treatments revealed non-significant results suggesting homogeneity in different plots. Nematode population extracted after 6 months from the samples of 200 cm^3 soil and 5g roots revealed least number of nematodes was found in plants treated with *P. lilacinus* + FYM. Least Root Knot Index (RKI) was however recorded in *P. lilacinus* + mustard cake followed by *P. chlamydosporia* along with mustard cake and carbofuran (Table 28).

c) Citrus: MPKV (Rahuri)

The experiment was conducted at MPKV,

Table 27. Efficacy of biotic agents against *Meloidogyne incognita* on tomato.

Treatments	Egg mass/ root system	Parasitized egg mass/root system (45 DAP)	Egg mass/ root system at harvest	Parasitized egg mass/root system at harvest	Final nematode population at harvest
P. lilacinus @ 20 kg/ha	16.94[c]	8.80[a]	62.60[c]	27.20[a]	210.30[c]
P. chlamydosporia @ 20 kg/ha	25.56[b]	10.72[b]	78.40[b]	30.00[a]	268.40[b]
Carbofuran 2 kg ai/ha	8.66[d]	0.00[c]	38.50[d]	0.00[b]	212.00[c]
Control	49.98[a]	0.00[c]	127.50[a]	0.00[b]	525.00[a]

Figures followed by the same letter in a column are not significantly different from each other by DMRT (P=0.05)

Table 28. Effect of Biocontrol agents and organic manures on plant growth parameters and Root Knot population in pomegranate

Treatment	Nematode Count / 200 cm3 soil+ 5 g roots*	Saprozooic Count / 200 cm3 soil+ 5 g roots*	Root knot index
P. lilacinus @ 100g/Plant (T1)	1,732 d	2,751 b	2.7 cd
P. chlamydosporia @ 100g/Plant (T2)	363 e	1,982 de	3.0 d
Mustard Cake alone @ 2.0 T/ha (may vary with the crop age) (T3)	70 f	12,214 a	2.3 bc
FYM alone @ 2.5 T/ha (may vary with the crop age) (T4)	1950 cd	2,825 b	2.7 c
T1 + T3	41 g	2,150 cd	1.0 a
T2 + T3	44 g	1,751 f	1.3 a
T1 + T4	4,646 a	2,951 b	2.7 cd
T2 + T4	1,892 d	1,931 e	2.7 cd
Carbofuran 2.0 kg ai/ha	3,785 ab	1,134 h	2.0 b
Phorate 10 G	2,783 bc	1,482 g	2.7 cd
Control	2,370 cd	2,274 c	3.7 e

Figures followed by the same letter in a column are not significantly different from each other by DMRT (P=0.05)

Rahuri during *Kharif* 2007 on sweet orange with 6 x 6 m spacing. The bioagents *P. lilacinus* @ 20 kg/ha talc formulation (10^8 spores/g), *P. chlamydosporia* @ 20 kg/ha talc formulation (10^8 spores/g) and carbofuran 3G @ 2 kg a.i./ha were applied in soil along with FYM and basal dose of fertilizers.

Both *P. lilacinus* and *P. chlamydosporia* @ 20 kg/ha talc formulation (10^8 spores/g) were equally effective in reducing the citrus nematode population and number of females in roots and increasing yield of sweet orange (Table 29).

Table 29. Efficacy of bioagents on the citrus nematode

Treatment	Nematode population / 200 cm³ soil	females/ 5 g roots	Yield (kg/ ha)	ICBR
P. lilacinus	348.0 ᵃ	13.2 ᵃ	1490 ᵃ	1: 8.18
P. chlamydosporia	408.0 ᵃ	15.2 ᵃ	1470 ᵃ	1: 7.16
Carbofuran 3G	420.0 ᵃ	15.8 ᵃ	1440 ᵃ	1: 6.28
Untreated control	772.0 ᵇ	23.4 ᵇ	1270 ᵇ	-

In a column means followed by similar letter are not different statistically (P=0.05) by D.M.R.T.

d) FCV CTRI (Hunsur)

A field experiment was conducted at Hunsur on FCV tobacco var. Kanchan to evaluate various biocontrol agents against the root knot nematode.

At 60 DAS, *P. lilacinus* @ 100g/ m^2 recorded a lower root knot index compared to untreated check and was on par with *P. lilacinus* + neem cake and *P. lilacinus* + vermicompost. *P. lilacinus* in combination with neem cake significantly reduced the number of egg mass/g root and root knot nematode soil population to the extent of 40.5 and 55.1 per cent respectively (Table 30). Application of *P. lilacinus* increased the number of root knot free healthy transplants by 32.1 % over untreated check and was on par with *P. lilacinus* + neem cake and *P. lilacinus* + vermicompost. The VAM fungi, *Glomus fasciculatum* was found to be not effective in decreasing the root knot nematode incidence or in increasing the number of healthy transplants in tobacco nursery. However, there was no significant difference in FCV tobacco cured leaf yield in all the treatments.

Table 30. Biological control of *Meloidogyne* in FCV-tobacco nurseries.

Treatments	Healthy transplants count	Root knot Index at 60 DAS	No. of egg mass / g root	Final soil popln. /100 g soil	Yield of green leaf (kg/ha)
G. fasciculatum (VAM) @ 10g/ m²(T1)	492.0[c]	2.70[c]	16.5[b]	114.0[de]	10,071[b]
P. lilacinus (PDBC strain) @ 10g/ m²(T2)	610.5[a]	2.05[a]	12.5[a]	73.5[b]	9,939[b]
Carbofuran @ 50g/ m² (T3)	622.0[a]	2.00[a]	11.5[a]	70.0[ab]	10,177[a]
Neem Cake @ 1kg/ m² (T4)	540.0[b]	2.37[b]	14.5[b]	85.5[c]	10,186[a]
Vermicompost @ 1kg/ m² (T5)	510.5[c]	2.42[b]	16.0[b]	95.0[c]	10,220[a]
T1+T4	562.5[b]	2.52[b]	15.0[b]	91.5[c]	10,191[a]
T1+T5	534.0[b]	2.62[b]	15.5[b]	95.5[d]	10,194[a]
T2+T4	622.5[a]	1.87[a]	11.0[a]	64.0[a]	10,227[a]
T2+T5	618.0[a]	1.82[a]	11.5[a]	63.5[a]	10,229[a]
T1+T2+T4	625.5[a]	1.82[a]	10.5[a]	64.5[a]	10,314[a]
T1+T2+T5	609.0[a]	1.90[a]	11.0[a]	65.5[a]	10,249[a]
Control	462.0[d]	3.75[d]	18.5[c]	142.5[f]	9,704[c]

In vertical column, means by similar letter are not different statistically (P=0.05) by DMRT

5.2.6. Bilogical suppression of sugarcane pests

(i) Demonstration of *Trichogramma chilonis* against the plassey borer *Chilo tumidicostalis*

AAU (Jorhat)

Large scale demonstration of effectiveness of *T. chilonis* against the plassy borer was carried out in a farmer's field on Co BLN 9605 variety at Halowa gaon in Golaghat district over an area of 10 ha. Eleven releases of *T. chilonis* were made @ 50,000/ha/release at 10 days interval from June middle to end of October, 2007.

The release of *T. chilonis* resulted in significantly reduced infested cane and higher cane yield (82,500 kg/ha) than in farmers' practice (Fig. 22).

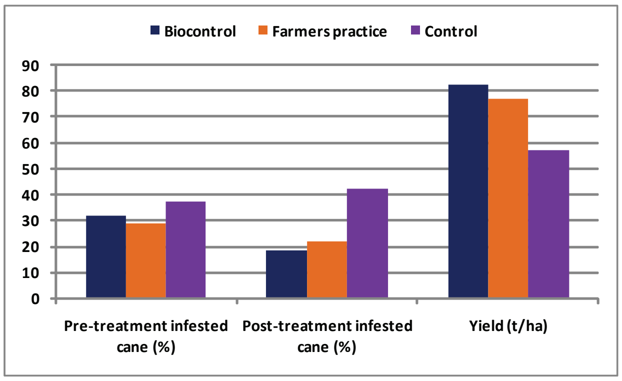


Fig. 22. Evaluation of *Trichogramma chilonis* against plassey borer.

(ii) Biological control of the sugarcane woolly aphids (SWA)

(a) Monitoring of the parasitoid *Encarsia flavoscutellum*

SBI

Surveys of sugarcane fields with woolly aphid incidences showed that the parasitoid, *E. flavoscutellum* has established well in the released areas in Coimbatore district. About 90% of parasitized aphids sampled contained three or less number of parasitoids per aphid and upto seven parasitoid were found in one aphid. Data from shade-net and field study indicated a significant negative correlation between per cent parasitism and per cent hosts showing single parasitoid. In the laboratory, *Encarsia* adult emergence was noticed up to six days of captivity depending on the intensity of colonization but >75% adults emerged in the first three days. Adults held in glass specimen tubes with food (50:50 honey: water) source survived slightly longer than those left in tubes without honey source.

AAU (Jorhat)

From October, 2007 to January, 2008 the woolly aphid population decreased from 41.3 to 15.7/leaf and the number of *E. flavoscutellum* varied from 3.0 to 2.4 per leaf and *D. aphidivora* from 9.2 to 5.2 per leaf indicating the suppressing effect of the parasitoid and the predator on SWA population.

TNAU

One thousand *E. flavoscutellum* adults were released three times during July, September and December 2007 at Elayamuthur. The parasitoid adult activity was noticed up to 7 kms away from released spots in all directions. A maximum number of 12 *E. flavoscutellum* adults were observed on a single leaf. The sugarcane woolly aphid incidence was remarkably reduced in the released and adjacent plots. The observations confirmed the establishment of *Encarsia*. The efficacy of *Encarsia* in reducing the SWA was up to 44.0 per cent in the released field and in the adjoining three fields.

MPKV (Pune)

The parasitoid *E. flavoscutellum* was recovered to the extent of 12.6 per cent after two months of its release. The SWA infestation disappeared from April to June 2007 and it was again noticed in 2nd week of July 2007. However, the parasitoid was not recovered till March 2008.

(b) Demonstration on use of bioagents for management of sugarcane woolly aphid

MPKV (Pune)

In a demonstration conducted on a one hectare sugarcane cv. Co 86032 (spacing of 90 x 90 cm), inoculative release of the predator *D. aphidivora* @ 1,000 larvae/pupae in 10 spots/ha significantly reduced the SWA population from 40.3 to 17.5 per 6.25 cm^2 (Fig. 23) and aphid intensity rating from 3.9 to 1.9 and increased the predator population from 0.1 to 3.5 and resulted in a cane yield of 1,18,400 kg/ha. In farmers practice (no release of the predator) the SWA population increased from 37.7 to 98.5 per 6.25 cm^2 and aphid intensity rating from 3.9 to 4.8 with yield of only 97,300 kg/ha.

Fig. 23. Successful establishment of *Dipha aphidivora* and control of sugarcane woolly aphid.

TNAU

Three field demonstrations of one hectare each were conducted at Arumuga Goundenur, Elayamuthur and Kuniamuthur village in Coimbatore district. The predator *D. aphidivora* was released @ 1,000 larvae in 10 spots / ha and compared with farmers practice (no release of the predator).

Release of the predators resulted in significant reduction in the population of the aphids and increase in the number of predators as well as cane yield in all the three locations (Table 31).

SBI

The early appearance of the parasitoid *E. flavoscutellum* along with the predator did not allow SWA population build up. The population of *D. aphidivora* and *M. igorotus*, the predators of SWA remained low due to low aphid population throughout the year.

Table 31. Effectiveness of *Dipha aphidivora* for the management of SWA

Location (Variety)	Treatment	SWA/ 6.25 cm^2	*Dipha*/ clump	Yield (kg/ ha)	C:B ratio
Arumuga Goundenur (Co 86032)	Dipha	4.8 [a]	3.4 [a]	68,900[a]	1:2.6
	Control	76.3[b]	0.6 [b]	61,200[b]	
Kuniamuthur (Co 99004)	Dipha	2.6 [a]	2.8 [a]	66,100 [a]	1:2.2
	Control	63.2 [b]	0.8 [b]	58,700 [b]	
Elayamuthur (Co 86032)	Dipha	3.2 [a]	3.6 [a]	72,300 [a]	1:3.0
	Control	74.6 [b]	0.8 [b]	63,200 [b]	

NAU

Mass production of *M. igorotus* was done in shade net on SWA-infested sugarcane.

MPKV

Mass production of *D. aphidivora* was carried out in two shade nets (bamboo structures of 5 x 5 x 4 m) on sugarcane variety Co86032 infested with woolly aphid. When SWA incidence reached to 70 per cent, *D. aphidivora* @ 50 larvae and/ or pupae were released in each shade net. This resulted in a good development of *D. aphidivora* population and on an average 2,820 larvae / pupae were collected per shade net within 65 days.

(c) Development of IPM strategies for sugarcane woolly aphid

MPKV

The IPM module consisting of paired row planting (Co 265 with 90 x 90 cm spacing), normal dose of N, intercrop with groundnut and border row of cowpea and two releases of *D. aphidivora* @ 1,000 larvae/ha was found effective in the suppression of SWA infestation in *Adsali* crop. In IPM module the SWA infestation was reduced from 21.7 to 9.8%, SWA population from 21.5 to 12.2/6.5 cm^2, aphid intensity rating from 2.6 to 1.3 and predator population increased from 0.1 to 3.0, whereas in farmers practice the SWA incidence increased from 20.9 to 36.9%, SWA population 22.4 to 52.3/6.5 cm^2 and the aphid intensity rating from 2.6 to 4.2.

TNAU

The IPM module consisting of paired row planting (Co 86032 with 90 x 150 cm spacing), normal dose of N, intercrop with groundnut and border row of cowpea and two releases of *D. aphidivora* @ 1,000 larvae/ha was found significantly effective in the suppression of SWA infestation at Sundakkamuthur village near Coimbatore. In IPM module the SWA population was reduced significantly resulting in yield of 74,700 kg/ha with C:B ratio of 1:2.6 and was better than farmers practice (Table 32). The IPM module also recorded higher population of *E. flavoscutellum*, coccinellids and syrphids compared to farmers' practice.

Table 32. Efficacy of *D. aphidivora* for management of SWA (Sundakkamuthur, Coimbatore District)

Treatment	SWA/ 6.25 cm^2	*Dipha*/ Clump	Yield (kg/ha)	C:B Ratio
IPM module-Two release of *D. aphidivora* @ 1000 larvae/ha	3.8 [a]	4.3 [a]	74,700[a]	1: 2.6
Farmers practice- no release of predator	61.3 [b]	0.9 [b]	59,400[b]	

Means followed by similar letter in a column are not significantly different (P=0.05) by DMRT

(iii) Demonstration on the use of *T. chilonis* (temperature-tolerant strain) against the early shoot borer (In 2007-08= 40 ha & 2008-09=100ha).

PAU

Field evaluation of *T. chilonis* against the early shoot borer *C. infuscatellus* was carried out at villages Nangal Khera (Distt. Jalandhar) and Paddi Khalsa (Distt. Kapurthala) and the results compared with chemical control. The plot size was 20 ha and the parasitoid, *T. chilonis* was released 8 times at 10 days interval during April to June @ 50,000 per ha. In chemical control, cartap hydrochloride (Padan 4G) @ 25 kg/ha was applied 45 days after planting.

The incidence of early shoot borer was significantly reduced by *T. chilonis* release (Table 33). The mean parasitism of eggs of *C. infuscatellus* in *T. chilonis* release plot was 50.8%. The yield was enhanced significantly a cost:benefit ratio of 1:11.1.

Table 33. Demonstration of *T. chilonis* (temperature-tolerant strain) against *C. infuscatellus* at village Nangal Khera (Distt. Jalandhar) and Paddi Khalsa (Distt. Kapurthala) during 2007.

Treatments	Incidence of *C. infuscatellus* (%)	Parasitism (%)	Yield (kg/ ha)	Cost: Benefit ratio
T. chilonis (temperature tolerant strain)	7.1 [a]	50.8[a]	680.0 [a]	1: 11.1
Chemical control (Padan @25kg/ ha)	7.0 [a]	3.9 [b]	699.5 [a]	1: 7.4
Control	15.0 [b]	6.8 [b]	629.5 [b]	

Means followed by the same letter in a column are not significantly different (P=0.05)

(iv) Large scale demonstration of efficacy of *T. chilonis* against the stalk borer

PAU

Large scale demonstration of effectiveness of *T. chilonis* against the stalk borer *Chilo auricilius* over an area of 4500 acres was carried out in collaboration with three sugar mills i.e. Doaba Co-operative Sugar Mills Ltd. Nawanshahar, Morinda Co- operative Sugar Mills Ltd. and Morinda and Nahar Sugar Mills, Amloh. The egg parasitoid, *T. chilonis* was released from July to October in all the three mill areas at 10 days interval @ 50,000/ha (IPM). The incidence of *C. auricilius* at Nawanshahar, Morinda and Amloh in IPM fields was 2.8, 1.7 and 9.6 per cent respectively. The corresponding figures in control fields were 6.0, 3.6 and 30.6 per cent. The reduction in damage over control in these three mills was 53.2, 53.8 and 68.7 per cent, respectively proving the efficacy of *T. chilonis* in the control of stalk borer, *C. auricilius*.

In another field demonstration, over an area of 40 ha at village Karni Khera (Distt. Ferozepur) 12 releases of *T. chilonis* @ 50,000 per ha at 10 days interval proved effective and reduced the incidence of stalk borer by 57.3 per cent.

(v) Survey for natural enemies of sugarcane whitefly in south Gujarat

NAU

The incidence of whitefly was observed throughout the year. Number of nymphs ranged from 10.5 to 38.7 per 3 leaves and puparia from 9.7 to 46.2. The maximum population (38.7 nymphs and 46.2 puparia/3leaves) was observed at Mohani village of Chalthan Sugar Factory area. Among the natural enemies of sugarcane whitefly, the nymphal-pupal parasite *Encarsia* sp. was most prevalent in Chalthan and Bardoli. The predators *Serangium parcesetosum* and *Menochilus sexmaculatus* were found associated with the whitefly particularly during rainy season.

(vi) Survey for pests of sugarcane and their and natural enemies at Haryana

CCSHAU

Natural parasitism of the white fly puparia by the fungus *Aschersonia* sp. was recorded in the post monsoon period at RRS Uchani. The fungal infection increased from 6.3 per cent (August) to 24.7 per cent (October) and declined to 7.2 per cent by November and by December the white fly was not observed.

Pyrilla parasitism increased from 19.8 (August) to 90.7 per cent (September). Mean parasitism by *Cheiloneurus pyrillae* was 16.6 per cent whereas that of *Tetrastichus pyrillae* and *Epiricania melanoleuca* was 23.3 and 35.8 per cent, respectively. *C. pyrillae* was more abundant upto mid September whereas, *E. melanoleuca* was abundant from mid August onwards. White muscardine fungus *Beauveria bassiana* infected 12.7 per cent of root borer and 8.7 per cent of stalk borer larvae whereas, granulosis virus (GV) killed 7.4 per cent of the root borer larvae upto December 2007.

5.2.7. Biological suppression of cotton pests

(i) Demonstration of bio-Intensive Pest Management in *Bt* cotton

Multi-location demonstrations were conducted during the year 2007-08 to evaluate the biocontrol based-IPM (BIPM) package for the management of pests and disease in Bt cotton. The following two modules were tested in 15 ha plots.

Module I: *Bt* cotton with BIPM package

1. Seeds were treated with *Trichoderma viride* (8g/kg seed).
2. Maize was sown as border crop.
3. Bird perches were erected @ 10/ha.
4. Three day old larvae of *C. carnea* @ 14,000/ha were released twice at weekly interval at initial aphid build up stage.
5. Sl NPV @ $3X10^{12}$ POBs/ha was sprayed along with protectant and surfactant, on occurrence of *S. litura* (applied to 1-3 larval stage).
6. Initial spray of neem seed kernel suspension @ 5% if sucking pests were seen.
7. Three releases of *Trichogrammatoidea bactrae* @1.5 lakhs/ha/week were made synchronizing with the appearance of pink bollworm.

Module II: *Bt* Cotton with farmers' practices

1. Gaucho-treated seeds were used for sucking pests.
2. Two systemic insecticides were sprayed on the occurrence of sucking pests 45 days after germination.
3. Recommended insecticides were sprayed for bollworms in the instances where population exceeded ETL.

ANGRAU

Data from the experiment laid out in a farmers' field at Kothapalli Village during *Kharif* 2007 showed that the mean square and boll damage was significantly less and the yield was higher in *Bt* cotton with BIPM practice as compared to farmers practice (Table 34). The cost:benefit ratio was 1:1.71 in BIPM package compared to 1:1.03 in farmers' practice. Higher egg parasitism and higher coccinellids and spiders were recorded in BIPM package compared to farmers practice.

Table 34. Impact of BIPM on *Bt* cotton (Kothapalli, Andhra Pradesh)

	BIPM	Farmer's practice
Aphids/ 3 leaves	12.7	22.1
Thrips/3 leaves	12.1	15.2
Leaf hoppers/3 leaves	3.8	7.2
White flies/3 leaves	2.2	3.7
Mean square damage (%)	4.8	5.2
Mean bolls damage (%)	4.6	5.2
Seed cottonl yield (kg/ha)	1,943	1,535
CBR	1:1.71	1:1.03
Egg parasitism (%)	1.8	0.4
Coccinellids/50 plants	24.8	3.1
Spiders/50 plants	29.3	2.7

AAU (Anand)

The experiment was laid out in a farmer's field at Bamania Kampa village on one hectare Ankur 155 *Bt* cotton during *Kharif* 2007. Incidence of aphids, leafhopper and whiteflies was relatively lower in BIPM package compared to farmers' practice. BIPM package recorded lower percentage of damage to buds, green bolls and locule by *Earias* and pink bollworm whereas these figures in farmers' practice were significantly higher (Table 35). The seed cotton yield was significantly higher compared to farmers' practice. There was 16.23% increase in seed cotton yield in BIPM package over farmers' practice.

The number of *C. carnea*, coccinellids, *Geocoris* bugs and spiders per 25 plants in BIPM package were 12.2, 47.1, 6.0 and 12.7 whereas the corresponding figures in farmers' practice were 6.6, 21.4, 3.5 and 7.6.

PAU

The experiment on demonstration of BIPM of *Bt* cotton was conducted at Karni Khera (Distt. Ferozepur) on RCH 134 *Bt* cotton over an area of 10 acres during 2007. It was compared with

Table 35. Impact of BIPM in *Bt* cotton (Bamania Kampa, Andhra Pradesh)

Treatments	Sucking pests / 3 leaves			Damage by bollworms (%)				Seed cotton yield (kg/ha)
	Aphid	Leaf hopper	Whitefly	Buds	Green bolls	Locules		
						Earias	PBW	
BIPM	87.7[b]	1.9[b]	0.8[b]	1.5[b]	0.2[b]	0.6[b]	0.4[b]	4,868[b]
Farmer's practice	129.0[a]	2.9[a]	2.5[a]	3.5[a]	0.6[a]	1.0[a]	0.7[a]	4,078[a]

Means followed by the same alphabet in a column are not significantly different (P=0.05)

farmers' practice (Two sprays of imidacloprid @ 100 ml/ ha and endosulfan @ 2.5 l/ ha).

The number of leaf hoppers, whiteflies and predators per three leaves in BIPM package was higher than in farmers' practice. The seed cotton yield in BIPM package was however on par with farmers' practice (Table 36).

Table 36. Impact of BIPM in *Bt* cotton (Karni Khera, Punjab)

Treatments	Sucking pests / 3 leaves		Predators/ 3 leaves	Seed cotton yield (kg/ha)
	Leaf hopper	Whitefly	Buds	
BIPM	2.7[b]	2.7[b]	0.3	3,260
Farmer's practice	2.9[a]	2.5[a]	0.1	3,350

Means followed by the same alphabet in a column are not significantly different (P=0.05)

MPKV

A demonstration was conducted in a farmers' field at village Ambapur, Dist. Dhule over 5 ha on RCH 2*Bt* with 90 x 60 cm spacing (Fig. 24). The BIPM package on *Bt* cotton was found superior over farmers' practice in suppressing the population of sucking pests and reducing the boll worm damage especially *E. vitella* and increased seed cotton yield (Table 37). The infestation of *H. armigera* and *P. gossypiella* was very low.

Fig. 24. BIPM experimental plot on *Bt* cotton

TNAU

BIPM package on *Bt* cotton recorded significantly low population of leafhoppers, aphids, thrips and whiteflies per 5 plants. The bollworm damage by *Earias* and *H. armigera* was also low in BIPM package on *Bt* cotton. BIPM package on *Bt* cotton recorded significantly higher seed cotton yield than in farmers' practice (Table 38).

(ii) Bio-intensive management of pink boll worm, *Pectinophora gossypiella* on cotton

Multi-location trials were conducted to evaluate the efficacy of *Trichogrammatoidea*

Table 37. Impact of BIPM on *Bt* cotton (Ambapur, Maharashtra)

Treatment	Sucking pests population / 3 leaves					Bollworm damage (%) (*E. vitella*)	Seed cotton yield (kg/ha)
	Aphid	Leaf hopper	Thrip	Whitefly	Mealy bug		
BIPM package	19.8[a]	3.3[a]	10.5[a]	6.4[a]	22.1[a]	3.3[a]	1850[a]
Farmers' practice	31.5[b]	3.7[a]	24.2[b]	7.3[a]	25.1[a]	6.3[b]	1680[b]

Means followed by the same alphabet in a column are not significantly different (P=0.05)

Table 38. Impact of BIPM in *Bt* Cotton (Chinnakanur, Tamilnadu)

Treatments	Population of Sucking pests /5 plants				Boll damage (%)		Seed cotton yield (kg/ha)
	Leaf hoppers	Aphids	Thrips	whiteflies	*Earias* sp.	*H. armigera*	
BIPM	25.3[a]	6.3[a]	1.3[a]	5.7 [a]	2.0[a]	1.3[a]	2093[a]
Farmer's practice	41.7[b]	37.3 [b]	9.3[b]	13.3[b]	4.0[b]	2.7[b]	1965[b]

Means followed by the same alphabet in a column are not significantly different (P=0.05)

bactrae against the pink bollworm (PBW) *P. gossypiella*. The parasitoids were released 3-4 times @ 1,50,000 adults/ha per week synchronizing with appearance of pink bollworms. Other BIPM practices are as detailed in (i) of section 5.2.7.

MPKV

The experiment was conducted on NHH-44 cotton at Rahuri with 90 x 90 cm spacing. Release of *T. bactrae* @ 1.5 lakhs/ ha three times at weekly interval starting from 78 days after germination was found effective in reducing the larval population of PBW and its damage to bolls and locules and increasing the seed cotton yield (Table 39).

Table 39. Efficacy of *T. bactrae* on incidence of PBW in *Bt* cotton (Rahuri, Maharashtra)

Treatment	Larvae/ plant	% Damage to		Seed cotton yield (kg/ha)
		Bolls	Locules	
Release of *T. bactrae* + BIPM	2.7[a]	14.3 [a]	17.6 [a]	1,770 [a]
Farmer's practice	2.3 [a]	13.8 [a]	16.2 [a]	1,890 [a]
Untreated control	3.3 [b]	16.9 [b]	18.7 [b]	1,590 [b]

Means followed by the same alphabet in a column are not significantly different (P=0.05)

ANGRAU

The experiment was conducted during Kharif, 2007 at Warangal. The pink bollworm population was lower in BIPM package compared to farmers' practice and untreated control. Significantly lower square, boll and locule damage was recorded in BIPM package compared to farmers' practice and untreated control. Seed cotton yield was also higher in BIPM package (Fig. 25).

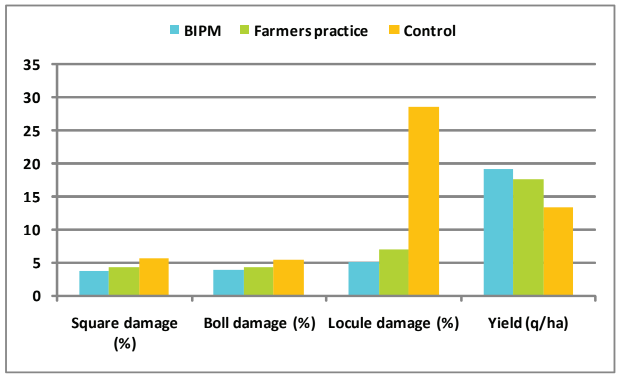


Fig. 25. Impact of BIPM package on pink boll worm damage

AAU (Anand)

The experiment was carried at Anand during *Kharif,* 2007 on H-10 cotton with 120 x 60 cm spacing. Significantly lower larval population of pink bollworm was recorded in BIPM package plots and farmers' practice over the untreated control. Similarly, the BIPM package resulted in lower boll and locule damage as compared to farmers' practice and untreated control (Fig. 26).

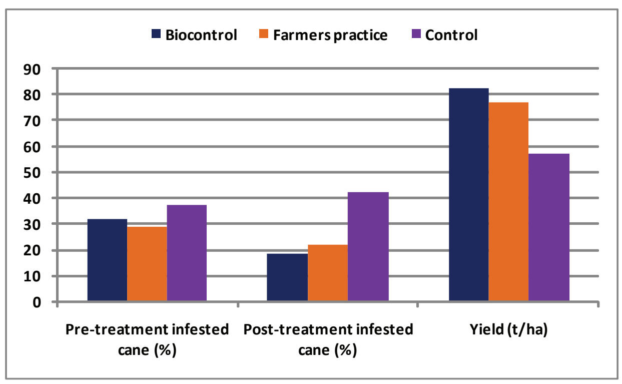


Fig. 26. Efficacy of *T. bactrae* against pink bollworm

(iii) Enhancement of natural enemy population in cotton by habitat manipulation

a) Rainfed cotton

Multilocation experiments were conducted during the year 2007-08 to enhance the natural enemy population by habitat manipulation in rainfed cotton. The following modules were tested in PAU and ANGRAU:

M_1: **Habitat Management**: Four paired rows of cotton interspersed with one paired row consisting of one row of cowpea and one row of marigold were sown. One paired row of sorghum was grown all-round the plot as border crop. Eight releases of *T. chilonis* @1,50,000/ha were made at weekly interval from July to October.

M_2: **BIPM practice**: Twelve releases of *T. chilonis* @1,50,000/ha at weekly interval from July to October. Need based NPV spray against *H. armigera* and *S. litura.*

M_3: **Insecticidal control**: One spray of imidacloprid 200SL @100ml/ha for the control of cotton leaf hoppers. One spray of deltamethrin 2.8EC @ 11.2 g a.i./ha and second of endosulfan 35 EC @ 87.5 g a.i./ha against spotted bollworm (*Earias* sp.).

PAU

The experiment on enhancement of natural enemy population in cotton by habitat manipulation was conducted at the Entomological Farm, PAU, Ludhiana. Leaf hopper population was significantly lower in the insecticidal control plot (2.6 nymphs/ 3 leaves) as compared to habitat management (4.9 nymphs/ 3 leaves) and BIPM (5.1 nymphs/ 3 leaves) plots. The white fly population remained below ETL (18 adults/ 3 leaves) throughout the season. Mean whitefly population was significantly lower (1.4 adults/ 3 leaves) in the insecticidal control plot as compared to habitat management (2.1 adults / 3 leaves) and BIPM (2.0 adults/ 3 leaves) plots.

There was no incidence of *H. armigera* and *S. litura* during 2007. Lowest mean bollworm (spotted) incidence (5.6%) was recorded in insecticidal control plot and it was significantly lower than in habitat management (12.1%) and BIPM (13.0%). Habitat management plot recorded yield on par with BIPM practice (Table 40).

ANGRAU

Results of the experiment at ARS, Warangal during *Kharif* 2007-08 showed that the population of aphids, leaf hoppers and whitefly was lower in habitat management compared to BIPM and Insecticidal spray plots. The per cent square and boll damage by spotted bollworm was lowest in habitat management plot as compared to BIPM and farmers' practice. Habitat management plot recorded significantly higher yield as compared to BIPM plot and farmers practice (Table 41). Habitat management plot also recorded higher population of *C. carnea*, coccinellids and spiders. Natural parasitism by *T. chilonis* was 3.21% in habitat management as compared to 2.78% in BIPM and only 0.92% in farmers' practice.

AAU (Anand)

The experiment was conducted in the agronomy farm, Anand during Kharif, 2007 on H-10 cotton with 120 x 60 cm spacing. The following three modules were tested:

Table 40. Enhancement of natural enemy population in cotton by habitat manipulation in Punjab during 2007.

Treatments	Leaf hoppers / 3 leaves	White fly / 3 leaves	Fruiting bodies damage by *Earias* sp. (%)	Green boll damage (%)	Natural enemies** per plant	Seed cotton yield (kg/ha)
Habitat Management	4.9[b]	2.1[b]	12.1[b]	5.7[b]	1.6	1,020[b]
BIPM	5.1[b]	2.0[b]	13.0[b]	5.7[b]	1.2	1,000[b]
Insecticidal control	2.6[a]	1.4[a]	5.6[a]	1.7[a]	0.2	1,260[a]

Means followed by the same alphabet in a column are not significantly different (P=0.05)
**Natural enemies included *Chrysoperla* sp., *Zelus* sp., *Geocoris* sp. and spiders

Table 41. Impact of habitat manipulation on cotton pest complex (Warangal, Andhra Pradesh)

Crop Module	Sucking pests/3 leaves			% Damage by boll worms			Seed cotton yield (kg/h)
	Aphids	Leaf hoppers	White fly	Square	Boll	Locule	
Habitat management	3.1[a]	2.2[a]	5.7[a]	4.3[a]	0.6[a]	22.3[b]	1,852[a]
BIPM	5.2[b]	3.9[b]	9.1[b]	5.7[b]	2.8[b]	19.7[a]	1,578[b]
Insecticidal spray	8.1[c]	5.1[c]	11.2[c]	7.2[c]	3.2[b]	28.2[c]	1,627[b]

Means followed by the same alphabet in a column are not significantly different (P=0.05)

M_1: Treatment of cotton seeds with *Trichoderma* @ 5 g/kg seeds + cotton interspersed with *Cassia occidentalis* (6:1) + planting of maize and zinnia @ 10 % plants + one release of *T. chilonis* @ 1.5 lakh/ha with the oviposition by *Catopsilia pyranthe* on *C. occidentalis* + 5000 larvae of *C. carnea* coinciding with the appearance of aphids (one release).

M_2: Treatment of cotton seeds with *Trichoderma* @ 5 g/kg seeds + cotton interspersed with *C. occidentalis* (6:1) + sowing/ planting of maize and zinnia @ 10 % plants.

M_3: Insecticidal Control (University recommended insecticides)

M_4: Untreated Control

The results revealed that the module M_1 recorded lowest number of aphids, leaf hoppers and whitefly per 15 leaves. Similarly, significantly lower damage to buds, green bolls and locules was recorded in M_1 module. M_1 module recorded highest yield of seed cotton (Table 42). The habitat manipulation plot also recorded higher numbers of *C. carnea*, coccinellids, Geocoris bug, Staphylinids and Rogas per 25 plants. The parasitism by *T. chilonis* was higher in habitat manipulation plot and lowest in insecticidal spray plot.

MPKV

The trial was laid out on the agricultural college research farm at Pune on Ajeet-11 cotton with 90 x 90 cm spacing. The following three modules were tested for their impact on the sucking pest complex and bollworm damage and yield of cotton.

M_1: Four paired rows of cotton interspersed with one paired row of cowpea and one row of marigold, paired row of maize as border crop around the plot, release of *C. carnea* @ 5,000 larvae/ ha synchronizing with appearance of sucking pests, release of *T. chilonis* @ 1.5 lakh adults/ ha /week coinciding with egg laying of boll worm

M_2: Cotton without intercrop/ border crop (with BIPM practice)

M_3: Farmers' practice

The treatments with habitat management in cotton with intercrop and BIPM practices were significantly more effective than farmers' practice

Table 42. Impact of habitat manipulation on insect pests and yield of cotton at Anand

Treatments	Sucking pests / 15 leaves			Damage by bollworms (%)				Seed cotton yield (kg/ha)
	Aphid	Leaf hopper	Whitefly	Buds	Green bolls	Locules		
						Earias	PBW	
M_1	1.1 [c]	1.6 [d]	1.2 [d]	7.7 [c]	9.9 [d]	7.3 [d]	3.0 [d]	2,333 [a]
M_2	1.3 [b]	2.1 [c]	1.5 [c]	8.8 [c]	12.1 [c]	9.7 [c]	4.4 [c]	2,144 [ab]
M_3	1.3 [bc]	2.5 [b]	1.9 [b]	10.7 [b]	14.1 [b]	11.8 [b]	6.2 [b]	2,011 [bc]
M_4	2.1 [a]	5.0 [a]	3.6 [a]	18.6 [a]	21.1 [a]	15.4 [a]	8.6 [a]	1,742 [c]

Means followed by the same alphabet in a column are not significantly different (P=0.05)

Table 43. Impact of crop habitat manipulation on sucking pest complex and yield of cotton (Pune)

Module	Pest population / 3 leaves				Green boll damage (%)		Locule damage (%)	Seed cotton yield (kg/ha)
	Aphid	Leaf hopper	Thrip	Whitefly	*E. vitella*	*H. armigera*		
M_1	25.0 a	3.6 a	17.2 a	4.8 b	6.2a	0.8 a	7.1 a	1,603 a
M_2	21.8a	2.8 a	23.6 b	3.3 a	7.2 a	0.9 a	8.1 a	1,670 a
M_3	30.0 b	4.2 a	21.0 b	5.2 b	10.3 b	1.9 b	10.4 b	1,280 b

Means followed by the same alphabet in a column are not significantly different (P=0.05)

in reducing the sucking pest population, boll worm damage and increasing natural enemy population and yield of seed cotton. The bollworm damage especially *E. vitella* was significantly low in cotton with intercrop (M_1) as well as BIPM blocks (M_2). Though, the yield of seed cotton was maximum in BIPM blocks (1,603 kg) there were additional returns from cowpea (99.8 kg/ha) and marigold (3.2 kg/ha) in habitat manipulated plot (Tables 43). The habitat manipulation plot recorded higher population of chrysopids and coccinellids.

b) *Bt* cotton

AAU (Anand)

The experiment was conducted at biocontrol farm, Anand Agricultural University, Anand during *Kharif*, 2007 on Vikram-5 Bt cotton with 120 x 60 cm spacing. The impact of the following combinations of intercrops was assessed on pests and natural enemies of *Bt* cotton:

T1- Cotton + Maize (Interspersed @ 10 %)

T2- Cotton + Cowpea (In between two rows)

T3- Cotton + Sesamum (In between two rows)

T4- Cotton + Cassia (One row after 5 rows)

T5- Cotton + Marigold (On border of cotton plot)

T6- Cotton as sole crop

Significantly least population of leafhopper and whitefly was recorded in the plots having cotton with maize interspersed followed by cotton+ cowpea, cotton + sesamum, cotton + *Cassia occidentalis* and cotton + marigold. On the other hand, cotton as sole crop registered significantly highest incidence of leaf hopper and whitefly.

Bollworm incidence was significantly lower in cotton + maize and cotton + sesamum than cotton as sole crop. Similarly, the bollworm damage to green bolls was significantly lower in case of cotton + maize, cotton + sesamum and cotton + cowpea in comparison to cotton crop grown alone. The impact of cowpea, *Cassia* and marigold with cotton as habitat manipulation for natural enemies was more or less equal. Maximum seed cotton yield was harvested in plots having cotton interspersed with maize followed by cotton + cowpea. Both the treatments differed significantly from rest of the treatments evaluated (Table 44).

Table 44. Impact of intercrops on pest complex and natural enemies in *Bt* cotton.

Treatments	Sucking pests / 3 leaves		Boll damage (%)	Natural enemies/25 plants				Seed cotton yield (kg/ ha)
	Leaf hopper	Whitefly		*C. carnea*	Coccinellids	Geocoris bug	Spiders	
T1	2.0 f	1.4 f	0.2 d	16.0	88.0	11.0	20.8	2,539a
T2	2.5 e	2.2 e	0.4 bcd	9.8	67.0	7.0	20.0	2,394ab
T3	3.0 d	2.6 d	0.3 cd	7.2	35.0	5.0	16.6	2,111bc
T4	3.3 c	23.0 c	0.5 bc	5.0	30.0	4.0	9.0	2,044cd
T5	3.7 b	3.5 b	0.7 ab	3.0	28.0	3.8	10.4	1,817cd
T6	4.8 a	4.1 a	1.0a	3.0	18.55	3.4	9.4	1,772d

Means followed by the same alphabet in a column are not significantly different (P=0.05)

Greater number of *Geocoris* bugs was recorded in cotton + maize. Similarly, more number of predatory spiders was recorded in cotton plots having maize, cowpea and sesamum as inter crops. Maximum egg parasitism due to *Trichogramma* was noticed in treatment of cotton interspersed with maize followed by cotton + sesamum (13.47 %) and cotton + *C. occidentalis* (13.47 %).

(iv) Identification of natural enemies of mealy bugs on cotton and evaluation of potential natural enemies

Multi-location experiments were conducted to evaluate the potential of *Cryptolaemus montrouzieri* in suppressing the mealy bugs on cotton. The predators were released @ 2-4 grubs per infested plant twice at 15 days interval and compared with farmers practice and untreated control.

AAU (Anand)

The experiment was conducted in the agronomy farm of Anand Agricultural University on H-10 cotton with 120 x 60 cm spacing. Significantly least percentage of mealybug infested plants was recorded in insecticide treated plots (8.9%) followed by *C. montrouzieri*-released plots (10.52 %). Both the treatments registered significantly lower incidence of mealybugs over untreated control. Similarly, the plots treated with insecticides (Farmers' practice) exhibited significantly minimum (14.14 %) bolls infested by mealy bugs. The *C. montrozieri*-released and untreated control plots did not show much variation in terms of mealybug infested cotton bolls. Population of *Chrysoperla* and coccinellids was highest in *C. montrouzieri* release plots compared to farmers practice and control. Highest seed cotton yield was obtained in plots treated with insecticides (Farmers' practice) followed by *C. montrouzieri* released plots (Fig. 27).

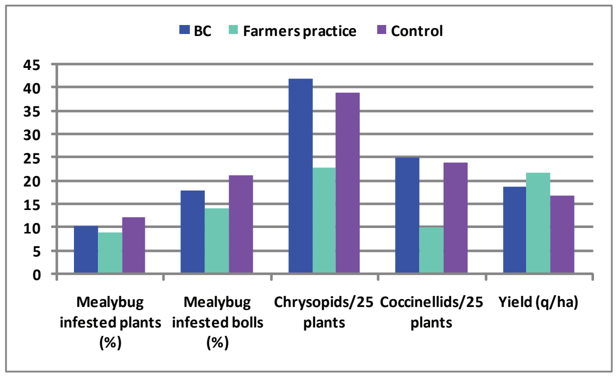


Fig. 27. Impact of release of *C. montrouzieri* on incidence of mealybug and yield of cotton (Anand, Gujarat)

MPKV

The experiment on evaluation of potential predator *C. montrouzieri* was conducted on the research farm, MPKV, Rahuri on cotton cv. NHH-44 with 90 x 90 cm plant spacing. Three releases of *C. montrouzieri* @ 2 - 4 grubs/plant were found as effective as farmers' practice in reducing the mealy bug infestation and increasing the yield of seed cotton (Table 45). The predator-released plots harboured higher number of chrysopids and other cocconellid beetles.

5.2.8. Biological suppression of tobacco pests

(i) Studies on the influence of water quality on the efficacy of entomopathogens against tobacco pests

CTRI

Aluminum chloride (for low pH) and sodium bicarbonate (for high pH) were used to prepare water solutions with pH 5, 6, 7, 8 and 9. SlNPV @ 1.5 x 10^{12} PIB/ha was added to the solutions and used for spraying in both field and laboratory

Table 45. Effect of release of *C. montrouzieri* against mealy bug in cotton

Treatment	Mealy bug population / 5 cm twig	Natural enemy population/plant			Seed cotton yield (kg/ha)
		chrysopid	coccinellid	*Cryptolaemus*	
Release of *C. montrouzieri*	65.3[a]	8.3	4.5	2.1	1,770[0a]
Dichlorvos (0.1%)	111.6[a]	1.3	2.5	0.0	1,680[a]
Control	254.3[b]	2.3	2.8	0.0	1,590[b]

Means followed by the same alphabet in a column are not significantly different (P=0.05)

experiments. Observations were made on per cent mortality at 2, 3 and 7 days post treatment.

SlNPV suspension with pH 8 recorded the lowest seedling damage by *S. litura*, 7 days after application indicating greater NPV action. SlNPV with pH 5 and 9 recorded relatively more seedling damage indicating lesser NPV activity. In laboratory, 72 hours after application, the mortality of larvae was highest in SlNPV with pH 7 followed by pH 6 and 8 without significant difference between them. Lowest mortality was noticed in control (water spray) followed by SlNPV applied at pH 5 and pH 9. After 7 days, the mortality was cent per cent in all the treatments except in control (Table 46).

Table 46. Effect of water quality (pH) on SlNPV

pH	Seedlings damage after 7 days (%)	Larval mortality days after	
		3	7
5	11.13^{b}	46.66^{C}	100
6	9.88^{ab}	50.55^{b}	100
7	8.38^{ab}	71.10^{a}	100
8	7.75^{a}	50.00^{b}	100
9	14.63^{c}	41.66^{d}	100
Control (water spray)	28.63^{d}	32.21^{e}	35.56

Means followed by the same letter in a column are not significantly different (P=0.05%)

It was concluded that to obtain satisfactory control of *S. litura* in tobacco nurseries using SlNPV, the pH of spray solution must be between 6 and 8. The pH below 6 or above 8 is detrimental to the performance of SlNPV under field conditions.

(ii) Comparative study of virulence of different isolates of SlNPV in tobacco, soybean and chilly ecosystem.

CTRI

Spodoptera litura cultures from tobacco nurseries were obtained from Jeelugumilli (West Godavari), Guntur, Rajahmundry (East Godavari), Nandyal (Kurnool) and Jeddangi (East Godavari). The cultures were reared on tobacco leaves at 27° C and 70% RH in laboratory. Larvae showing NPV symptoms were isolated and NPV was extracted after pelleting by centrifugation at 5000 rpm in a refrigerated centrifuge. The SlNPV thus obtained from different regions was inoculated to larvae obtained from sterilized egg masses under UV light, by contaminating the tobacco leaf discs. Sufficient NPV culture was obtained to spray on tobacco plants @ 1.5 x 10^{12} PIB/ha for 176 plants per plot with five treatments and control (water spray) in tobacco transplanted crop.

Sl NPV strain collected from Rajhamundry and Jeelugumilli were highly virulent recording lowest number of larvae/ plant, 7 days after the spray. The leaf damage percentage was lowest in these two strains, 7 days after the spray (Table 47).

Table 47. Efficacy of different isolates of SlNPV on *Spodoptera litura.*

Treatments (SlNPV Strains)	Number of larvae/plant	Leaf damage (%)
Jeelugumilli	1.25^{ab}	4.35^{a}
Guntur	2.20^{c}	8.89^{b}
Rajahmundry	1.05^{a}	3.89^{a}
Nandyal	3.35^{d}	9.49^{b}
Jeddangi	1.45^{b}	5.90^{a}
Control (water spray)	4.80^{e}	16.87^{c}

Means followed by the same letter in a column are not significantly different (P=0.05%)

(iii) Studies on Biological control options for suppression of tobacco stem borer *Scrobipalpa heliopa* (Lepidoptera: Gelichidae)

CTRI

A laboratory experiment was conducted to evaluate the efficacy of *B. thuringiensis* against the stem borer, *S. heliopa* on tobacoo. Serial dilutions of *Bt* was sprayed on seedlings with 20 eggs of the stem borer and evaluated after 10 days. The egg hatching was significantly less at 1:10 and 1:100 dilutions of *Bt* without significant differences between them. Egg hatching was significantly affected compared to control even at 1:1000 dilutions. At dilutions 1:10^4 to 10^6, the egg hatching was significantly higher and equal to control. On leaf, highest larval mortality was observed at dilutions 1:10 followed by 1:10^2 to 10^6 in the descending order. Least mortality was observed in control (Table 48). On veins, significantly highest larval mortality was obtained in case of dilutions 1:10 followed by 1:10^2 to 10^5 in descending order. Lowest mortality was observed at dilution 10^6 and control (water spray). *Bt* at 1:10 dilution was very effective against stem borer.

Table 48. Effect of *Bt* (PDBC) on tobacco stemborer.

Treatments (*Bt* dilution)	Egg hatching (%)	Larval mortality (%)	
		On leaf	On veins
1:10	45.0^a	62.48^f	40.12^e
1:100	48.3^a	44.78^e	28.97^d
1:10^3	60.04^b	36.69^d	13.34^c
1:10^4	73.56^c	26.56^c	7.89^b
1:10^5	73.85^c	23.00^c	3.40^a
1:10^6	82.24^c	15.35^b	2.23^a
Control (water spray)	85.24^c	5.85^a	1.33^a

Means followed by the same letter in a column are not significantly different (P=0.05%)

5.2.9. Biological suppression of pulse crop pests

(i) Demonstration of biocontrol of pests and diseases of Pigeonpea

ANGRAU

Field demonstration of biocontrol of pests and diseases of pigeonpea was conducted during *Kharif* 2007-08 at Sangamkurdu Village. The BIPM package consisting of (a) seed treatment with *Trichoderma* (6g/kg seed) (b) inter crop with maize – 1 in 10 rows (c) application of HaNPV @ 1.5 X 10^{12} POB /ha against *H. armigera* (d) application of *Bt* @ 1 kg / ha - 2 sprays against other pod borers and (e) NSKE 5% – 2 sprays was evaluated against farmers' practice. The results revealed lower incidence of pod borers in BIPM module than farmers' practice. BIPM package recorded higher yield and cost: benefit ratio (Fig. 28).

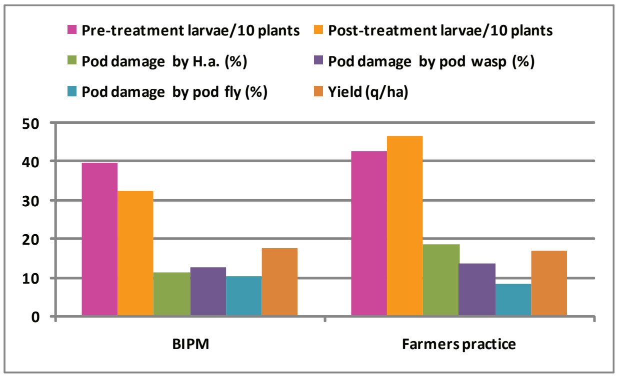


Fig. 28. Impact of BIPM module on the pod borer complex in pigeonpea

(ii) Demonstration of Biological control of seed-borne diseases of chickpea and *Helicoverpa armigera*

PAU

The biocontrol package consisting of (a) Seed treatment with trichoderma @ 8g/kg of seeds, Spray of 1.5×10^{12} POB/ha +crude sugar 2.5 kg/ha +Teepol 125ml/ha at 7-10 days interval at flowering stage and Birds perches 10/ha (b) endosulfan @ 350 g a.i./acre (farmers' practice) and (c) control was demonstrated on GPF-2 variety of chickpea at the Entomological farm PAU Ludhiana in plot size of one acre. Mean population of *H. armigera* larvae per 10 plants was lowest in endosulfan sprayed plots followed by biocontrol treatments. The mean per cent pod damage in farmers' practice and biocontrol treatment was significantly lower than the control. The grain yield was highest in endosulfan and significantly better than the biocontrol treatment (Fig. 29). The disease incidence was negligible in all the treatments.

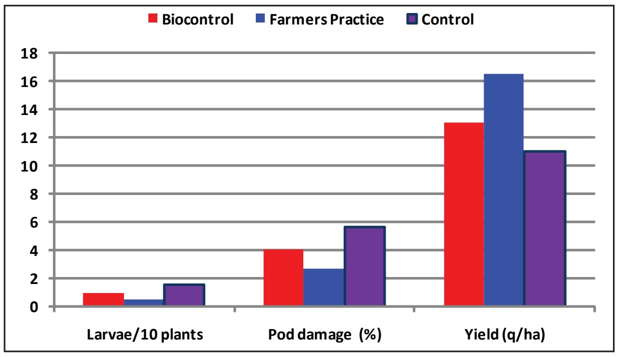


Fig. 29. Demonstration of biological control of seed-borne disease of chickpea and *H. armigera* (PAU, Ludhiana)

(iii) Fixing economic threshold level for NPV application for the control of *H. armigera* on chickpea

The experiment was conducted on GPF-2 variety of chickpea at Entomological farm, PAU Ludhiana in exploded block design of plot size 20×20 sqm. The plot was sprayed with HaNPV @ 1.5×10^{12} POB/ha + crude sugar 2.5 kg/ha + Teepol 125 ml/ha as and when the population of *H. armigera* exceeded the fixed number. The *H. armigera* larval populations per 10 plants, per cent pod damage and grain yield were recorded.

The pooled data revealed that larval population per 10 plants was lowest in plot treated with HaNPV and adjuvants at ETL of 1 larva/ 10 plants, this was at on a par with plot sprayed at flowering stage. However, all other treatments were better than control. The pod damage was lowest in plot treated at ETL of 1 larva/ 10 plants. The highest yield was recorded in plot treated with HaNPV and adjuvants at ETL of 1 larva/ 10 plants and this was on a par with plots treated at ETL of 2 larvae/10 plants but was significantly better than all other treatments (Table 49). Highest net return was obtained with the ETL level of 1 larva/ 10 plants.

(iv) Survey for natural enemies of pigeonpea pod wasp, *Tanaostigmodes cajaninae* and pod fly, *Melanagromyza obtusa*

ANGRAU

During *Kharif* 2007-08, more than 12.0 per cent pod damage was recorded by pod wasp while the pod damage by pod fly ranged between 8.0 to 9.0 per cent in pigeon pea growing belt of Tandur region. However, no natural enemies were recorded on pod wasp and podfly.

(v) Evaluation of EPN (*Heterorhabditis* sp.) against lepidopteran pod borers of pigeonpea

ANGRAU

Field evaluation of EPN (*Heterorhabditis* sp.) was done during *Kharif* 2007-08 at Agricultural Research Station, Tandur (A.P.) at 0.5, 1and 1.5 billion nematodes/ha. The results revealed that spray application of 1.0 and 1.5 billion nematodes/ ha resulted in better suppression of pod borer complex. However the yield differences were not significant (Table 50).

Table 50. Effect of *Heterorhabditis* on the incidence of *H. armigera* and yield in pigeonpea

EPN dos-ages (billion/ha)	Larvae/ plant	Pod damage (%)	Yield* (kg/ha)
0.5	8.90[b]	17.80[b]	1,671
1.0	4.10[a]	10.20[a]	1,702
1.5	3.90[a]	11.50[a]	1,752
Control	20.20[c]	23.70[c]	1,582

Means followed by the same letter in a column are not significantly different (P=0.05)
*Differences between the means not significant

(vi) Demonstration of Biological control of pests and diseases in Chickpea

NCIPM

Large scale field demonstration of biological control of pests and diseases in chickpea was conducted in 450 acres at an adopted village Karoan near Allahabad in collaboration with

Table 49. Economic threshold of *H. armigera* for NPV application on chickpea.

Treatments (Number of larvae /10 plants)	Number of sprays	Total cost of sprays (Rs)	Yield of grain (kg/ha)	Increase in yield over control (kg/ha)	Profit over control (Rs)
1	6	19,242	1,380	300	7,500
2	5	16,035	1,300	220	5,500
3	4	12,828	1,180	100	2,500
4	3	9,624	1,100	20	500
Flowering stages	5	16,035	1,230	150	3,750
Control	-	-	1,080	-	-

Means followed by the same letter in a column are not significantly different (P=0.05%)

BIOVED, Allahabad. Five quintal of moderately disease resistant variety "KBR-108" was supplied along with biofertilizers (Rhizobium) and *Trichoderma* preparation for seed treatment. For monitoring *H. armigera* population, pheromone traps were installed @ 5 traps/ha and HaNPV was applied for its management. The observations on the infestation of pod borer and diseases were recorded at weekly interval.

The results indicated a significant reduction in the infestation of pod borer and wilt mortality caused by *Fusarium* and *Rhizoctonia* in IPM as compared to Non-IPM. The IPM plot recorded higher yield of 1,560 kg/ha while the non-IPM plot recorded only 540 kg yield (Table 51).

Table 51. Impact of IPM package on pests and diseases of chickpea during rabi-2007-08 (Koroan, Uttar Pradesh).

Treatment	Wilt incidence (%)	*H. armigera*		Grain yield (kg/ha)
		Larvae/ plant	Pod Infestation (%)	
IPM	5.30[a]	0.02[a]	3.84[a]	1,560[a]
Non-IPM	8.80[b]	0.13[b]	30.62[b]	540[b]

Means followed by the same letter in a column are not significantly different (P=0.05)

5.2.10. Biological suppression of rice pests

(i) Large-scale demonstration of IPM for rice pests and diseases in the farmers' field

Large-scale demonstration trials on IPM of rice pests and diseases were laid out. The IPM package included (a) seed treatment with *P. fluorescens* @ 8 g/kg of seeds/ seedling dip in 2% solution (b) *B. bassiana* 10^{13} spores/ha against sucking pests, (c) bird perches at 10/ha (d) *T. japonicum* @ 1 lakh/ha on occurrence of leaf folder or stem borer (e) *Bt* at 2 kg/ha, 2-4 sprays depending on pest occurrence (f) *P. fluorescens* spray against foliar diseases and (g) need-based or spot application of botanicals.

KAU

The demonstration was laid out on 0.5 ha area at Koorkkenchery on variety Jyothi during Rabi 2007. There was no significant difference in leaf folder and stem borer incidences between IPM and farmers' practice. But leaf hopper, coccinellid and spider counts were significantly higher in IPM area. However, rice bug affected ear head infestation was significantly high in farmers practice. Grain yield and net return were significantly higher in IPM plots (Fig. 30).

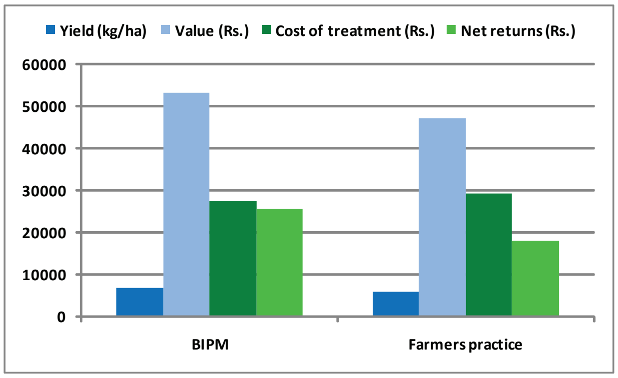


Fig. 30. Impact of IPM on rice pests and diseases (Koorkkenchery, Kerala)

AAU (Jorhat)

The demonstration was conducted on a 10 ha plot of Mahsuri variety in the farmers' field at Barokuri gaon, Teok, (Dist: Jorhat) during Kharif 2007. The data revealed that the population of GLH, damage by stem borer and leaf folder was much lower in the IPM package than the farmers' plot. Higher yield was obtained in the IPM package than the farmers practice. The cost benefit analysis showed net return of Rs. 7,720.00 in IPM package over farmers' practice (Table 52).

Table 52. Demonstration of IPM for rice pests and diseases in the farmers' field (Kharif, 2007) (Barokuri, Jorhat)

Treatment	GLH/hill (7 DAT)	Dead Heart (%) (60 DAT)	White ear (%)	Leaf folder damage (%)	Grain yield (kg/ha)	Net return over farmers practice (Rs./ha)
IPM Package	3.5	4.04	4.48	2.82	3,140	7,720
Farmers' practice	6.5	7.75	8.95	6.73	2,960	

PAU

A demonstration of biocontrol-based IPM of rice was carried out at three locations viz., Karni Khera, Kohali and Jasso Majara on variety *Basmati* – 386 over an area of 5 acres each. In farmers' practice two applications of cartap hydrochloride (Padan 4G) were given @ 25kg/ha, at 40 and 60 DAT.The data on the incidence of leaf folder and stem borer and grain yield showed that IPM package was as effective as farmer's practice of application of chemical pesticides (Table 53).

Table 53. Efficacy of IPM on pests of rice (Basmati 386) in farmers' field during 2007. (Punjab)

Treatments	Leaf folder damage (%)	Dead hearts (%)	White ears (%)	Yield (kg/ha)
IPM	1.2	2.0	2.8	2,680
Farmers practice	1.0	1.7	2.6	2,760

(ii) Validation of BIPM practices in organic rice production

Multi-location demonstrations on biointensive pest management (BIPM) practices in organic rice were conducted during 2007-08. The BIPM package consisting of (a) use of disease resistant variety (b) seed treatment with *P. fluorescens* @ 8g/kg seed (c) FYM @ 5 t/ha (d) *B. bassiana* @ 10^{13} spores/ha against sucking pests (e) bird perches at 10/ha (f) release of *T. japonicum* @ 1 lakh/ha on occurrence of pests (g) spray of *P. fluorescens* against foliar diseases.

PAU

The experiment was carried out at Punjab Agricultural University, Ludhiana on *Basmati* rice and coarse rice. BIPM package as in the above was followed. Organic farming treatment included green manuring with *Dhaincha* (*Sesbania aculeata*), 7 releases of *T. chilonis* and *T. japonicum* each @ 1 lkah/ha/week starting from 30 DAT. Recommended package consisted application of inorganic fertilizers and one spray of monocrotophos and 4 releases of *T. chilonis* and *T. japonicum* @1 lakh/ha/week starting from 30DAT.

In both the experiments the incidence of leaf folder and stemborers was less than 2% indicating that the pest management practices in the three methods were effective in terms of yield. However, the BIPM package recorded better performance in both coarse and Basmati rice (Table 54 and 55).

Table 54. Validation of BIPM package in organic rice in Punjab.

Treatments	Leaf folder (%)	Dead hearts (%)	White ears (%)	Yield (kg/ha)
Organic practices	0.9	1.4 [a]	2.0	6,070 [a]
Recommended practices	0.6	1.3 [a]	1.9	5,950 [a]
BIPM practices	0.7	1.2 [b]	1.8	7,150 [b]

Means followed by the same letter in a column are not significantly different (P=0.05)

Table 55. Validation of BIPM package in organic *Basmati* rice in Punjab.

Treatments	Leaf folder (%)	Dead hearts (%)	White ears (%)	Yield (kg/ha)
Organic practices	0.8 [b]	1.5 [b]	2.1	3,270 [b]
Recommended practices	0.7 [b]	1.4 [ab]	2.0	3,510 [a]
BIPM practices	0.5 [a]	1.1 [a]	1.9	3,500 [a]

Means followed by the same letter in a column are not significantly different (P=0.05)

KAU

Biointensive pest management package was demonstrated over an area of 2ha of organic rice variety Jyothi during *kharif* and *rabi* of 2007-08. BIPM package details are as above.

The results revealed that the population of coccinellids and spiders were relatively higher in organic farming as compared to conventional practice. There was no significant difference in dead hearts incidence during *kharif*, however dead hearts were low in organic package during *rabi*. Earhead bug damage was significantly lower in organic practice during *rabi*. The grain yield was significantly higher in conventional practice compared to organic practice (Table 56).

Table 56. Impact of organic farming on the pests of rice (cv.Jyothi) in Thrissur, Kerala

Parameter	Kharif		Rabi	
	Organic	Conven-tional	Or-ganic	Conven-tional
Dead hearts (%)	0.5	0.3	0.6	1.8
Leaf folder incidence (%)	5.3	4.4	0.2	0.2
Coccinellids/hill	0.1	0.03	0.3	0.06
Spiders/hill	0.2	0.07	0.2	0.02
Ear bug damaged earheads/ sq. m	1.5	1.7	0.8	1.8
Organic carbon content (%)	0.5	0.4	0.5	0.4
Grain yield (kg/ ha)	2,437	2,748	3,645	4,223

AAU (Jorhat)

The field experiment was conducted on 10 ha plot in the farmers field during *kharif*, 2007 on the rice variety was Mahsuri. The BIPM practice was compared with conventional and farmers practice.

The incidence of GLH, leaf folder damage and dead heart incidence were lower in BIPM as well as conventional method than in farmer's practice. Eventhough the grain yield was highest in conventional method, the net return was higher in BIPM (Table 57).

Table 57. Validation of BIPM package in organic rice (Cv.Mahsuri) in Assam

Parameter	Package		
	BIPM/ Organic	Conve-ntional	Farmers practice
GLH/hill	3.5[a]	4.6[a]	8.4[b]
Leaf folder damage (%)	4.69[b]	3.61[a]	7.46c
Dead hearts (%)	5.64[a]	5.43[a]	8.77b
Yield of grain (kg/ha)	2,781[b]	2,904a	2,311[c]
Net return (Rs/ha)	9,350	4,800	

Means followed by the same letter in a column are not significantly different (P=0.05)

NCIPM

Validation of BIPM package in organic rice was carried at Kaithal in farmers' field with a susceptible HSB-16 rice (taraori). The field was augmented with *Trichoderma*-enriched FYM. The seedlings were dipped in 2% *P. flurescens*. One release of *T. japonicum* was done. The crop was sprayed with *P. fluorescens* @ 2kg/ha as preventive measure to contain foliar diseases specially BLB and check their further spread. In case on conventional method, the crop was sprayed with chlorpyriphos 20 EC @ 2 ml/lit to contain the insect menace. Similarly fungicides such as carbendazim and hexaconazole were sprayed to contain foliar diseases such as brown spot and bacterial leaf blight.

The incidence of stem borer, leaf folder, brown spot disease, bacterial leaf blight, sheath blight, blast and false smut was lower in BIPM package as compared to farmers practice (Table 58).

Table 58. Impact of BIPM package on pests and diseases of organic rice (Kaithal village)

Pest incidence	IPM	Conventional
Stem borer (%)	1.46 [b]	1.96[a]
Leaf folder (%)	2.59[b]	3.16[a]
Brown spot (%)	3.01[b]	17.63[a]
BLB (%)	0.14[b]	1.46[a]
Sheath blight (%)	0.58[b]	3.44[a]
Blast (%)	0.74[b]	1.11[a]
False smut (%)	0.03[b]	1.40[a]

Means followed by the same letter in a horizontal column are not significantly different (P=0.05)

(iii) Evaluation of DOR *Bt* against leaf folder of rice

PAU

The experiment on evaluation of DOR *Bt* against leaf folder of rice was conducted on PR 116 rice variety at farmers' field at Jasso Majara (Distt. Jalandhar). Significantly lower leaf folder incidence was recorded in all the treatments as compared to control. The lowest incidence was observed in standard chemical check (monocrotophos 36SL @ 1400ml/ ha), which was on a par with higher dose of *Bt* @ 2 kg/ha and incidence in both these was significantly lower than in the remaining treatments. The per cent leaves folded at 60 DAT were significantly lower in all the treatments as compared to control. The incidence of leaf folder at 60 DAT was significantly lower in standard chemical check followed by higher dose of *Bt* (2 kg/ha) and it was significantly lower than medium and lower dose of *Bt*. Among the *Bt* treatments, the highest yield of grain was recorded in *Bt* 2 kg/ha which was on a par with monocrotophos 36SL (Table 59).

Table 59. Evaluation of DOR *Bt* against leaf folder of rice at village Jasso Majara (Distt. Jalandhar) during 2007.

Treatments	Per cent Leaves folded DAT		Grain yield (kg/ha)
	45	60	
Bt @ 2.0kg/ha	1.0[a]	1.0[a]	5,980[a]
Bt @ 1.5kg/ha	2.0[b]	1.9[b]	5,790[b]
Bt @ 1.0kg/ha	2.7[c]	2.5[c]	5,650[c]
Monocrotophos 500 g a.i./ha	1.0[a]	0.9[a]	6,020[a]
Untreated Control	4.3[d]	3.3[d]	5,380[d]

Means followed by the same letter in a column are not significantly different (P=0.05)

Analysis of data pooled from three years experiments revealed that *Bt* at 2 kg/ha was as effective as monoctophos in controlling the leaf folder and increasing the yield (Table 60).

Table 60. Evaluation of DOR *Bt* against leaf folder of rice during 2005-2007 (pooled data)

Treatments	% leaves foloded DAT		Grain yield (kg/ha)
	45	60	
Bt @ 2.0kg/ha	1.4[a]	1.1[a]	6,080[ab]
Bt @ 1.5kg/ha	1.9[b]	2.1[b]	5,910[b]
Bt @ 1.0kg/ha	2.9[c]	2.5[b]	5,700[c]
Monocrotophos 500 g a.i./ha	1.4[a]	1.1[a]	6,110[a]
Untreated Control	4.6[d]	3.2[c]	5,380[d]

Means followed by the same letter in a column are not significantly different (P=0.05)

5.2.11. Biological suppression of oilseed crop pests

(i) Laboratory evaluation of Trichogrammatids against castor capsule borer

ANGRAU

Laboratory evaluation of trichogrammatids *viz., Trichogramma chilonis, T. japonicum, T. achae* and *Trichogrammatoidea bactrae* against castor capsule borer was done on potted plants during 2007-08. The results revealed that 28.7% castor capsule borer eggs were parasitized by *T. chilonis* followed by *Tr. bactrae* (22.7%). *T. japonicum and T. achae* could parasitise only 12.7 and 15.2 per cent eggs, respectively.

(ii) Biological suppression of coconut pests

(a) Collection of geographic populations of braconid parasitoids of coconut pests

CPCRI

During the year 2007-08, the incidence of black-headed caterpillar (*Opisina arenosella* Wlk.) was very low in Kerala and only *Meteoridea hutsoni* was collected from Malappuram district. *Bracon hebetor* was collected from Orissa from nut borer of coconut. The *Bracon* species collected so far are being maintained in the lab as separate live cultures.

(b) Large scale validation on biocontrol of coconut leaf caterpillar *O. arenosella*

KAU

The experiment was carried out at Muthalamada area in Palaghat district. The treatments included (a) two releases of *T. embryophagum* adults @ 1000/palm at 5 days interval (b) three release of *Cardiastethus exiguus* nymphs @ 50/palm (c) four releases of *Goniozus nephantidis* adults @ 10/palm (d) sequential release of *T. embryophagum* and *G. nephantidis* and (e) sequential release of *C. exiguous* & *G. nephantidis*.

The incidence of *O. arenosella* was very low, however least number of larvae was recorded on *C. exiguous* and sequential release of *T. embryophagum* and *G. nephantidis* release palms (Table 61).

(c) Evaluation of *Hirsutella thompsonii* for the biocontrol of coconut eriophyid mite

CPCRI

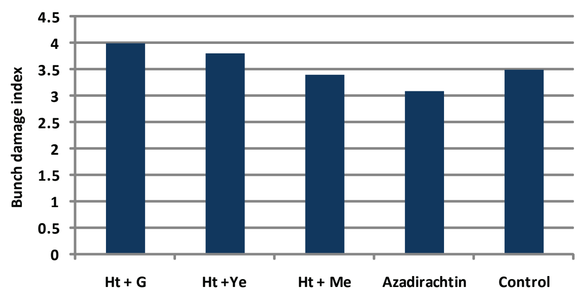
Results of field trial laid during 2006-07 are

Table 61. Impact of parasitoid release on *Opisina arenosella*

Treatments	Larvae/ 10 leaf lets
T. embryophagum adults @ 1000/palm	1.4[b]
C. exiguus numphs @ 50/palm	0.6[bc]
G. nephantidis adults @ 10/palm	1.0[bc]
Sequential release of *T. embryophagum* & *G. nephantidis*	0.6[bc]
Sequential release of *C. exiguus* & *G. nephantidis*	0.0[c]
Untreated control	5.0[a]

Means followed by the same letter in a column are not significantly different (P=0.05)

concluded during August, 2007. Application of *H. thompsonii* with malt extract as adjuvant scored the lowest bunch damage index of 3.4 (1 to 5 scale) and was on par with other treatments (Fig. 31).



Ht: *Hirsutella thompsonii*; G: Glycerin; Ye:Yiest extract; Me: Malt extract

Fig. 31. Bunch damage index at pre harvest stage

KAU

Results of the field experiment to find out the efficacy of *H. thompsonii* with different adjuvants conducted at Cashew Research Station, Madakkathara revealed no significant differences between the treatments. However, the percentage reduction over untreated control was maximum in Dicofol treated palms followed by *H. thompsonii* with glycerin and *H. thompsonii* with conidia and glycerin as adjuvant (Table 62).

(d) Large area demonstration of *Oryctes rhinoceros* management using *Metarrhizium anisopliae* var. *major* and baculovirus

KAU

The demonstration was carried out in cow dung pits at three locations of Thrissur district, Vellanikkara, Mannuthy and Nettissery. The fungal culture is mixed in 300 ml water to obtain a spore concentration of 5 x 10^{11} spores which is sprinkled and mixed with one m^3 breeding medium (FYM) before and after the monsoon. There was cent per cent mortality of *O. rhinoceros* grubs in cow dung pits treated with *M. anisopliae* (Table 63).

Table 62. Efficacy of *H. thompsonii* on coconut mite

Treatments	Mites/ mm^2	Percentage reduction over control
H. thompsonii – Mycelia	2.2	37.1
H. thompsonii - Mycelia + Glycerin	1.4	60.0
H. thompsonii - Mycelia + Conidia	1.5	57.1
H. thompsonii - Mycelia+Conidia +Glycerin	1.4	60.0
Triazophos 0.2%	1.9	45.7
Dicofol	1.1	68.6
Control	3.5	

Table 63. Efficacy of *Metarrhizium anisopliae* var. *major* on *Oryctes rhinoceros*.

Locations	Post-treatment number of diseased grubs/ pupae per m^3 in pits		
	1	2	3
Vellanikkara	10	9	9
Mannuthy	10	12	8
Nettissery	12	5	10

Oryctes baculovirus-treated beetles were released in the field @ 10/ha. Observations were recorded on rhinoceros beetle damage from 15 palms before the release of OBV treated beetles and at six months intervals after the release. The incidence of rhinoceros beetle has came by 50 per cent.

(e) Management of *Oryctes* through integration of Green muscardine fungus (GMF), *Oryctes baculovirus* (OBV) and attractant-baited pheromone traps

CPCRI

The experiment was conducted with 7 treatments, i.e. a) GMF to be treated in 5 pits of 1 m^3 per hectare @ 5 x 10^{11} spores m^3, b) OBV to be released @ 12-15 infected beetles/ha c) Pheromone traps (pt) @ 2 traps/ha. Observations were recorded from 20 palms under each treatment. The Oryctalure pheromone manufactured by Chem Tica International, Cost Rica was used in the PVC trap. The percentage of leaf damage was recorded prior to initiation of treatment and also at 3 months interval for a period of 9 months. Reduction in leaf damage in various treatments varied from 6-58% (Fig. 32). Maximum percentage reduction in leaf damage (58%) was obtained in the treatment where all the three components viz*.,* OrV+ GMF+ Pheromone trap were imposed. There was an average collection of 20-30 adult beetles/trap/ month in the pheromone trap.

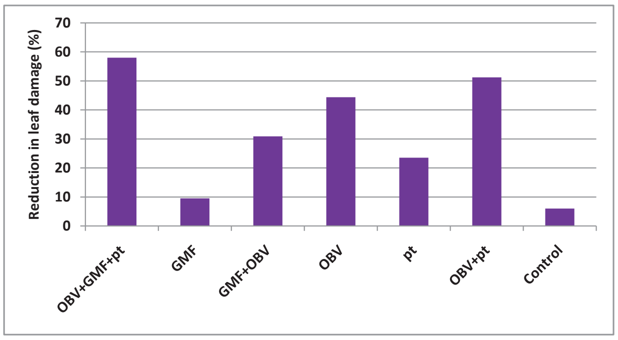


Fig. 32. Efficacy of biocontrol components on management of *Oryctes*

5.2.12. Biological control of cutworm *Agrotis ipsilon* on maize with Entomopathogenic Nematode (EPN)

SKUAS&T (Jammu)

Steinernema carpocapsae and *Hetertorhabditis indica* were applied at 1 and 2 billion ijs/ha. The population of *A. ipsilon* varied from 2.25 to 3.00 larvae per 10 plants in the field before application of the treatments. The population of cutworm after treatment ranged from 0.25 to 1.75. The data on per cent plant damage at coleoptile stage ranged from 4.86 to 9.46 with *H. eterorhabditis indica* @2 billion per hectare being the most effective. The yield was higher in *H. indica* 2 billion ijs/ha followed by *H. indica* 1 billion (Table 64).

5.2.13. Biological suppression of pests of tropical fruits

(i) Evaluation of biological control agents against mango hoppers

IIHR

Field evaluation of the entomopathogens was carried out against mango hoppers on variety Alphonso. Off-season spraying of *M. anisopliae* @ 1 x 10^7 spores/ml and *V. lecanii* @ 1x10^9 spores / ml was made twice at weekly intervals during off-season on the trunk during the month of November. One spray of imidocloprid @ 0.3ml/l was also made during off-season. Observations on the incidence of mango hoppers during off-season revealed that the incidence of hoppers was not found on the tree trunk. However, observations on the incidence of mango hoppers at flowering indicated sporadic occurrence and very low population of hoppers in one or two inflorescence.

MPKV

An experiment was conducted in the research farm of RFRS, Ganeshkhind, Pune on the mango (cv. Keshar) orchard planted at 7 x 7 m spacing over 0.4 ha. The treatments are detailed in Table 65.

Three sprays of *M. anisopliae* @ 1x10^7 conidia/lit on tree trunk during off season as well as during flowering was the most effective among the biocontrol treatments in suppressing the population of the mango leaf hoppers. However spraying of imidacloprid @ 0.3 ml/lit on tree trunk

Table 64. Efficacy of EPN against *Agrotis ipsilon* on maize at Jammu

Parameter	*S. carpocapsae (ijs/ha)*		*H. indica (ijs/ha)*		Control
	1 billion	2billion	1 billion	2 billion	
Larvae/plant (Pre-treatment)	2.75	2.25	2.75	3.00	3.00
Larvae/plant (Post-treatment)	1.75	1.25	1.00	0.25	2.00
Plant damage (%)	22.5	20.70	16.88	11.25	29.16
Yield (kg/ha)	1,785	1,855	1,940	2,200	1,760

as well as another spray at flowering during first week of February 2008 was more effective in reducing the hopper population during flowering stage of mango (Table 65).

Table 65. Efficacy of entomofungal pathogens against the mango leaf hopper

Treatments	Hopper population/ inflorescence and leaf	
	Pre-treatment	Post-treatment
M. anisopliae @ 1x10^7 conidia/lit on tree trunk + at flowering	76.7	19.8 ^{b}
M. anisopliae @1x10^7 conidia/lit on tree trunk	82.6	29.0 ^{d}
V. lecanii @ 1x10^9 conidia/lit on tree trunk + at flowering	79.7	31.0 ^{d}
V. lecanii @ 1x10^9 conidia/lit on tree trunk	80.9	39.8 ^{e}
One spray of imidacloprid 0.3 ml/lit during off season	84.4	23.3 ^{c}
One spray of imidacloprid 0.3 ml/lit during off season + one spray at flowering	83.4	11.6 ^{a}
Untreated control	81.2	91.9 ^{f}

Means followed by the same letter in a column are not significantly different (P=0.05)

TNAU

A field experiment was laid out in Unjavelampatti near Pollachi in Neelum mango in a 10 year old plantation. Among the biocontrol agents tested, application of *M. anisopliae* @ 1x10^7 or *V. lecani* @ 1x10^9 spores/ml on tree trunk during off season and at flowering recorded the lowest mango hopper population (Table 66). However, one spray of imidacloprid @ 0.3 ml/lit during off season followed by one spray at flowering period recorded the lowest hopper population and significantly better than the biocontrol agents.

(ii) Demonstration of biological suppression of pink mealy bugs, *Maconellicoccus hirsutus* with *Cryptolaemus montrouzieri*

a) Grape vine: 1. NRC Grapes, Pune

In a grape garden at MRDBS farm near Pune,

Table 66. Efficacy of entomofungal pathogens against the mango leaf hopper (Unjavelampatti, Tamilnadu)

Treatments	Mango hopper/ inflorescence	
	Pretreatment	Post treatment
M. anisopliae @ 1x10^7 on tree trunk during off season + at flowering	29.9	17.6^b
M. anisopliae @ 1x10^7 on tree trunk during of season	32.3	23.5^c
V. lecani @ 1x10^9 on tree trunk during off season + at flowering	30.9	19.2^b
V. lecani @ 1x10^9 on tree trunk during off season	37.1	23.0^c
One Spray of imidacloprid 0.3 ml/lit during off season	29.6	18.4^b
One Spray of imidacloprid 0.3 ml/lit during off season + 1 Spray at flowering period	38.5	8.1^a
Control	31.4	33.1^d

Means followed by a common letter in a column are not significantly different by DMRT

larvae of *C. montrouzieri* were released @ 2000 / acre in August- September 2007 and repeated in the last week of December. A mean of 0.75% bunch infestation was observed in the released plot as compared to 60.50% bunch infestation in the non-release plot clearly showing the efficacy of biological control.

2. MPKV, Pune

The demonstration was conducted in a farmers' field at village Narayangaon (Tal. Junnar, Dist. Pune) over 1.5 ha. The grape vine plantation (cv. Thompson seedless) was four years old and planted at 3 x 3 m spacing. Two releases of *C. montrouzieri* @ 5,000 beetles/ha during off season as well as two months after October pruning was effective in reducing the mealy bug infestation in grapes as compared to farmer's practice (Table 67).

b) Custard apple: MPKV, Pune

The demonstration of effectiveness of *C.*

Table 67. Efficacy of *C. montrouzieri* for the control of mealy bugs in grape vine

Particulars	Release of *C. montrouzieri*	Farmer's practice
Off season release		
Pre-treatment mealy bugs/shoot	18.6	19.2
Pre-treatment mealy bugs/trunk	26.2	24.5
Post-treatment mealy bugs/shoot	4.5	27.6
Post-treatment mealy bugs/trunk	7.8	29.5
Seasonal release		
Pre-treatment mealy bugs/bunch	26.4	27.5
Pre-treatment bunch infestation (%)	30.7	32.8
Pre-treatment grade in infestation	Medium	Medium
Post-treatment mealy bugs/bunch	5.7	8.4
Post-treatment bunch infestation (%)	6.1	5.8
Post-treatment grade in infestation	Low	Low

montrouzieri against the mealy bug was conducted in a farmers' field at village Pimpale, Tal. Purandhar, Dist. Pune. A custard apple (cv. Balanagar) orchard of 6 years old planted at 4 x 4 m spacing over 1 ha was selected and the predator *C. montrouzieri* @ 2,500 beetles/ ha was released during the second fortnight of July 2007. The farmers' practice with spraying of dichlorvos 0.1% + FORS 2.5 g/lit was maintained for comparison.

Release of *C. montrouzieri* was found effective in reducing the mealy bug population to the extent of 72% with 33% increase in yield of marketable custard apples (Table 68).

(iii) Survey and record of natural enemies of pests on pomegranate, grape vine and mango

a) Pomegranate: MPKV

The chrysopids, *Chrysoperla* sp. and *Mallada* sp. were recorded in pomegranate orchards on

Table 68. Effect of release of *C. montrouzieri* for the control of mealy bugs in custard apple (Pimpale, Pune)

Particulars	Release of *C. montrouzieri*	Farmer's practice
Pre-treatment mealy bug population/fruit	19.8	21.5
Post-treatment mealy bug population/fruit	4.3	48.6
Pre-treatment mealy bugs/fruit	26.8	28.2
Post-release mealy bugs/fruit	7.5	42.3
Per cent reduction / increase (%)	72.0 (decrease)	50.0 (increase)
Number of marketable fruits*	68	47
Fruit yield (kg)*	37.5	28.2
Increase over control (%)	33.0	-

*Average of 20 plants

thrips in Pune, Ahmednagar and Nasik districts of Western Maharashtra during 2007.

b) Grapes: NRC Grapes, Pune

The green lacewing *Chrysoperla carnea* was commonly found in many of the vineyards as a predator of the mealybugs and thrips. *Anagyrus dactylopii* was recorded on the pink mealy bug *Maconellicoccus hirsutus*. *Lepomastix dactylopii* was found parasitizing *Planococcus citri* on grape vines.

Trichogramma manii sp. nov., a new egg parasitoid of pomegranate fruit borer, *Deudorix isocrates* was described.

c) Mango: NAU, Navsari

Activity of *Chrysoperla* sp. was observed on mango thrips and 5 Chrysopa eggs per twig were recorded during 52nd (24-31 December) standard week. On an average 21 mango thrips were consumed by a single larva of chrysoperla.

(iv) Biological suppression of anar butterfly on wild pomegranate

SKUAS&T (Jammu)

The experiment was conducted on wild pomegranate. The tricho cards were glued inside an inverted plastic cup to protect from rain and such cups were tied to trees with vaseline impregnated thread to protect from ants. Six releases of *Trichogramma* starting from end of June onward at weekly interval proved effective in suppression of this pest and reduction of the fruit damage from 33.3 to 14.2 per cent (Fig. 33).

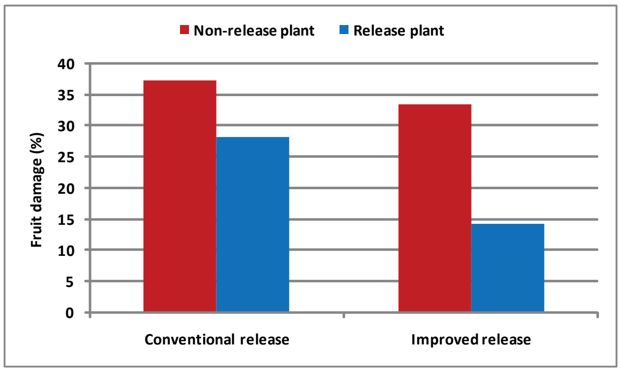


Fig. 33. Efficacy of *T. chilonis* against the anar butterfly on wild pomegranate in Jammu

(v). Field evaluation of formulations of *Verticillium lecanii* of MPKV and PDBC against grape vine mealybug, *M. hirsutus*

NRC Grapes, Pune

In a grape garden at NRC farm, Pune, formulations of *V. lecanii* of MPKV and PDBC against grape mealybug, *M. hirsutus* were sprayed twice at 10 days interval in August- September 2007 and again once in the first week of January 2008. The formulations were ineffective against the mealy bugs.

(vi) Relative toxicity of some chemical insecticides to *C. montrouzieri*

NRC Grapes, Pune

A total of 14 insecticides approved for use in grape vine pest managment were tested for the relative toxicity to *C. montrouzieri*. Buprofezin (1.25ml/l), spinosad (0.25ml/l), thiamethoxam (0.25g/l) and abamectin 0.3ml/lwere found to be relatively less toxic. Imidacloprid (0.3ml/l) was found to be moderately toxic causing 26.67 % mortality one day after application but proved non-toxic after 3 days of application. Methomyl was found to be toxic to the beetle even seven days after application.

(vii) Relative toxicity of some chemical insecticides to the mealybug parasitoid *Anagyrus dactylopii*

NRC Grapes

Among the 14 insecticides tested, lambda cyhalothrin 0.5ml/l, emamectin benzoate 0.22g/l, difenthiuron 0.80g/l, azadirachtin 2ml/l and buprofezin 1.25ml/l were found to be relatively less toxic. Thiamethoxam 0.25g/l, imidacloprid (0.3ml/l) and spinosad (0.25ml/l), were found to be toxic only on the day of application and methomyl was found to be non toxic to the parasitoid on the 7th day of application.

5.2.14. Biological suppression of pests of temperate fruits

(i) BIPM of San Jose Scale on apple: SKUAS&T, Srinagar

Present study was conducted in three different orchards during 2007-08, one with IPM another with conventional chemical pesticides (Farmers' practice) treatment and the third with no treatment. The IPM consisted of six releases of *Encarsia perniciosi* @ 1000 individuals / tree starting from May and 1.5% oil spray (ATSO) during March 2007 and the farmer's practice (FP) received normal practice of winter/ summer oil and need-based chemical sprays and no treatment in unmanaged orchard.

Comparison of three years data (2005-07) through ANOVA, revealed significant difference in parasitism in IPM (F= 7.01**; d.f.= 6) and FP (F= 31.88***; d.f.= 6) whereas non- significant in control (F= 0.97NS; d.f.= 6). Considerable reduction in scale parasitism during 2007 was due to overall decline in number of parasitoids as compared to 2006. Although a positive correlation was found to exist between San Jose scale and its parasitism both in IPM (r= 0.88**; d.f.= 5) and control (r= 0.94; d.f.=5) which indicated gradual build up of parasitoids, it did not result in sufficient level of suppression of the pest. This was primarily because of inadequate quantity of released parasitoids as well as increased hyperparasitic activity of *Marietta* sp., *Azotus* sp. and other aphelinid parasitoids in field conditions.

(ii) Evaluation of some microbial pesticides against the apple stem borer (*Aeolesthes sarta*)

SKUAS&T (Srinagar)

The experiment was carried out in the apple orchard at Shalimar during 2007. The treatments evaluated were *B. bassiana* @ 1x10^{8} spore/ml, *M. anisopliae* @ 10^{13} spores/ml, neem, Celphos and dichlorvos. *B. bassiana* and *M. anisopliae* and the insecticide were injected and celphos was placed into the holes and covered with cotton followed by mud plugging. The perusal of the data revealed that maximum mortality was obtained with celphos followed by neem and dichlorvos. *B. bassiana* and *M. anisopliae* resulted in lower mortality (Table 69).

Table 69. Evaluation of microbial pesticides against the apple stem borer (*Aeolesthes sarta*)

Treatment	Mean mortality (%) (21 DAT)
Celphos	87.3^{a}
Neem	78.8^{b}
B. bassiana @ 1x10^{8} spore/ml	45.6^{e}
M. anisopliae @ 10^{13} spores/ml	51.0^{d}
Dichlorovos	62.4^{c}
Control	12.0^{f}

Means followed by a common letter in a column are not significantly different by DMRT

YSPUH&F

The experiment was conducted at the University apple orchard, Kuftoo farm, Kotkhai (Shimla district). The treatments consisted *B. bassiana* and *M. anisopliae* each at 0.5 g/100 ml (10^{9} conidia/g: 5 X 10^{8} conidia/infested branch), *B. brongniartii* (5 X 10^{8} conidia/branch), *S. feltiae* and *H. bacteriophora* (each at 5000 IJ/infested branch through 10 ml suspension), Eco Neem Plus (containing 10000 ppm azadirachtin @ 0.05 ml/10 ml, *i.e.* 0.5 mg azadirachtin/branch through 10ml emulsion, or 10 ml of 50 ppm suspension), chlorpyriphos 0.1%, dichlorvos 0.1% and emulsified water injected control. The microbials and other insecticides were injected into the holes and plugged with mud.

The results showed that biocontrol agents like *B. bassiana* and *H. bacteriophora* gave only modest level of mortality of the stem borer (less per cent closed holes) and none was as effective as the chemical insecticides (Fig. 34).

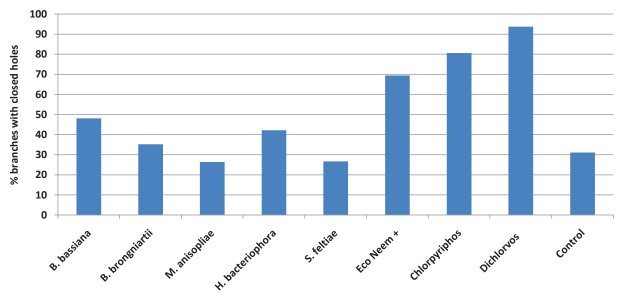


Fig. 34. Impact of biocontrol agents on apple stem borer

(iii) Evaluation of fungal pathogens against the apple wooly aphid (*Eriosoma lanigerum*) on apple

YSPUH&F

Four entomofungal pathogens *B. bassiana*, *M. anisopliae*, *V. lecanii* (each at 10^{7} conidia/ml suspension) and *H. thompsoni* (5 g/l water) were sprayed on apple plants by using a 5-litre sprayer. Post treatment observations on the number of colonies as well as the size of colony showed that none of the fungi could effectively control the aphids (Table 70). The activity of *Coccinella septempunctata* and *Hippodamia variegata* reduced the aphid numbers in control plot.

(iv) Laboratory evaluation of some bioagents against the apple root borer *Dorysthenes hugelii*

YSPUH&F

Entomopathogenic nematodes *S. feltiae* (in sponge sheets @ 8.7 X 10^{7}IJ/sheet) and *H.*

Table 70. Effect of some entomopathogens on woolly apple aphid colonies

Treatment	Pre-treatment		Post- treatment	
	Size in mm	Number	Size in mm	Number
B. bassiana (10^7conidia/ml)	22.05 $\pm$ 4.89	21	17.68 $\pm$ 3.75	19
M. anisopliae (10^7conidia/ml)	19.09 $\pm$ 3.22	32	19.71 $\pm$ 3.27	34
V. lecanii (10^7conidia/ml)	16.05 $\pm$ 1.66	20	12.53 $\pm$ 1.97	19
H. thompsoni (5g/litre)	16.98 $\pm$ 2.57	23	13.87 $\pm$ 1.93	23
Control (emulsified water)	15.73 $\pm$ 3.23	22	10.43 $\pm$ 2.32	21

bacteriophora in talc formulation (with 8 X 10^4 IJ/g product) were applied to the soil. The treated soil was put in petri plate and fresh root borer grubs were released. There was 90-100 per cent mortality of the grubs. There was no mortality of grubs when root bits containing grubs were placed in the treated soil.

(v) Studies on the predators of phytophagous mites on apple and beans

YSPUH&F

The gross and net reproductive rate was higher for the predator mite *Amblyseius longispinosus* when reared on *Tetranychus urticae* than on *Panonychus ulmi*. There was not much variation in approximate and true generation time between *T. urticae* and *P. ulmi*. However, intrinsic rate of increase (r_m) was higher on *T. urticae* than on *P. ulmi*, primarily due to higher net reproductive rate (Table 71). Thus, among the two, *T. urticae* would be an ideal host for multiplication of the predator.

A predator : prey ratio of 1:30 or 1:40 was found appropriate for effective suppression of *T. uriticae* on beans in 15 days after release. A predatory thrips, *Scolothrips sexmaculatus* has also been observed predating upon *T. urticae.*

The larval stage of the predatory mite, *A. longispinosus* did not feed on any of the stages of the European red mite, *P. ulmi.* The protonymph and deutonymph of the predatory mite consumed almost equal number of eggs, nymphs and adults of *P. ulmi*, while adult predatory mite preferred to feed on nymphs and adults rather than eggs during its mean duration of survival of 24 days (Table 72).

Table 72. Feeding potential of *A. longispinosus* on *Panonychus ulmi*

Stage of the predator	Number of different stages of *P. ulmi* consumed			Duration (days)
	Egg	Nymph	Adult	
Larva	0.0	0.0	0.0	0.75$\pm$0.03
Protonymph	3.27$\pm$0.10	2.93$\pm$0.13	2.13$\pm$0.09	1.78$\pm$0.03
Deutonymph	2.40$\pm$0.18	2.77$\pm$0.17	1.97$\pm$0.18	1.87$\pm$0.10
Adult	3.10$\pm$0.29	37.2$\pm$2.36	30.03$\pm$2.05	24.10$\pm$6.97

Table 71. Life table studies of *A. longispinosus* on *T. urticae* and *P. ulmi*

Parameters	*T. urticae*	*P. ulmi*
Gross reproductive rate (females eggs/female)	45.18	28.53
Net reproductive rate, R_o (females eggs/female)	37.88	22.22
Approximate generation time, T_c (days)	19.5	18.30
Innate capacity for natural increase (r_c)	0.18	0.16
True rate of intrinsic increase (r_m)	0.226	0.191
True generation time (days)	16.08	16.23
Finite rate of increase (λ)	1.68	1.55
Weekly multiplication rate	4.85	3.78
Doubling time	3.06	3.62

5.2.15. Biological suppression of pests of vegetables

(i) Field evaluation of *Trichogramma brassicae* against *Plutella xylostella* on cabbage/ cauliflower

Multi-location trials were conducted to evaluate *T. brassicae* against *P. xylostella* on cabbage/ cauliflower. The treatments consisted of (a) 6 releases of *T. brassicae* @ 1 lakh/ha (b) 6 releases of *T. chilonis* @ 1 lakh/ha (c) farmers practice (chemical spray).

AAU (Jorhat)

The experiment was conducted in a farmers' field at Alengmora village (Dist: Jorhat). Both the parasitioids were equally effective in reducing the larval population of *P. xylostella*, but in terms of leaf damage *T. brassicae* was more effective. The highest yield was recorded in *T. brassicae* plots followed by *T. chilonis* plots (Fig. 35). The minimum yield was recorded in the farmers' practice plot.

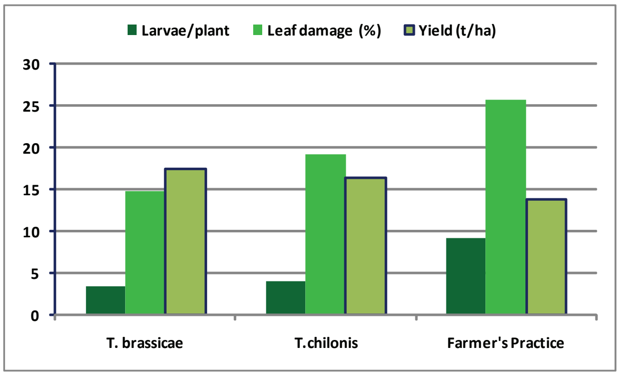


Fig. 35. Efficacy of *Trichogramma brassicae* against *Plutella xylostella* on cabbage

MPKV

An experiment was carried out in the research farm of Agricultural college, Pune on Golden acre cabbage with 45 x 30 cm spacing. Five releases of *T. brassicae* @ 1 lakh/ha/release was made at weekly interval starting from 45 days after transplanting found significantly better than the farmers' practice in reducing the larval population and leaf damage due to DBM and increasing the marketable cabbage head yield. However, both species of parasitoids were on par (Table 73).

Table 73. Evaluation of *T. brassicae* against *P. xylostella* on cabbage (Pune)

Treatment	Larvae/ plant	Leaf damage (%)	Parasitism through retrieval (%)	Yield of market-able heads (kg/ha)
T. brassicae @ 1 lakh /ha	1.7 [a]	23.6 [a]	52.6	28,300 [a]
T. chilonis @ 1 lakh /ha	1.9 [a]	27.7 [a]	48.4	26,600 [a]
Farmer's Practice	4.4 [b]	38.2 [b]	-	21,700 [b]

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

TNAU

An experiment was carried out at Devarayapuram near Thondamuthur for the management of *P. xylostella* on cauliflower. The parasitoids were released three times at weekly intervals following which one round of *Bt* @ 1 kg /ha and neem oil 3.0% were applied at weekly intervals as common sprays except in plots receiving chemical insecticides (Farmers' practice). Data on larval population and yield indicated that both the parasitoids were equally effective in controlling the pest (Table 74). However, *T. brassicae* had a higher cost-benefit ratio, inview of the marginally higher yield.

Table 74. Comparative efficacy of *T. chilonis* and *T. brassicae* against DBM in cauliflower (Thondamuthur, Tamilnadu)

Treatment	Larvae/ plant	Parasitism through retrieval (%)	Yield of market-able heads (kg/ha)	Cost Benefit Ratio
T. brassicae	0.5 [a]	32.5 [a]	16,300 [a]	1:2.5
T. chilonis	0.7 [a]	12.5 [b]	15,700 [a]	1:1.7
Farmer's Practice	3.3 [b]	0.0 [c]	14,500 [b]	

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

SKUAS&T (Jammu)

Weekly releases of *T. brassicae* @ 1 lakh/ ha six times resulted in significant protection of cauliflower from damage by *P xyllostella* recording significantly higher yield and net return than *T. chilonis* with a C:B ratio of 1:9.75. It was better than the prevailing farmers' practices comprising

Table 75. Field evaluation of *T. brassicae* and *T. chilonis* against *Plutella xylostella* on cauliflower (Jammu)

Treatment	Larvae/ plant	Leaf infestation/ m²	Egg parasitism (%)	Yield (kg/ha)	Net Profit (Rs/ha)	Profit over control (Rs/ha)	C:B ratio
T. brassicae	5.2[a]	22.1[a]	46.4[c]	25,120[a]	1,23,500	19,500	1:9.75
T. chilonis	7.1[ab]	29.0[b]	34.5[b]	23,320[b]	1,14,500	10,500	1:5.25
Farmers' Practice	9.3[b]	32.3[b]	02.41[a]	22,630[b]	1,09,000	5,000	1:1.25
Control	15.8[c]	48.5[c]	05.25[a]	20,810[c]	1,04,000		

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

of 1-2 spray applications of napthalene/ganda phenyl followed by 2-3 application of conventional insecticides (Table 75).

(ii) Bio-suppression of *Pieris brassicae*

a) Field evaluation of *Trichogramma brassicae* against *Pieris brassicae* on cabbage

SKUAS&T (Srinagar)

Two field experiments were conducted at two different cabbage fields at Shalimar, isolated by a distance of 2 km. The treatment consisted of release of *T. brassicae* @ 1 lakh/ha and comparing with farmers practice of application of dichlorvos and monocrotophos. Data showed that release of *T. brassicae* failed to control *P. brassicae* population. The egg parasitism was very low indicating unsuitability of *T. brassicae* against *P. brassicae* on cabbage.

(b) Effectiveness of various microbial pesticides and a summer oil against *P. brassicae* on Knol khol

SKUAS&T (Srinagar)

The field experiment on evaluation of various microbials and oils against *P. brasicae* on knol khol was carried out in the farm of Division of Entomology, SKUAST-K during 2007. The treatments consisted of *B. bassiana* @ 1x10^8 spore/ml, *B. thuringiensis* @ 1 kg/ha, *M. anisopliae* @ 10^{13} spores/ha, *H. indica* @ 2 billion /ha, and oils, D.C.Tron Plus @ 0.75%, Neem @ 1.0% and an insecticide dichlorvos @ 0.05% and untreated control (Check).

Application of *B. bassiana* resulted in 53.3 % larval mortality and was on par with *M. anisopliae* (46.6%), *B. thuringiensis* (40.0%), neem (50.0%) and oil (46.7%). The EPN *H. indica* was ineffective recording only 16.3% mortality. Dichlorvos, however recorded cent per cent mortality 16 days after spray.

(c) Field evaluation of entomopathogenic nematodes against *P. brassicae*

SKUAS&T (Jammu)

Application of *S. carpocapsae* (PDBC), *S. carpocapsae* (JMU) and *H. indica* (PDBC) @ 1 and 2 billion IJs/ha failed to control *P. brassicae* on cabbage at Jammu during 2007-08.

(iii) Evaluation of *T. brassicae* and *Bt* against DBM of cabbage

IIHR

A field experiment was carried out of Bangalore to evaluate the efficacy of various biological control agents in controlling DBM on cabbage var. Maharani during 2007-08. The treatments consisted (a) DOR Bt - 1kg/ha (b) *T. brassicae* @1 lakh /ha/release (6 releases) (c) DOR Bt - 1kg/ha + *T. brassicae* @1 lakh /ha/release (6 releases) (d) control.

Combined application of Bt and *T. brassicae* was the more effective in controlling the pest population and increasing the yield (Table 76).

Table 76. Effect of biological control agents on the incidaence of DBM

Treatments	Larvae/plant	Yield (Kg/ha)
Bt	0.72	69,180
Bt + T. brassicae	0.47	75,460
T. brassicae	0.86	61,940
Control	4,022	45,040

MPUAT, Udaipur

A field experiment was laid out to test the efficacy of bicontrol agents against *P. xylostella* in cabbage. The treatments are detailed in table 76. The biopesticides were applied at weekly interval after 20 DAP. Lowest numbers of larvae were recorded per plant in DOR *Bt* which was on par with release of *T. brassicae* and spray of *B. bassiana*. Among the biocontrol agents *Bt* recorded the highest yield of cabbage and highest net return, spinosad however registered a significantly higher yield and net return than *Bt* (Table 77).

(iv) Evaluation of *Trichogramma chilonis*, EPN and *Bt* against fruit borer of brinjal and Okra

KAU

Results from a field experiment inThrissur, Kerala indicated that application of *S. carpocapsae* @ 2 billion/ha, *Bt* @ 2 kg/ha and release of *T. chilonis* @ 50,000/ha were equally effective in increasing the fruit yield in brinjal (Table 78).

PAU

The field experiment was conducted on okra variety Punjab 8 for the management of fruit borer, *Earias* spp. Significantly lowest fruit damage and highest yield was recorded in DOR *Bt* @ 2 kg/ha which was on par with endosulfan application (Table 79). All the treatments gave significantly

Table 78. Efficacy of bioagents on brinjal shoot and fruit borer infestation

Treatments	Damage (%)		Fruit yield (kg/ha)
	Shoots	Fruits	
EPN @1b/h	6.8	29.3	6,869[b]
EPN @2b/h	9.8	26.0	11,416[a]
B. t. 2kg/h	4.4	26.5	10,305[a]
T.chilonis @ 50000/h	9.6	27.5	10,885[a]
Carbaryl (0.2 %)	8.3	21.7	8,746[ab]
Control	4.3	30.8	6,676[b]

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

Table 79. Effect of biocontrol agents on fruit borer, *Earias* spp in okra (Punjab)

Treatments	Fruit damage (%)	Marketable yield (kg/ha)
DOR *Bt* @ 2.0 kg/ha	17.5 [a]	6,130 [a]
DOR *Bt* @ 1.5 kg/ha	22.1 [b]	5,550 [b]
T. chilonis @ 50,000/ha	24.1 [bc]	5,150 [cd]
EPN @ 2 billion/ha	24.5 [bc]	5,490 [bc]
EPN @ 1 billion/ha	28.8 [c]	5,080 [d]
Endosulfan 300 g a.i./ha	18.4[a]	6,160[a]
Control	37.0 [d]	4,230 [e]

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

Table 77. Evaluation of bioagents against lepidopterous pests of cabbage (Udaipur)

Treatments	Larvae/ plant	Yield (kg /ha)	Value of yield/ha (Rs)	Cost of treatments (Rs/ha)	Net return (Rs/ha)	C:B ratio
T. brassicae @ 1 lakh/ha/release (6 releases)	1.44 [a]	58,525[c]	2,92,625	1,320	2,91,305	1:1.12
B. bassiana ($1x10^8$ spores/ml)	1.51 [b]	55,094[b]	2,75,468	2,040	2,73,428	1:1.05
DOR *Bt* 1 kg/ha	1.34 [a]	69,819[e]	3,49,093	7,440	3,41,653	1:1.29
NSP 4%	1.40 [a]	65,300[d]	3,26,500	2,640	3,23,860	1:1.24
Spinosad 0.75 ml/l	1.33 [a]	74,700[f]	3,73,500	5,211	3,68,289	1:1.40
S. carpocapsae	1.48 [ab]	58,153[c]	2,90,765	2,440	2,88,325	1:1.11
Control	1.73[c]	51,669[a]	2,58,343	-	2,58,343	

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05) higher yield than control but among the biocontrol treatments, none was on par with *Bt* @ 2 kg/ha.

Results of another field trial on brinjal also showed that Bt @ 2 kg/ha was the most effective in reducing the fruit damage and increasing the yield of fruits (Table 80).

Table 80. Evaluation of biocontrol agents against shoot and fruit borer of brinjal (Punjab)

Treatments	Fruit damage (%)	Yield (kg/ha)
DOR Bt (2.0 kg/ha)	38.7^{ab}	32,190^{a}
EPN @ 2 billion /ha	44.8^{cb}	26,450^{b}
EPN @ 1 billion /ha	54.4^{e}	23,820^{c}
T. chilonis@ 50,000/ha	46.3^{e}	27,700^{b}
Hostathion 40EC @ 500ml/ac	37.1^{ab}	33,750^{a}
Control	56.4^{e}	20,250^{d}

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

AAU (Jorhat)

Evaluation of *T. chilonis*, EPN and *Bt* against shoot and fruit borer of brinjal in the farmers' field located at Alengmora (Dist: Jorhat) showed that lowest fruit damage was recorded in endosulfan treatment which was on par with EPN @ 2 b/ha. Among the biocontrol treatments, *T. chilonis* recorded the highest fruit yield which however was only second to endosulfan (Table 81).

Table 81. Biological control of fruit borer of brinjal (Jorhat)

Treatments	% fruit damage	Fruit yield (kg/ha)
Bt @ 2 kg/ha	26.4^{b}	12,992^{d}
EPN @ 1 billion/ha	26.0^{b}	13,327^{c}
EPN 2 billion/ha	22.7^{a}	14,630^{c}
T. chilonis @ 50,000/ha	28.8^{b}	17,997^{b}
Endosulfan 35EC @ 300 ai/ha	20.7^{a}	19,917^{a}
Control	41.4^{c}	9,552^{e}

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

(v) Demonstration of biological control of tomato fruit borer *Helicoverpa armigera*

PAU

The experiment was conducted at Entomological Research Farm, PAU, Ludhiana. BIPM consisting of application of talc formulation of *Pochonia chlamydosporia* @ 20 kg/ha (10^8 spores/g) + three releases of *T. chilonis*/ *T. pretiosum* @ 1 lakh/ha at 10 days interval + alternate two sprays of HaNPV @ 1.5 x 10^{12} POB/ha in 0.5% crude sugar was compared with farmers practice of two sprays of endosulfan 35 EC @ 700 g a.i./ha at two weeks interval.

The results revealed that the number of larvae/10 plants and per cent fruit borer damage in the plot of chemical control was lower than BIPM plot (Fig.36). However, 35.31% parasitisation was recorded in the BIPM plot, whereas there was no parasitisation noticed in the farmers' practice. There was no mortality due to nematodes and no incidence of disease. The yield was higher in the farmers' practice as compared to BIPM. It may be concluded that the farmers' practice was better than the BIPM practice in controlling tomato fruit borer.

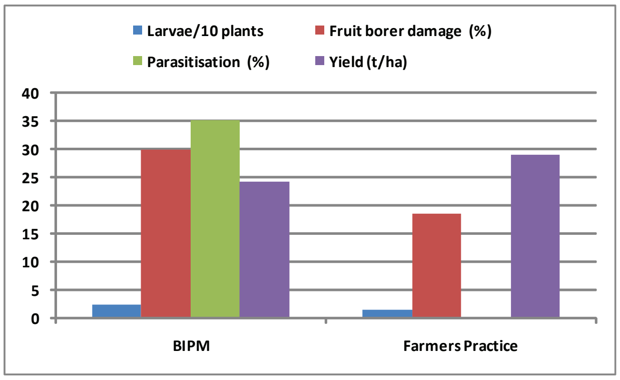


Fig. 36. Demonstration of biological control of tomato fruit borer, *H. armigera*

(vi) Demonstration of Potato Tuber Moth suppression by releasing *Copidosoma koehleri*

MPKV

The demonstration was undertaken in a farmer's field at village Peth (Tal. Ambegaon, Dist. Pune) to show the effectiveness of *C. koehleri* against PTM on Kufri Jyoti variety with 45 x 30 cm spacing.

Inundative releases of *C. koehleri* @ 5,000 mummies/ha in four equal dosages by placing them in perforated plastic vials (3- 4 mummies/vial) at weekly interval starting from 45 days after planting was found significantly more effective than farmers' practice of two sporays of endosulfan 0.07% at 15 days interval and untreated control in reducing the leaf mines as well as tuber infestation due to PTM and increasing marketable potato yield (Table 82).

Table 82. Effect of release of *C. koehleri* against PTM in potato (Peth Village, Pune)

Treatments	Leaf mines/ m row	Tuber infestation (%)	Marketable yield (kg/ ha)
C. koehleri	0.5 [a]	5.4 [a]	19,530 [a]
Farmers' practice	1.0 [b]	8.1 [b]	17,280 [b]
Untreated control	3.7 [c]	26.3 [c]	14,620 [c]

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

(vii) Survey of natural enemies of greenhouse whiteflies (GHWF)

YSPUH&F

The survey revealed parasitisation of green house white fly by *Encarsia sophia* (= *E. transvena*), *Encarsia inaron* and *Eretmocerus delhiensis.*

5.2.16. Biological suppression of white grubs

(i) Biological suppression of white grubs in potato

YSPUH&F

Efficacy of *S. feltiae* and *H. bacteriophora* was tested against the white grub, *Brahmina coriacea* in the laboratory. The maximum mortality obtained was 20 and 40% with *S. feltiae* and *H. bacteriophora,* respectively, after 3 weeks of treatment; however, EPN was not recovered from dead white grubs, while these could be detected in *G. mellonella* larvae used to monitor survival of EPNs in the soil. With *H. bacteriophora*, mortality obtained was 30, 40, 50 and 70% in the first four weeks at 1.6 X 10^{10} IJs/ha. The surviving white grubs had made earthen cells for overwintering. The live or dead EPNs or their developing stages were present in dead grubs at 1.6 X 10^{10} IJs/ha dose. Among the fungi, *B. bassiana* gave 20% mortality of the white grubs.

Two field trials were laid out (in collaboration with Department of Entomology, CSKHPKV, Palampur), one at Agriculture Department Potato Farm, Kedadhar (Sirmaur district) and other at Shilaroo Potato Farm (Shimla district). The treatments were *B. brongniartii* and *M. anisopliae* each at 10^{14} conidia/ha, *H. indica* @ 4X10^{9} IJ/ha, chemical control check (chlorpyriphos 800g a.i. / ha) and control.

At Kedadhar, both entomopathogenic fungi significantly reduced the white grub population in the treated fields as compared with untreated control but the reduction was not to the extent obtained with the chemical treatment (Table 83). Both fungal preparations were equally effective and per cent tuber damage was just half of that in untreated control (21.7-25.7%). Nevertheless, insecticide treatment was the best in reducing the tuber damage. The marketable yield was also highest in insecticide treatment. With entomopathogenic fungi, the yield was moderate though significancly better than control.

In the field experiment at Shilaroo, *H. indica* was the most effective in reducing the white grub population and damage to tubers and increasing the tuber yield. The fungus *B. brongniartii* was equally effective but better than *M. anisopliae* (Table 83).

MPKV

The local isolates of *M. anisopliae* and *B. bassiana* were tested under laboratory conditions to determine LC_{50} and LT_{50} values. In the Initial Evaluation Trial (IET) the estimated LC_{50} values were 5.8 x 10^{5} conidia/ml for *M. anisopliae* and 7.5 x 10^{5} conidia/ml for *B. bassiana.* The LT_{50} values

Table 83. Efficacy of entomofungi against white grubs of potato at Keradhar, Sirmaur

Treatments	White grubs / 10 plants		Tuber damage (%)		Tuber yield (kg/ha)	
	Keradhar	Shilaroo	Keradhar	Shilaroo	Keradhar	Shilaroo
B. brongniartii (10^{14}conidia/ha)	22.7[b]	23.9[ab]	21.7[b]	22.8[a]	7,473[c]	7,049[a]
M. anisopliae (10^{14}conidia/ha)	24.3[b]	29.7[b]	25.7[b]	45.3[b]	8,780[b]	5,120[b]
H. indica (4 X 10^9 J/ha)	-	18.6[a]	-	18.0[a]	-	7,432[a]
Chlorpyriphos (800g a.i./ha)	7.7[a]	-	7.6[a]	-	14,507[a]	-
Control	35.7[c]	51.4[c]	50.4[c]	61.3[b]	5,800[d]	3,172[c]

Means followed by a common letter in a column are not significantly different by DMRT (P=0.05)

were 4.9 days for *M. anisopliae* and 6.7 days for *B. bassiana*. It indicates that *M. anisopliae* is more pathogenic to white grubs than *B. bassiana.*

A field experiment was carried out in a farmer's field at village Kolharwadi (Tal. Ambegaon, Dist. Pune) on Kufri jyoti variety with 45 x 30 cm spacing. The treatments consisted of (a) *M. anisopliae*-enriched FYM (2 x 10^{10} conidia/kg) @ 20 kg/ plot (b) *B. bassiana*-enriched FYM (2 x 10^{10} conidia/kg) @ 20 kg/ plot (c) *M. anisopliae* + *B. bassiana*-enriched FYM @ 20 kg / plot (d) Phorate 10G @ 10 kg / ha and (e) Untreated control

The results revealed that soil application of *M. anisopliae*-enriched FYM (2 x 10^{10} conidia/ kg) @ 20 kg/plot at the time of planting of tubers significantly reduced the larval population of white grubs as well as tuber damage and increased the marketable potato yield (Table 84).

Table 84. Efficacy of entomofungal pathogens against white grubs in potato (Kolharwadi, Pune)

Treatment	White grubs /m row	Mycosis (%)	%Tuber damage	Marketable yield (kg/ha)
M. anisopliae	1.5 [a]	44.4	6.9 [a]	27,100 [a]
B. bassiana	1.9 [b]	30.2	14.7 [b]	23,000 [a]
M. anisopliae + *B. bassiana*	1.8 [b]	31.8	9.1 [a]	26,400 [a]
Phorate 10 G	1.3 [a]		16.1 [b]	25,300 [a]
Untreated Control	3.0 [c]		27.8 [c]	19,800 [b]

Means followed by the same letter in a column are not significantly different (P=0.05%)

ii) Biological suppression of white grubs using FYM-enriched with *Beauveria bassiana* in sugarcane.

CCSHAU

The experiment was laid out in sugarcane in the farms of Cooperative sugar Mills, Sonipat (Haryana) on a 0.4 ha field. *B. bassiana* in three different concentrations viz. 2X10^{10}, 4 X 10^{10} and 6 X 10^{10} conidia per kg of farmyard manure were applied in furrow at the time of sugarcane planting while untreated plots received farmyard manure only. Insecticide application was made at the end June with irrigation water. The lowest number of healthy grubs and highest per cent of infected grubs were recorded in plots provided with FYM containing the highest dose of *B. bassiana* i.e. 6x10^{10} conidia/kg (Table 85).

Table 85. Efficacy of *Beauveria bassiana* against white grubs in sugarcane (Sonipat, Haryana)

B. bassiana dosage/ kg FYM	Grub number/ m	Infected grubs (%)
2 x 10^{10} conidia	1.98	10.6
4 x 10^{10} conidia	2.09	13.8
6 x 10^{10} conidia	1.75	14.9
Control (FYM alone)	3.26	-
Phorate @ 2 kg a.i./ha	0.87	-

5.2.17. Biological suppression of weeds

(i) Biocontrol of *Cyperus rotundus*

KAU

In a survey, the banana mealy bug *Geococcus citrinus* was recorded on roots of *Cyprus rotundus*, in Thrissur.

NRCWS, Jabalpur

Only *Bactra minima* and *Rhopalosiphum nymphacae* were observed to attack *C. rotundus* in very mild form (2-9%) and did not cause any significant damage to the weed.

An unidentified rust fungus of genus *Puccinia* was found to infect only *C. rotundus* and did not show any infection on 72 crop plants, 45 weeds and five other species of *Cyperus* in host specificity tests. This rust bioagent may be considered for the biological control of *C. rotundus*.

(ii) Biocontrol of *Chromolaena odorata* using *Cecidochares connexa*

KAU

Out of 182 galled shoots received from the PDBC, 108 adults emerged which were released on caged potted *Chromolaena* plants. A total of 101 adults from second and third generation were field released during November 2007. Only two galls were observed in December 2007 indicating poor field establishment in Kerala.

AAU, Jorhat

Out of the total of 30 pairs of adults, 20 pairs were released in Hahsara and 10 pairs at Halwa goan, Golaghat district of Assam during 2007. The gall fly had established in Assam as could be seen from the presence of fresh galls during 2008.

TNAU

The stem gall fly released at Periapodu village near Anamalai during 2007 has established well on Chromolaena plants resulting in several stem galls leading to significant reduction in plant height, internodal length, number of panicles per plant, number of capitula per panicle and seed germination (Table 86).

(iii) Investigations on the differential performance of *Cyrtobagous salviniae* against *Salvinia*

KAU

Water samples were drawn from locations where *Salvinia* is controlled successfully by *Cyrtobagous* and the results are given below (Table 87).

Table 87. Water quality analysis

Parameters	Contents
Turbidity	1.6 NTU
pH	5.43
Electrical conductivity	87 Micro mhos/cm
Acidity	16 mg/l.
Alkalinity	22 ”
Hardness (as Ca CO_3)	20 ”
Calcium (as Ca)	5.6 ”
Magnesium (as Mg)	1.45 ”
Chloride (as Cl)	20 ”
Fluoride (as F)	Nil
Iron (as Fe)	0.35 ”
Nitrate (as NO_3)	6.20 ”
Bacteriological analysis	+ No. of Coliforms/100 ml 1100 No. of E.Coli/100ml
Sulphate (as SO_4)	3.8 mg/l
Phosphate (as PO_4)	0.04 mg/l
Manganese	Nil

A survey was conducted in Thrissur and Ernakulam districts to collect water samples from ponds without *Cyrtobagous* on *Salvinia.* But the weevils were present in all the areas.

Table 86. Impact of *Cecidochares connexa* on *Chromolaena odorata*

Treatments	Plant Height 120 days after release (in cm)	Branches/ plant	Panicles/ plant	Capitula/ panicle	Seeds/ head	Seed germi-nation (%)
Released Field (Plants with galls)	156.2[a]	26.9	22.3[a]	11.4[a]	24.1	76.4[a]
Non released field	194.4[b]	29.1	25.0[b]	12.6[b]	26.2	87.0[b]
Reduction over non released field (%)	14.5	7.2	10.8	9.5	7.3	12.2

Means followed by a common letter are not significantly different by paired‘t’ test

5.2.18. Biological suppression of polyhouse crop pests

(i) Evaluation of biological control agents against *T. urticae* on rose: MPKV

An experiment was conducted at the Agricultural College, Pune on rose (variety Gold strike) at 90 x 60 cm spacing. The treatments consisted of (a) *B. bassiana* @ 10^{10} conidia/lit (b) *M. anisopliae* @ 10^{10} conidia/lit (c) *H. thompsonii* @ 10 g formulation/lit (d) *V. lecanii* @ 10^{10} conidia/lit (e) *Steinernema* sp. @ 1 lakh in sponge formulation /lit (f) Standard chemical insecticide (Abamectin 1.9 EC) 0.5 ml /lit and (g) Untreated control.

H. thompsonii recorded significantly the least mite population after the third spray and was on par with abamectctin spray (Table 88). The next best treatment in reducing mite population was *V. lecanii*.

Table 88. Effect of fungal pathogens and EPN against *T. urticae* on rose

Treatment	Mite population/ compound leaf	
	Pre-treatment	Post-treatment
B. bassiana	68.5 ^{a}	28.4 ^{d}
M. anisopliae	68.7 ^{a}	24.2 ^{c}
H. thompsonii	70.0 ^{a}	13.7 ^{a}
V. lecanii	72.5 ^{a}	15.8 ^{b}
Steinernema sp.	64.0 ^{a}	45.2 ^{e}
Abamectctin	70.7 ^{a}	11.3 ^{a}
Untreated control	65.0 ^{a}	133.8 ^{f}

(ii) Evaluation of anthocorid predator, *Blaptostethus pallescens* against spider mites on carnation: MPKV

A trial was laid out at commercial Hi-Tech Floriculture Project, Agricultural College, Pune on carnation cv. Tempo in pots arranged in 5 x 2 m bed size with 60 x 30 cm plant spacing. Four to five releases of the predator *B. pallescens* were made @10 and 20 adults/plant.

Four releases of anthocorid predators @20 per plant at weekly interval reduced the mite population significantly. However spraying of abamectin @ 0.5 ml /lit at 15 days interval was the most effective in reducing mite population in carnation (Table 89).

Table 89. Effectiveness of anthocorid predators against spider mites on carnation in poly-house

Treatment	Mites number per flower bud
Release of 10 anthocorids/plant	44.7 ^{c}
Release of 20 anthocorids/plant	32.7 ^{b}
Abamectin 0.5 ml/lit spray	27.5 ^{a}
Untreated control	91.5 ^{d}

(iii) Biological control of thrips, *Frankliniella* sp. in gerbera: KAU

The experiment was conducted at the college of Horticulture, Vellanikkara on Gerbera in polyhouse. The lowest thrips population per leaf was recorded in verticel followed by *B. bassiana*, *H. thompsonii*. Significantly higher thrips population was recorded in EPN treatment. In control, the thrips count was persistently high throughout the experimental period (Table 90).

Table 90. Efficacy of bioagents against thrips on ger-bera at Kerala

Treatments	Mean number thrips /leaf after spray		
	I	II	III
Metarhizium anisopliae @10^{10} conidia/lit.	5.3	2.6^{abcd}	1.4^{cde}
Beauveria bassiana @10^{10} conidia/lit.	3.0	1.1^{cd}	0.3^{de}
Verticel @10^{10} conidia/lit.	2.6	3.4^{abc}	0.2^{e}
Hirsutella thompsonii @10 g formulation/lit.	3.5	1.3^{bcd}	0.7^{de}
Verticillium lecanii @10^{10} conidia/lit.	3.6	1.5^{bcd}	1.0^{de}
S. carpocapsae 1 lakhs/m^2	1.5	1.5^{bcd}	3.1^{bc}
H. indica 1 lakhs/m^2	2.7	4.6^{a}	3.9^{b}
Triazophos 2 ml/lit.	2.1	0.7^{d}	0.9^{cd}
Control	5.0	3.6^{ab}	9.4^{a}

5.2.19. Establishment of biocontrol laboratory

AAU (Jorhat)

Biocontrol Laboratory was established to mass produce *Trichogramma japonicum, T. chilonis, T. brassicae, T. mwanzai* and *Trichogrammatoidea bactrae.* The biocontrol agents produced in the laboratory are being utilized for teaching and training of farmers, Extension Workers, enterpreneurs and also students of P.G. Research.

Cultures of parasitoids have been supplied to different Regional Research stations of AAU, KVKs, and Agricultural Officers Govt. of Assam for their field demonstration.

PAU

During 2007-08, the following biocontrol agents were mass produced.

Bioagents mass produced at PAU

Name of Biocontrol agents produced during 2007-08	Monthly production capacity	Total annual production (2007-08)
T. chilonis	2000 cards	18,700 cards
T. japonicum	400 cards	4000 cards
Chelonus blackburni	3200 adults	20,000 adults
Chrysoperla carnea	10,000 grubs/adults	90,000 grubs/adults

MPKV

The following cultures of bioagents were maintained in the laboratory along with their hosts. These bioagents were used for experimental purposes at this centre as well as supplied to other AICRP centres. *Trichogramma* spp., *C. koehleri, C. montrouzieri* and *D. aphidivora* were mass cultured and used for demonstrations and distributed to farmers (Table 91).

Table 91. Mass production of bioagents in MPKV, Pune

Bioagent	Quantity produced	Quantity sold	Receipt accrued (Rs.)	Balance quantity
Trichocard	750	46	1,840	Nil
C. koehleri	5,000 mummies	-	-	200
C. montrouzieri	17,500	1,885	3,370	1,200
D. aphidivora	7,000	-	-	Nil

Parasitoids: *C. koehleri, C. blackburni, T. chilonis, T. japonicum, T. pretiosum, Tr. bactrae, T. brassicae*

Predators: *C. montrouzieri*t, *D. aphidivora, Chrysoperla carnea*

Laboratory hosts: *P. operculella, C.cephalonica, M. hirsutus, C. lanigera*

NAU, Navasari

Chrysoperla carnea was mass reared and a total of 4,84,945 eggs of *C. carnea* was produced from August 2007 to March 2008.

CCSHAU

The nymphal-adult parasitoid, *Epiricania melanoleuca* and egg parasitoids of leaf hopper, *Pyrilla perpusilla* were multiplied *in vivo* using various life stages of natural host at Biological control Laboratories located at CCS Haryana Agricultural University's Regional Research Station, Karnal and Biological Control Laboratories located in the premises of Cooperative Sugar Factories, Sonipat, Maham, Shahbad and Jind. A total of 21,476 egg-masses and 38,966 cocoons of *E. melanoleuca* and 18,519 egg masses of an egg parasitoid of *P. perpusilla* were produced/ collected and supplied to farmers for their liberation in 6,946, 6,532 and 8,273 acres of sugarcane and sorghum fields from July 2007 to October 2007. Simultaneously the laboratories also produced 46,78,84,000 egg parasitoids, *Trichogramma chilonis* and 1,63,48,000 *T. japonicum* and supplied these to farmers of Haryana state for inundative releases in 25,836 and 1,619 acres of borer infested fields of sugarcane and rice (Table 92).

Table 92. Details of biocontrol agents produced and supplied to farmers during 2007

No. of biocontrol units/labs/state/central	Name of bio-agent	Monthly production	Total annual production	Crops covered	Area covered (in acres)
Five (Biocontrol laboratory, CCS HAU, RRS, Karnal and Bio-control laboratories,Co-op. Sugarmills Sonipat, Jind, Meham and Shahbad)	*T. chilonis*	1,54,583600	4,67,88,4000	sugarcane	25836
	T. japonicum	59,76,000	1,63,48,000	sugarcane	1619
	Epiricania melanoleuca	2548 3793	21476 38966	sugarcane sorghum	6946 6532
	Egg parasitoids of Pyrilla	4267 card	18519	sugarcane	8273
	Beauveria bassiana	produced for research trials	2.05 Kg for research trial		

6. TECHNOLOGY ASSESSED, TRANSFERRED AND MATERIALS DEVELOPED

Technology developed and transferred

PDBC, Bangalore - Talc-based formulation of *Heterorhabditis indica* and *Steinernema carpocapsae* PDBC-EN 6.11 developed for use against the arecanut root grub, *Holotricha indica*.

ANGRAU, Hyderabad - Sequential application of bio agents, *Bt* – *Ha*NPV – endosulfan - *Bt* in pigeonpea against *Helicoverpa* Bio-intensive management of pod borer complex through *Ha* NPV-NSKE alternation in pigeonpea.

GBPUA & T, Pantnagar - Improved method of vermin-composting developed by addition of *Pseudomonas fluorescens* which multiplies in the compost and enhances population of earthworm by 2 to 3 times. Such vermicompost acts as both biopesticide and biofertilizers.

MPKV, Pune - Developed mass production technique of *Dipha aphidivora*, a predator of sugarcane woolly aphid in shade net conditions and demonstrated in International Hi-Tech Agro-Week held at College of Agriculture, Pune during November 17-21, 2007. About 1500 farmers visited this demonstration.

PAU, Ludhiana - Eight releases of *Trichogramma chilonis* and *T. japonicum* each @ 50,000/ha from mid April to end June at 10 days interval for the management of early shoot borer of sugarcane, *Chilo infuscatellus* as well as top borer, *Scirpophaga excerptalis.*

DNA sequences generated and deposited

Jalali, S. K., Ashok Kumar, G., Niranjana, P., Venkatesan, T., Murthy, K. S. and Lalitha, Y. 2007. Internal transcribed spacer 2 sequence variation in Trichogramma – *Trichogrammatoidea armigera*, 401bp. (GenBank Accession No. EU251072).

Jalali, S. K., Ashok Kumar, G., Niranjana, P., Venkatesan, T., Murthy, K. S. and Lalitha, Y. 2007. Internal transcribed spacer 2 sequence variation in Trichogramma – *Trichogrammatoidea bactrae*, 486bp. (GenBank Accession No. EU251071).

Jalali, S. K., Ashok Kumar, G., Niranjana, P., Venkatesan, T., Murthy, K. S. and Lalitha, Y. 2007. Internal transcribed spacer 2 sequence variation in Trichogramma – *Trichogramma achaeae*, 607bp. (GenBank Accession No. EU251070).

Srinivasa Murthy, K., Jalali, S. K., Vankatesan, T., Rjaeshwari, R. and Ashok Kumar, G. 2007. ITS-2 sequence variation in *Goniozus nephantidis* (bases 1- 467 bp) (Kerala). 5.8 S rRNA partial sequence. (GenBank Accession No. EU 16231).

Srinivasa Murthy, K., Jalali, S. K., Vankatesan, T., Rjaeshwari, R. and Ashok Kumar, G. 2007. ITS-2 sequence variation in *Goniozus nephantidis* (bases 1- 599 bp) 18 S rRNA Partial sequence (Andhra

Pradesh). (GenBank Accession No. EU 516348).

Srinivasa Murthy, K., Jalali, S. K., Venkatesan, T., Rjaeshwari, R. and Ashok Kumar, G. 2007. ITS-2 sequence variation in *Cotesia flavipes* (bases 1- 555) (GenBank Accession No. EU 516349).

Materials developed

PDBC, Bangalore

Sunil Joshi & Poorani, J. 2007. *Aphids of Karnataka*. URL: www.aphidweb.com (compendium on the aphid fauna of Karnataka covering 67 species, covering diagnostic and other information such as host plants and natural enemies with photographs and other illustrations).

Poorani, J. 2007. Aphids of Karnataka - Web photo album on Picasaweb (the largest of its kind with 1160 digital photographs of aphids of Karnataka). URL: : http://picasaweb.google.com/home Dr. M. Nagesh - Clones of two novel genes with functional proteins were developed from *Photorhabdus luminescens* which can be potentially useful for insect control.

7. EDUCATION AND TRAINING

Name	Training programme	Duration	Place
Project Directorate of Biological Control, Bangalore			
Ms. Shashikala S. Kadam	Purchase procedure	14-05-2007 to 16-05-2007	ISTM, New Delhi
Dr. K. Srinivasa Murthy & Dr. S. S. Hussaini	Right to Information Act, 2005	15-06-2007 to 16-06-2007	Hotel Capitol, Bangalore
Mr. R. Rangeshwaran	Biocontrol of plant pathogens	01-08-2007 to 21-08-2007	IARI, New Delhi
Ms. M. Pratheepa	E – Learning	20-08-2007 to 25-08-2007	NAARM, Hyderabad
Ms. M. Pratheepa & Mr. P. K. Sonkusare	Nodal Officers/Data entries of Intelligent Reporting System (I. R. S)	30-08-2007 to 31-08-2007	NAARM, Hyderabad
Dr. Deepa Bhagat	IPM in Rice	03-09-2007 to 07-09-2007	Rajendranagar, Hyderabad
Dr. K. Srinivasa Murthy	Right to Information Act 2007	15-10-2007 to 16-10-2007	The Capitol Hotel, Bangalore
Dr. A. N. Shyalesha	Technology commercialization	22-10-2007 to 02-11-2007	Administrative College of India, Hyderabad
Ms. M. S. Uma	3rd National Convention on Ten years of post based rosters	03-12-2007 to 05-12-2007	The Capitol Hotel, Bangalore
Dr. N. Bakthavatsalam	Strategies for stress management for enhanced organizational effectiveness	16-01-2008 to 22-01-2008	NAARM, Hyderabad
Dr. A. N. Shyalesha	Managing digital resources using open source software	21-01-2008 to 25-01-2008	UAS, GKVK, Bangalore
Ms. Y. Lalitha	Molecular biology techniques	21-01-2008 to 16-02-2008	National Research Centre on Plant Biotechnology, Lal Bahadur Shastri Centre, Pusa campus, New Delhi
Dr. M.Pratheepa	GIS-Based Decision Support for Sustainable Agriculture under NAIP	01-02-2008 to 21-02-2008	NAARM, Hyderabad
Dr. Deepa Bhagat	Synthesis of pheromones and other allelochemicals	01-02-2008 to 01-03-2008	IICT, Hyderabad
Dr. Deepa Bhagat	Encapsulation of compounds	03-03-2008 to 16-03-2008	Department of Pharmaceutical Sciences & Technology, N. P. Marg, Matunga, Mumbai
Dr. S. K. Jalali	Management Development Programme on PME for Agricultural Research	24-03-2008 to 28-03-2008	IIM, Lucknow Co-implemented by NAARM, Hyderabad
Dr. A. N. Shyalesha	Intellectual property rights	28-02-2008 to 10-03-2008	IIHR, Bangalore

8. AWARDS AND RECOGNITIONS

PDBC, Bangalore

Dr. R. J. Rabindra

- ❖ ICAR representative on the Board of Management of University of Agricultural Sciences, Bangalore 2006-09.
- ❖ Member, QRT, National Research Centre for Weed Science, Jabalpur.
- ❖ Member, QRT, Indian Institute of Vegetable Research, Varanasi.
- ❖ Judge for Nagamma Dattatreya Award for the best researcher of the UAS, Bangalore.

Dr. B. S.Bhumannavar

- ❖ Nominated as Executive Member for "Society for Biocontrol Advancement" during the Annual Meeting of the Society in March, 2008.

Dr. Chandish R. Ballal

- ❖ Received the Professor T.N. Ananthakrishnan Award 2006 (National Award) on 18th August, 2007 for contributions made in the field of Biological Control.
- ❖ Member of the Organising Committee & Chairperson of a session on General Perspectives and Drudgery during the National Workshop on Women in Agriculture during April 10th to 12th, 2007 at GKVK, Bangalore.
- ❖ Member of the Executive Council of the Society For Biocontrol Advancement.
- ❖ Participated as Resource person on 4th July, 2007 at Karnada Village to speak on Biological Control as part of the DBT Rural Bio-resources Complex Project at Doddaballapur (organized by ISRO-UAS Bangalore).

Dr. M. Nagesh

- ❖ Received the Best Poster Award during the International Conference on Biotechnology, VIT, Vellore, (6-8 February, 2008).

Dr. P. Sreerama Kumar

- ❖ Recognised by the University of Mysore as a Research Guide for guiding candidates leading to Ph. D. degree in Zoology.

Dr. S. Sriram

- ❖ Nominated as Associate Editor for the "Journal of Biological Control" for the years 2008 and 2009.
- ❖ Recognized as Guide/ Chairman, Student Advisory Committee to Mr. Suresh Patil, M.Sc. (Agri) Student, Department of Plant Pathology, GKVK, UAS, Bangalore.

Dr. R. Rangeshwaran

- ❖ Nominated as Executive Member for "Society for Biocontrol Advancement" during the Annual Meeting of the Society in March, 2008.

IIHR, Bangalore

Dr. Ganga Visalakshy:

Honoured with the ISWS Honarary fellowship award in recognition of her outstanding contribution to weed science by the Indian Society of Weed Science in the Biennial conference on weed management in modern agriculture: Emering challenges and oppurtunities held at Patna, from 27-28 February, 2008.

9. LINKAGES AND COLLABORATION IN INDIA AND ABROAD INCLUDING EXTERNAL PROJECTS

Research Projects – Lateral sources at Project Directorate of Biological Control, Bangalore

DBT

1. Development of biocontrol strategies for the management of sugarcane woolly aphid, *Ceratovacuna lanigera.*
2. Development of invert-emulsion formulation of *Trichoderma harzianum* and prolonged shelf- life and enhanced biocontrol potential.
3. Development of a strain of *Trichogramma chilonis* tolerant to newer insecticides and high temperature.
4. Isolation, purification and characterization of novel insecticidal toxins from *Photorhabdus* and *Zenorhabdus* spp. of bacteria from entomopathogenic nematodes.
5. Evaluation of arbuscular mycorrhizal fungi and entomopathogenic nematode cruisers. Interaction on the reproduction and development of root knot nematode, *Meloidogyne incognita.*
6. Management of cardamom root grub, *Basilepta fulvicorne* with entomogenous nematodes.

ICAR Cess-Fund

1. Network project of biosystematics.
2. Development of commercial formulation of antagonistic fungi (*Paecilomyces lilacinus* and *Verticillium chlamydosporium*) for biological control of *Meloidogyne incognita* and *Rotylenchulus reniformis.*

AMAAS (ICAR)

1. Development of a mycoherbicide-based biological control strategy for *Cyperus rotundus.*
2. Microbial control of insect pests – II.

DAC

1. Technology Mission for cotton.

DFID (UK)

1. Classical biological control of *Mikania micrantha* with *Puccinia spegazzinii*: implementation phase.

10. AICRP / COORDINATION UNIT / NATIONAL CENTRES

With a view to fulfill the mandate under PDBC and AICRP on BC effectively and efficiently, the Project Directorate is functioning with the following ICAR Institute-based and State Agricultural University-based centres.

Headquarters	
Project Directorate of Biological Control, Bangalore	Basic research
ICAR Institute-based centers	
Central Tobacco Research Institute, Rajahmundry	Tobacco, soybean
CPCRI Regional Centre, Kayangulam	Coconut
Indian Agricultural Research Institute, New Delhi	Basic research
Indian Institute of Horticultural Research, Bangalore	Fruits and vegetables
Indian Institute of Sugarcane Research, Lucknow	Sugarcane
Sugarcane Breeding Institute, Coimbatore	Sugarcane
State Agricultural University-based centres	
Acharya N.G. Ranga Agricultural University, Hyderabad	Sugarcane, cotton and vegetables
Anand Agricultural University, Anand	Cotton, pulses, oilseeds, vegetables and weeds
Assam Agricultural University, Jorhat	Sugarcane, pulses, rice and weeds
Dr. Y. S. Parmar University of Horticulture and Forestry, Solan	Fruits, vegetables and weeds
Govind Ballabh Pant University of Agriculture and Technology, Pantnagar	Plant disease antagonists
Kerala Agricultural University, Thrissur	Rice, coconut, weeds, fruits and coconut
Mahatma Phule Krishi Vidyapeeth, Pune	Sugarcane, cotton, soybean and guava
Punjab Agricultural University, Ludhiana	Sugarcane, cotton, oilseeds, tomato, rice and weeds

Sher-E-Kashmir University of Agricultural Sciences & Technology, Srinagar	Temperate fruits and vegetables
Tamilnadu Agricultural University, Coimbatore	Sugarcane, cotton, pulses and tomato
Voluntary centres	
Chaudhary Charan Singh Haryana Agricultural University, Hisar	Sugarcane
College of Agriculture, Kolhapur	White grubs, Weeds
Mahatma Phule University of Agriculture and Technology	Vegetables
National Research Centre for Soybean, Indore	Soybean
National Research Centre for weed Science, Jabalpur	Weeds
Navasarai Agricultural University	Sugarcane, Coconut
S.D. Agricultural University	Vegetables
University of Agricultural Sciences, Bangalore	Cotton, pigeonpea
University of Agricultural Sciences, Dharwad	Cotton, chickpea
Vasantdada Sugar Institute, Pune	Sugarcane

11. LIST OF PUBLICATIONS

Research papers published in referred scientific journals

PDBC, Bangalore

Ali Derakshan, S. H., Rabindra, R. J. and Ramanujam, B. 2007. Effect of entomopathogenic fungi on *Brevicoryne brassicae* at different temperatures and humidities. *Journal of Biological Control*, **21**: 65-72.

Ali Derakshan, S. H., Rabindra, R. J. and Ramanujam, B. 2007. Impact of the entomopathogenic fungus, *Verticillium lecanii* on natural enemies of the cabbage aphid and beneficial insects. *Journal of Biological Control*, **21** (special issue): 133-140.

Ali Mehrvar, Rabindra, R. J., Veenakumari, K. and Narabenchi, G. B. 2007. Susceptibility of crude and semi-purified extracts of nucleopolyhedrovirus isolates of *Helicoverpa armigera* (Hubner) to simulated sunlight. *Journal of Biological Control*, **21**: 91-96.

Ali Mehrvar, Rabindra, R. J., Veenakumari, K. and Narabenchi, G. B. 2007. Standardization of mass production in three isolates of Nucleopolyhedrovirus of *Helicoverpa armigera* (Hubner). *Pakistan Journal of Biological Sciences*, **10**: 3992-3999.

Ali Mehrvar, Rabindra, R. J., Veenakumari, K. and Narabenchi, G. B. 2007. Effect of natural sunlight on the activity of different geographic isolates of Nucleopolyhedrovirus of *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae). *Journal of Biological Control*, **21**: 235-240.

Arabjafari, K. H. and Jalali, S. K. 2007. Identification and analysis of host plant resistance in leading maize genotypes against spotted stem borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae). *Pakistan Journal of Biological Sciences*, **10**: 1885-1895.

Bakthavatsalam, N. and Tandon, P. L. 2007. Behaviour and Electrophysiological responses of *Chrysoperla carnea* (Stephens) to kairomones- acid hydrolysed/ oxidised L-tryptophan and its breakdown products. *Journal of Biological Control*, **21** (special issue): 79-84.

Bakthavatsalam, N., Tandon, P. L., Patil, S. B., Bhemanna Hugar and Hosamani, A. 2007. Kairomone formulations as reinforcing agents for increasing abundance of *Chrysoperla carnea* (Stephens) in cotton ecosystem. *Journal of Biological Control*, **21**: 1-8.

Bakthavatsalam, N., Tandon, P. L. and Ballal, C. R. 2007. Behavioral responses of *Campoletis chlorideae* (Ichneumonidae: Hymenoptera) to the kairomonal substances. *Journal of Entomological Research*, **31**: 217-223.

Bhumannavar, B. S., Ramani, S. and Rajeshwari, S. K. 2007. Field release and impact of *Cecidochares connexa* (macqwuart) (Diptera: Tephritidae) on *Chromolaena odorata* (L.) King and Robinson. *Journal of Biological Control*, **21**: 59-64.

Devi, P. S., Jalali, S. K. and Venkatesan, T. 2006. Inheritance of insecticides tolerance in resistant colonies of *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae). *Indian Journal of Genetics and Plant Breeding*, **66**: 324-328.

Ferkovich, S. M., Venkatesan, T., Shapiro, J. P. and Carpenter, J. E. 2007. Presentation of artificial diet: Effects of composition and size of prey and diet domes on egg production by *Orius insidiosus* (Heteroptera: Anthocoridae). *Florida Entomologist*, 90: 502-508

Gupta, A. and Poorani, J. 2008. New records of Chalcidoidea (Hymenoptera) from Southern India. *Biosystematica*, **1**: 33-45.

Gupta, T. and Ballal, C. R. 2007. Feeding preference of anthocorid predators for parasitised and un-parasitised eggs. *Journal of Biological Control*, **21**: 73-78.

Hussaini, S. S., Shakeela, V. and Sankaranarayanan, C. 2007. Boefficiency and progeny production of some indigenous EPN isolates against lepidopteran insect pest, *Trends in BioScience*, **1**: 131-138.

Hussaini, S. S., Nagesh, M., Rajeswari, R. and Manzoor Hussain Dar, 2007. Effect of protein and lipid sources in the standard Wout's media on the *in vitro* production and pathogenicity of *Steinernema carpocapsae* and *S. tami. Indian Journal of Plant Protection*, **35**: 93-96.

Jalali, S. K., Venkatesan, T., Murthy, K. S., Rabindra, R.

J. and Lalitha, Y. 2007. Vacuum packaging of *Corcyra cephalonica* (Stainton) eggs to enhance shelf life for parasitization by the egg parasitoid *Trichogramma chilonis*. *Biological Control*, **41**: 64-67.

Kodandaram, M. H., Rajiv Kumar, Shylesha, A. N. and Thakur, N. S. A. 2007. Efficacy of some botanicals and biorational insecticides against gladiolus thrips (*Taeniothrips simplex* (Morison) (Thysanoptera: Thripidae). *Journal of Ornamental Horticulture*, **9**: 148-149.

Kumar, P. S. 2007. A technique to study fungal diseases in and to isolate the causal organisms from *Aceria guerreronis*, with special reference to *Hirsutella thompsonii* infection. *Systematic and Applied Acarology*, **12**: 81-83.

Kumar, P. S. 2007. Identification of fungal pathogens of the spider mites, *Tetranychus neocaledonicus* André and *Tetranychus urticae* Koch from natural associations and through artificial inoculations. *Journal of Biological Control*, **21** (special issue): 187-192.

Kumar, P. S. and Leena Singh. 2007. Acarotoxicity of *Hirsutella thompsonii* Fisher exudate with reference to the two-spotted spider mite, *Tetranychus urticae* Koch. *Journal of Biological Control*, **21** (special issue): 197-202.

Kumar, P. S. and Leena Singh. 2007. Understanding the pathogenic interaction of *Hirsutella thompsonii* with *Tetranychus urticae. Journal of Acarology,* **17**: 29-31.

Misra, R. S., Maheswari, S. K., Sriram S., Sahu, A. K. 2007. Effect of borax for the control of Phytophthora blight of taro (*Colocasia esculenta* (L) Schott). *Journal of Root Crops* **33**: 49-52.

Misra, R. S., Maheswari, S. K., Sriram S., Sahu, A. K. 2007. Effect of intercropping on the incidence and severity of Phytophthora blight of taro (*Colocasia esculenta* (L) Schott). *Journal of Root Crops*, **33**: 67-69.

Misra, R. S., Maheswari, S. K., Sriram S., Sharma, K. and Sahu, A. K. 2007. Integrated management of Phytophthora blight of taro (*Colocasia esculenta* (L) Schott). *Journal of Root Crops*, **33**: 144-146.

Nagesh, M., Hussaini, S. S., Ramanujam, B. and Rangeshwaran, R. 2007. Molecular identification, characterization, variability and infectivity of Indian isolates of the nematophagous fungus *Pochonia chlamydosporia. Nematologia Mediterranea*, **35**, 47-56.

Nagesh, M., Hussaini, S. S., Chindandaswamy, B. S., Shubha, M.R. and Ruby, K.M. 2007. Relationship between initial water content of the substrate and mycelial growth and sporulation of the nematophagous fungi, *Paecilomyces lilacinus* and *Pochonia chlamydosporia. Nematologia Mediterranea*, **35**, 57-60.

Nirmala, R., Harlapur, S. I., Ramanujam, B., Rabindra, R. J. and Rao, N. S. 2007. Effect of entomofungal pathogens on sugarcane woolly aphid, (*Ceratovacuna lanigera*) and its predators. *Journal of Biological Control*, **21** (special issue):179-182.

Poorani, J. 2007. First record of *Hippodamia variegata* (Goeze) (Coleoptera: Coccinellidae) from South India. *Journal of Biological Control*, **21**: 295-296.

Prathapan, K. D., Priyadarsanan, D., Narendran, T. C., Viraktamath, C. A., Aravind, N. A. and Poorani, J. 2008. Death sentence on taxonomy in India. *Current Science*, **94:** 170-171.

Rabindra, R. J. and Ramanujam, B. 2007. Microbial control of sucking pests using entomopathogenic fungi. *Journal of Biological Control*. **21** (special issue): 21-28

Sithanantham, S., Varatharajan, R, Ballal, C. R. and Ganga Visalakshy, P. N. 2007. Research status and scope for biological control of sucking pests: Case study of thrips. *Journal of Biological Control*, **21**: 1-19.

Sriram, S. and Misra, R. S. 2007. Biological control of taro leaf blight caused by *Phytophthora colocasiae* (Racib.) and storage losses with rhizobacteria. *Journal of Biological Control*, **21:** 181-187.

Tandon, P. L. and Bakthavatsalam, N. 2007. Plant volatile diversity in different tomato genotyes (varieties/hybrids) and its influence on parasitization efficiency of *Trichogramma chilonis* Ishii on *Helicoverpa armigera* Hubner. *Journal of Biological Control*, **21**: 271-281.

Veenakumari, K., Rabindra, R. J., Srinivas Naik, C. D. and Shubha, M. R. 2007. *'In situ'* field level mass production of *Amsacta albistriga* nucleopolyhedrovirus in groundnut ecosystem. *International Journal of Tropical Insect Science*, **27**: 48-52.

Veenakumari, K., Prashanth Mohanraj and Sreekumar, P. V. 2007. Insect consumers of plants native to the forests of the Andaman islands (Indian Ocean: Bay of Bengal). *The Indian Forester,* **133**: 1109-1116.

Venkatesan, T., Jalali, S. K., Srinivasa Murthy, K., Rabindra, R. J. and Dasan, C. B. 2007. Economics of Production of *Goniozus nephantidis* (Muesebeck), an important parasitoid of coconut black headed caterpillar, *Opisina arenosella* Walker for biofactories. *Journal of Biological Control*, **21:** 53-58.

Venkatesan, T., Jalali, S. K., Murthy, K. S. and Bhaskaran, T. V. 2008. Development, survival and reproduction of *Orius tantillus* (Motschulsky) (Heteroptera: Anthocoridae) on artificial and natural diets. *Indian Journal of Agricultural Sciences*, **78:** 102-105.

CPCRI, Kayangulam

Chandrika Mohan and Sathiamma, B. 2007. Potential for lab rearing *Apanteles taragamae*, the larval endoparasitoid of coconut pest *Opisina arenosella*, on the rice moth *Corcyra cephalonica*. *Biological Control*, **52:** 747-752

Chandrika Mohan, Rajan, P. and Nair, C. P. R. 2007. Incidence of the white fly (*Aleurocanthus arecae* David) on coconut foliage. *Journal of Plantation Crops*, **35**: 119-121.

CTRI, Rajahmundry

Gunneswara Rao, S., Prasad, J. V., Venkateswarlu, P., Siva Raju, K., Singh, S. P. and Naik, P. K. 2007. Tobacco cultivar and tobacco type mediated effects on the population of aphid parasitoid, *Aphidius* sp. (Hymenoptera: Braconidae: Aphediinae) and predator *Cheilomenes sexmaculata* Fabricius (Coleoptera; Coccinellidae). *Journal of Biological Control*, **21**: 45-50.

IARI, New Delhi

Gujar, G. T., Nair, R., Singh, B. P., Kumari, A. and Kalia, V. 2008. Toxicity to the cotton bollworm, *Helicoverpa armigera* by some Cry1Ac toxins expressed in cotton in India. *Crop Protection*, **27**: 537-544.

Gujar, G. T., Kalia, V., Kumar, A., Singh, B. P., Mittal, A., Nair, R. and Mohan, M. 2007. *Helicoverpa armigera* baseline susceptibility to *Bacillus thuringiensis* (Bt) Cry toxins and resistance management for Bt cotton in India. *Journal of Invertebrate Pathology*, **95**: 214-219.

Gujar, G. T., Khawale, R. N. and Kalia, V. 2007. Genetic variability of *Helicoverpa armigera* (Hübner) attributable to cadherin gene specific molecular markers. *Current Science,* **92**: 800-804.

Mittal, A., Kumari, A., Kalia, V., Singh, D. K. and Gujar, G. T. 2007. Spatial and temporal baseline susceptibility of diamondback moth, *Plutella xylostella* (Linnaeus) to *Bacillus thuringiensis* subsp. *kurstaki* spore crystal complex, purified crystal toxins and mixtures of Cry toxins in India. *Biopesticides International*, **3**: 58-70.

IIHR, Bangalore

Ganga Visalakshy, P. N., Krishnamoorthy, A. and Manoj Kumar, A. 2007. The suitability of host plants for mass multiplication of *Scirtothrips dorsalis. Entomon*, **32:** 7-60.

Ganga Visalakshy, P. N., Krishnamoorthy, A. and Manoj Kumar, A. 2007. Compatibility between the plant antagonists *Trichoderma harzianum* Refai and *T. viride* potential entomopathogenic fungi of horticultural crops pest. *Entomon*, **31**: 129 – 132.

Ganga Visalakshy, P. N. 2007**.** Biological studies on *Ceutorhynchus portulacae*, a potential natural enemy of the purslane weed, *Portulaca oleracea*. *Biocontrol* (UK), **52**: 619-628.

Krishnamoorthy, A., Ganga Visalakshi, P. N., Manoj Kumar, A. and Mani, M. 2007. Influence of some pesticides on entomopathogenic fungis *Lecanicillium lecanii*. *Journal of Horticulture Science*, **2**: 53-57.

Mani, M. and Krishnamoorthy, A. 2007. Biological suppression of *Planococcus citri* (Risso) (Homoptera: Pseudococcidae) on *Crossandra undulifolia* Salish in India. *Journal of Biological Control*, **21**: 283 – 286.

Mani, M. Krishnamoorthy, A. and Pattar, G. L. 2007. Suppression of pink mealybug (*Maconellicoccus hirsuts*) on ber (*Ziyphus mauritiana*). *Indian Journal of Agriculture Science*, **77**: 135.

Mani, M. Krishnamoorthy, A. and Ganga Visalakshi, P. N. 2007. Natural parasitization by the exotic parasitoid, *Leptomastix dactylopii* Howard on *Planococcus citri* (Risso) infesting custard apple. *Journal of Biological Control*, **21**: 157 –158

Mani, M., Ganga Visalakshy, P. N. and Krishnamoorthy, A. 2006. *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae) on custard apple in India. *Entomon*, **31:** 237

Sithanantham, S., Varatharajan, R., Chandish R. Ballal and Ganga Visalakshy, P. N. 2007. Research status and scope for biological control of sucking pests in India: case study of thrips. *Journal of Biological Control*, **21**: 1-19

IISR, Lucknow

Baitha, A. and Srivastava, D. C. 2007. Preliminary observations on parasitisation and certain biological parameters of temperature tolerant strain of *Trichogramma japonicum* Ashmead on sugarcane top borer egg mass. *Egg Parasitoid News*, **18**: 20.

Baitha, A. 2007. Female emergence of three strains of *Trichogramma chilonis* Ishii during ovipositional period. *Egg Parasitoid News*, **18:** 20.

Baitha, A. 2007. Survival and adult emergence of *Tetrastichus howardi* (Olliff.) (Eulophidae: Hymenoptera) under field conditions. *Insect Environment*, **13:** 108-110.

Baitha, A. 2007. Spatial distribution of *Pyrilla perpusilla* Walker and their parasitoids. *Insect Environment*, **13**: 103-104.

AAU, Jorhat

Barkakati, R. N., Basit, A. & Hazarika, L. K. 2007. Effect of temperature and relative humidity on the seasonal abundance of water hyacinth weevil, *Neochetina eichhorniae* Warner and *N. bruchi* (Hustache). *Journal of Entomology Research*, **31**: 1-3.

Sarma, M., Basit, A. & Bhattacharyya, B. 2007. Ovicidal, acaricidal and growth inhibitory activity of *Xanthium strumarium* L., *Acorus calamus* L., and *Pongamia pinnata* L. (Pierre) against a major pest of tea *Oligonychus coffeae* Nietner (Tetranychidae: Acarina). *International Journal of Tea Science,* **6**: 2007.

Sarmah, S., Saikia, D. K., Bhattacharyya, B. and Dutta, S. K. 2007. Population fluctuation of sugarcane woolly aphid, *Ceratovacuna lanigera* Zehnter (Homoptera: Aphididae) and its natural enemies in plant and ratoon sugarcane crops in Assam. *Journal of Biological Control*, **21**: 241-246.

AAU, Anand

Bharpoda, T. M., Koshiya, D. J. and Korat, D. M. 2007. Varietal susceptibility and mechanism of resistance in Aonla, *Emblica officinalis* Geartn to apical twig gall maker, *Betousa stylophora* Swinhoe. *Indian Journal of Entomology*, 69: 230-233.

Bhatt, N. A., Borad, P. K., Darji, V. B. and Jani, J. J. 2007. Bio-Efficacy of botanicals against *Uroleucon compositae* (Theobald) (Homoptera:Aphididae) Infesting *Gaillardia pulchella* Foug. *Journal of Aphidology*, 21: 51-54.

Bhatt, N. A., Borad, P.K., Darji, V. B. and Jani, J. J. 2007. Population fluctuation of *Uroleucon compositae* (Theobald) (Homoptera: Aphididae) on *Gaillardia pulchella* Foug. in relation to biotic and abiotic factors. *Journal of Aphidology*, 21: 55-58.

Dalwadi, M. M., Korat, D. M. and Tank, B. D. 2007. Population dynamics of major insect pests of Indian bean in relation to weather parameters. *Research on Crops*, **8**: 672-677.

Dalwadi, M. M., Korat, D. M. and Tank, B. D. 2007. Screening of some genotypes / cultivars of Indian bean for its resistance against major insect pests. *Research on Crops*, **8**: 797-799.

Korat, D. M., Chougule, P. A. and Dabhi, M. R. 2008. Efforts to conserve and encourage the natural enemies of crop pests in Gujarat. *Green Farming*, **1**: 25-28.

Korat, D. M., Dabhi, M. R. and Chougule, P. A. 2007. A glimpse of entomopathological research in Gujarat. *Green Farming*, **1**: 29-33.

Korat, D. M. and Dabhi, M. R. 2008. Use of Biocontrol agents for suppressing insect pests in Gujarat. *Green Farming*, **1**: 34-36.

Korat, D. M. and Dabhi, M. R. 2007. Eco-friendly approaches to manage pests of vegetable crops in Gujarat. *Green Farming*, **1**: 37-38.

Korat, D. M. and Dabhi, M. R. 2008.Vermiwash as plant growth promoter. *Green Farming*, **1**: 52

Korat, D. M. and Dabhi, M. R. 2007. Eco-friendly approaches to manage pests of fruit crops in Gujarat. *Green Farming*, **1**:52-53.

Patel, D. B., Borad, P. K. and Korat, D. M. 2007. Bionomics and behaviour of mango leaf webber, *Orthaga eqadrasalis* Walker. *Karnataka Journal of Agricultural Science*, **20**: 644-647.

Tank, B. D. and Korat, D. M. 2007. Influence of weather parameters on population of *Cheilomenes sexmaculata* (Fab). *Karnataka Journal of Agricultural Science*, **20**: 642-643.

Tank, B. D. and Korat, D. M. 2007. Relative toxicity of some insecticides against *Cheilomenes sexmaculata* (Fab.) in laboratory. *Karnataka Journal of Agricultural Science*, **20**: 639-641.

Tank, B. D., and Korat, D. M. 2007. Biology of ladybird beetle, *Cheilomenes sexmaculata* (Fab.) in middle Gujarat conditions. *Karnataka Journal of Agricultural Science*, **20**: 634-636.

Tank, B. D., Korat, D. M. and Borad, P. K. 2007. Determination of dominant species of predatory coccinellid in Anand region of Gujarat. *Karnataka Journal of Agricultural Science*, **20**: 637-638.

ANGRAU, Hyderabad

Saritha, P. and Rahman, S. J. 2006. Optimization studies on incubation period and inoculum dosage for harvest of *Spodoptera litura* Fabricius NPV. *Journal of Life Sciences*, 21.

Saritha, P. and Rahman, S. J. 2006. Role of age and physical stage of *Spodoptera litura* Fabricius larvae for NPV (*Sl* NPV) production. *Journal of Life Sciences*, 21.

KAU, Thrissur

Beevi. S. P. and Mahapatro, G. K. 2007. A new field screening methodology for cashew genotypes against tea mosquito bug, *Helopeltis antonii* Sign. *Journal of Plantation Crops*, **35**: 139-145.

MPKV, Pune

Ghorpade, S. A., Pokharkar, D. S. and Rabindra, R. J. 2007. Mass production of *Dipha aphidivora* (Meyrick) (Lepidoptera: Pyralidae), a potential predator of sugarcane woolly aphid, in shade nets. *Journal of Biological Control*, **21**: 297-300.

Pokharkar, D. S., Kulkarni, N. S. and Palande, P. R. 2007. Toxicity of pesticides to Australian lady bird beetle, *Cryptolaemus montrouzieri* Mulsant (Coccinellidae: Coleoptera). *Pestology*, **31**: 39-42.

PAU, Ludhiana

Virk, J. S. and Brar, K. S. 2007. Parasitization efficacy of *Trichogramma chilonis* Ishii on different varieties/hybrids of cotton. *Journal of Insect Science*, **20**: 143-46.

Brar, K S., Virk, J. S., Jalali, S K., Sohi, A. S. and Shenhmar, M. 2007. Evaluation of multiple insecticide tolerant strain of *Trichogramma chilonis* Ishii for the management of cotton bollworms. *Journal of Insect Science*, **20**: 208-211.

Joshi, N, Brar, K. S. and Kaur, R. 2007. Field evaluation of *Bacillus thuringiensis* Berliner formulation against shoot and fruit borer, *Earias* spp. on Okra. *Journal of Insect Science*, **20**: 236-238.

Kaur, R, Brar, K. S, Singh, J. and Shenhmar, M. 2007. Large scale evaluation of BIPM for the management of rice leaf folder and stem borer on Basmati Rice. *Journal of Biological Control*, **21**: 255-259.

Khosa, J. K., Virk J. S., Brar K. S. 2007. Host searching ability of adults of *Trichogramma chilonis* Ishii in cotton. *Journal of Insect Science*, **20**: 260-62.

Khosa, J. K., Virk J. S., Brar K. S. 2008. Role of Sorghum (*Sorghum bicolor*) as trap crop in increasing parasitizing efficiency of *Trichogramma chilonis* Ishii against cotton. *Journal of Insect Science*, **21**: 79-83.

Kaur, R., Kaur, R., and Brar, K. S. 2008. Development and predation efficacy of *Chrysoperla carnea* (Stephens) on cotton mealy bug *Maconellicoccus hirsutus* (Green) as prey under laboratory conditions. *Journal of Insect Science*, **21**: 93-95.

SKUAS&T, Srinagar

Nagaraja, H., Ahmad, M. J. & Gupta, A. 2007. Description of a new species of *Trichogramma* (Hymenoptera : Trichogrammatidae), from Anantnag, J&K, India. *Journal of Biological Control*, **21**: 287- 289.

TNAU, Coimbatore

Jeyarani, S., Karuppuchamy, P. and Sathiah, N. 2008. Interaction between egg larval parasitoid, *Chelonus blackburni* and Nideopolyhedra virus in *Helicoverpa armigera* (Hubner). In: *Recent Trends in Insect Pest Management* (Eds: Dr. S. Ignacimuthu and Dr. S. Jeyarani) Elite Publishing House Pvt. Ltd. pp 126 – 130.

Jeyarani, S., Rabindra R. J., Sathiah, N., Karuppachamy, P and Subramanian, S. 2007. Efficacy of spiracular infection of *Helicoverpa armigera* with its nucleopolyhedrovirus and its role in virus production. *Journal of Virol. Methods,* **142**: 213–217.

Jeyarani, S., Sathiah, N. and Karuppuchamy, P. 2007. Comparative virulence of *In Vitro* and *In Vivo* produced UV selected *Ha*NPV against *Helicoverpa armigera* (Hub.). In: *Biotechnology and Insect Pest Management*. (Eds.) S. Ignacimuthu, S. J., Jayaraj, S. Elite Publishing House Pvt. Ltd, New Delhi. pp- 117-121.

Kuttalam, S., Karuppuchamy, P., Gunasekaran, K., Krishnamoorthy, S and Sathiah N. 2007. Recent advances in integrated pest management. Electronic compilation of the lectures on CAS Training on recent advances in IPM. 22 Feb 2006 to 13 March 2007, Tamilnadu Agric. Univ., Coimbatore, India.

Ravi, M., Dhandapani, N. and Sathiah, N. 2007. Safety of biopesticides to egg parasitoid, *Trichogramma chilonis* Ishii and predatory green lacewing, *Chrysoperla carnea*. In: *Biotechnology and Insect Pest Management*. (Eds.) S. Ignacimuthu, S.J., Jayaraj, S. Elite Publishing House Pvt Ltd, New Delhi. pp- 198-201.

Samiyappan, R., Sathiah, N., Suresh, S., Subramanian, S., Karthikeyan, S and Radhajeyalakshmi, K. 2007. Sustainable livelivelihood and rural prosperity. Proc. of the Absts. of the Poster Sessions of the 8th Indian Agric. Sci. Congress. Indian Academy of Agric. Sci., New Delhi India. 264p.

Sathiah, N., Balagurunathan, R., Santharam, G., Kennedy, J. S., Hussaini, S. S., Nagesh, M. and Rabindra, R. J. 2007. Evaluation of *Heterorhabditis indica* Poinar against *Mylabris pustulata* Thunberg and *Helicoverpa armigera* (Hubner) infesting pigeonpea in Tamilnadu. In: *Biotechnology and Insect Pest Management*. (Eds.) S. Ignacimuthu, S.J., Jayaraj, S. Elite publishing house Pvt Ltd, New Delhi. pp- 202-204.

Shanmugam, P.S. Balagurunathan, R. and Sathiah, N. 2007. Temporal and spatial variations in susceptibility of *Helicoverpa armigera* (Hub.) from different agronomic hosts to *Bt* cotton *Asian journal of plant Science*, **6**: 71 – 76.

Shivashankar, H. D., Sathiah, N., Kennedy, J. S., Ravi, M. and Jeyarani, S. 2007. Non- Target effects of UV- selected Nucleopolyhedrovirus of *Helicoverpa armigera* (HaNPV) to the gregarious larval parasitoid, *Bracon hebetor* Say. 2007 In: *Biotechnology and Insect Pest Management*. (Eds.) S. Ignacimuthu, S.J., Jayaraj, S. Elite publishing house Pvt Ltd, New Delhi. pp - 214-218.

Subramanian, S., Santharam, G., Kennedy, J. S., Sathiah, N. and Rabindra, R. J. 2007. Glycerol based aqueous – formulation of nucleopolyhedrovirus for the management of *Spodoptera litura*. In: *Biotechnology and*

Insect Pest Management. (Eds.) S. Ignacimuthu, S.J., Jayaraj, S. Elite Publishing House Pvt Ltd, New Delhi. pp- 107-116.

YSPUH&F, Solan

Chauhan, Usha, Thakur, Meena and Kadu, Sushil. 2007. *Amblyseius* (*Euseius*) *delhiensis* (Narayanan & Kaur)- a predator of whitefly on rose. *Insect Environment*, **13**: 28-29.

Chauhan, Usha, Kadu, Sushil and Gupta, P. R. 2007. Feeding potential of *Amblyseius longispinosus* Evans on summer eggs of *Panonychus ulmi* (Koch) on apple leaves under laboratory conditions. *Journal of Acarology*, **17**: 43-44.

Gupta, P. R. and Dayal, Kiran. 2007. Parasitization of the black bean aphid, *Aphis fabae solanella* Theobald by *Aphidius colemani* Viereck in Himachal Pradesh. *Insect Environment*, **13**: 9-10.

Gupta, P. R. and Singh, Inderjit. 2007. Growth, development and feeding potential of grubs of *Chilocorus infernalis* Mulsant (Coleoptera: Coccinellidae) on the San Jose scale, *Quadraspidiotus perniciosus* (Comstock). *Journal of Biological Control*, **21**(special issue): 119-124.

Gupta, P. R., Malhotra, Sarika and Verma, A. K. 2007. Parasitization of aphids on cauliflower seed crop in relation to their population build-up in mid-hills of Himachal Pradesh. *Journal of Biological Control*, **21** (special issue):37-43.

Gupta, P. R., Sood, Anil, and Verma, S. P. 2007. Over-wintering, emergence pattern, sex ratio and mating strategy of *Aphelinus mali* (Haldeman), an endoparasitoid of the woolly apple aphid. *Journal of Biological Control*, **21** (special issue):113-118.

Kumar, Ravinder and Gupta, P. R. 2006. Natural enemies associated with the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), on vegetable crops in the mid-hill region of Himachal Pradesh. *Pest Management and Economic Zoology*, **14**: 73-78.

Rattan, R. S., Reineke, A., Monje, J. C., Gupta, P. R. and Zebitz, C. P. W. 2006. Molecular characterization of *Cotesia glomerata* (Hymenoptera: Braconidae) based on NADH1 dehydrogenase and ITS2 gene sequences. *Pest Management and Economic Zoology*, **14**: 11-17.

Singh, Mohinder and Gupta, P. R. 2006. Occurrence of entomopathogenic nematodes in Himachal Pradesh, India and their pathogenicity against various insect species. *Pest Management and Economic Zoology*, **14**: 179-188.

Papers presented in symposia/ seminar/ workshops

PDBC, Bangalore

Azad Thakur, N. S. and Shylesha, A. N. 2007. Role of bees in horticultural crop production and enhancing farmers income. *Invited lecture. 2nd Indian Horticulture Congress 18-4-2007 to 21-4- 2007. P.63*

Ballal, C. R. 2007. Research Efforts in the field of Biological Control. *Prof. T. N. Ananthakrishnan Award Oration* presented during the National Symposium on "Thrust Areas in Entomological Research" organised by the Entomology Academy of India at COSTED, Chennai on 18-8-2007.

Ballal, C. R. 2007. Role of women in popularisation and adoption of bio-control technology. Abstract 6: Plenary 6, pp. 15-16 In Session I, Plenaries and Panel Discussion, *National Symposium on Women in Agriculture & XXXI Annual Conference of the Ethological Society of Iindia* April 10-12, 2007 at UAS, Bangalore.

Hussaini, S. S. 2007. Potential of entomopathogenic nematodes for insect pest control, Winter school, PDBC, Bangalore.

Hussaini, S. S. 2008. *Photorhabdus* & *Xenorhabdus* mutualistic bacteria associated with EPN for insect pest management presented during DBT Consultative interactive meeting for formulation of network project on EPN, 6-3-2008 to 7-3-2008, MPUAT, Udaipur, Rajastan.

Hussaini, S. S. 2007. Potential of entomopathogenic nematodes for pest control, Winter School, Maharana Pratap University of Agriculture and Technology, Udaipur.

Hussaini, S. S. 2007. Practical utilization of entomopathogenic nematodes for insect pest control in India, Winter School, Maharana Pratap University of Agriculture and Technology, Udaipur.

Hussaini, S. S. 2008. Status and potential of entomopathogenic nematodes for biological control of crop pests, Paper presented at the Refresher Course in Organic Pest Control, held at Dept. of Entomology, Faculty of Agriculture, Annamalai University, January 21-1-2008 to 10-2-008.

Jeyarani, S., Bhaskaran, E. V., Kavitha, J., Ramaraju, K., Kumar, P. S. and Rabindra, R. J. 2008. Evaluation of Mycohit (*Hirsutella thompsonii* Fisher) against eriophyid mite on coconut. Abstracts: National Symposium on Ecofriendly Insect Pest Management, Entomology Research Institute, Loyola College, Chennai, India, 7-2-2007 to 8-2-2007.

Kulkarni, N., Hussaini, S. S. and Joshi, K. C. 2007 Prospects of entomopathogenic nematodes in management of forest insect pests. Paper presented at National Symposium on "*Emerging Trends of Bioinoculants in Forestry*", 26-4-2007 to 27-4-2007, TFRI, Jabalpur.

Kulkarni, N., Sanjay Paunikar, Hussaini, S. S. and Joshi, K. C. 2007. Susceptibility of entomopathogenic nematode, *Heterorhabditis indica* Poinar against teak skeletonizer, *Eutectonic machaeralis* Walker. National Symposium on "*Ecofriendly insect Pest Management"*, Chennai, 7-2-2007 to 8-2-2007.

Kumar, P. S. 2007. Biological control of *Aceria guerreronis* with *Hirsutella thompsonii* on the coconut palm. Paper presented at the Workshop on the Coconut Mite, Salalah Agricultural Research Station, Salalah, Sultanate of Oman, 21-10-2007 to 24-10-2007.

Kumar, P. S. Rabindra, R. J. and Ellison, C. A. 2007. Expanding classical biological control of weeds with pathogens in India: the way forward. In: Abstracts of Papers, Twelfth International Symposium on Biological Control of Weeds, Montpellier, France, 22-4-2007 to 27-4-2007.

Nagesh, M., Hussaini, S. S., Rabindra, R. J. and Savithri, H. S. 2008. Molecular identification of Indian isolates of *Photorhabdus luminescens*, a bacterial symbiont of entomopathogenic nematode, *Heterorhabitis* species. Paper presented in Poster Session at the International Conference on Biotechnology, VIT, Vellore, 6-2-2008 to 8-2-2008.

Nagesh, M., Hussaini, S. S., Rabindra, R. J. and Savithri, H. S. 2008. Molecular identification of Indian isolates of *Photorhabdus luminescens*, a bacterial symbiont of entomopathogenic nematode, *Heterorhabitis* species. Paper presented at National Symposium on Molecular Biology held at CMC, Vellore, Feb. 2008.

Sankaran, K.V., Puzari, K. C., Ellison, C.A., Kumar, P. S., Usha Dev. 2007. Field release of the rust fungus *Puccinia spegazzinii* to control *Mikania micrantha* in India: protocols and awareness rising. In: Abstracts of Papers, Twelfth International Symposium on Biological Control of Weeds, Montpellier, France, 22-4-2007 to 27-4-2007.

Venkatesan, T. 2008. Success story on biological control of coconut black-headed caterpillar, *Opisina arenosella*. In: National Workshop for stakeholders on sustainable biocontrol programmes in India held at National Plant Protection and Training institute, Hyderabad during 30-1-2008 to 31-1-2008.

IIHR, Bangalore

Ganga Visalakshy, P. N. and Sushil Kumar 2008. Biological control of thrips of terrestrial and aquatic weeds in India. In: The Biennial conference on weed management in modern agriculture: Emering challenges and oppurtunities held at Patna from 27-2-2008 to 28-2-2008.

Ganga Visalakshy, P. N. 2008. Biological control of thrips of horticultural importance in India: Present status and future Scope national symposium on ecofriendly insect pests management held at Loyal College, Chennai, from 7-2-2008 to 8-2-2008.

Krishnamoorthy, A. 2008. Biological control of pests under Horticultural Ecosystems – presented at a Refresher course on Organic pest control – organized by Department of Entomology, Faculty of Agriculture, Annamalai University, Chidambaram, Tamilnadu on 1-2-2008.

Krishnamoorthy, A. 2008. Global reveiew of on biocontrol management of mealy bugs and success stories. Paper presented at National Consultation on Mealy bug Management held at CICR, Nagpur 28-1-2008 to 29-1-2008.

Krishnamoorthy, A. 2008. Biological control programmes: For promoting exports of fruits and vegetables – presented at workshop on biocontrol of crop pests held at NPPTI, Hyderabad on 30-1-2008 to 31-1-2008 Strategy for sustainable Biocontrol Programme in India and gave a talk on Biocontrol programme for exports of fruits and vegetables.

IISR, Lucknow

Baitha, A. 2007. Management of insect pests in sugarcane seed crop. Lead Paper presented in *Nat.Symp." Seed Cane",* IISR, Lucknow, 27-9-2007 to 28-9-2007.

ANGRAU, Hyderabad

Rahman, S. J. 2007. Certain regulatory aspects relating to commercialization and quality assessment in Bio Pesticides. Lead Paper presented at the National Symposium on Utilization of organic waste and eco friendly approaches in pest management. Organized by PPAI, Hyderabad. 15-3-2007 to 17-3-2007.

Rupela, O. P., Rahman, S. J., Ranga Rao, G. V., Rama, J., Sasi Jyothsna, J. S. and Humayun, P. 2006. Protecting Vegetables from Insect-pests Using Low-cost and Biological Options -A Two-year On-farm Experience Poster presented at the First International Conference on Indigenous Vegetables and Legumes, jointly organized by AVRDC-The World Vegetable Center, Regional Center for South Asia and ICRISAT, at ICRISAT campus, 12-12-2007 to 15-12-2007.

KAU, Thrissur

Rao, G. S. L. H. V. P. and Beevi, S. P. 2007. Forewarning tea mosquito bug *Helopeltis antonii* Sign. (Miridae: Hemiptera) in cashew. International Symposium on Agrometeorology and Food Security, 18-2-2009 to 21-2-2008, Hyderabad, India pp. 203.

MPKV, Pune

Kadam, J. R., Pokharkar, D. S. and Chandele, A. G. 2008. Bioagents and biopesticides for organic farming. *Proc. National Symposium on Recent Trends in Organic Farming, IAUA,* New Delhi and MPKV, Rahuri, September 11-12, 2008, pp. 77-88.

Pokharkar, D. S. and Nakat, R. V. 2007. Role of bioagents-parasitoids and predators in organic farming. *National Symposium on Recent Trends in Organic Farming,* September 11-12, 2007, pp. 16-17 (Abstract).

PAU, Ludhiana

Gill, C. K., Virk, J. S., Kaur, R. and Singh, P. 2008. Evaluation of some insecticides for the management of tomato fruit borer, *Helicoverpa armigera* (Hubner) in Punjab. Proceedings of *2nd Congress on Insect Science* held at Punjab Agricultural University Ludhiana. Feb. 21-22, 2008, pp 57-58 (Extended Abst).

Gill, R. S. and Kaur, R. 2008. Evaluation of *Beauveria bassiana* and *Metarhizium anisopliae* isolates against bruchids (*Callosobruchus* spp.) in green gram and chickpea in storage. Proceedings of *2nd Congress on Insect Science* held at Punjab Agricultural University Ludhiana. Feb. 21-22, 2008, pp 341-42 (Extended Abst).

Joshi, N., Kaur, R., Virk, J. S. and Kaur, R. 2008. Management of fruit borer, *Earias* spp in Okra. Proceedings of *2nd Congress on Insect Science* held at Punjab Agricultural University Ludhiana. Feb. 21-22, 2008, pp 143-44 (Extended Abst).

Kaur, R**,** Virk, J. S., Brar, K. S. and Mahal, M. S. 2008. Biointensive integrated pest management in *Bt* and non-*Bt* cotton. Proceedings of *2nd Congress on Insect Science* held at Punjab Agricultural University Ludhiana. Feb. 21-22, 2008, pp 181-82 (Extended Abst).

Kumari, J., Kaur, S., Singh P., Kaur, R. and Sharma, M. 2008. Extent of parasitism of *Plutella xyllostella* (L.) on cabbage in Amritsar (Punjab). Proceedings of *2nd Congress on Insect Science* held at Punjab Agricultural University Ludhiana. Feb. 21-22, 2008, pp 308 (Extended Abst).

Singh, P., Kaur, R. and Kaur, P. 2007. Field efficacy of Spinosad 45 % SC for the control of rice stem borer, *Scirpophaga incertulas* Walker and Leaf folder, *Cnaphalocrosis medinalis* (Guenee) on Paddy and Basmati rice. *National symposium on Plant Protection – Technology interface*, Dec 28-29, 2007. Association for Advancement in Plant Protection, BCKV, Kalyani, West Bengal, pp. 35 (Extended Abstract).

Virk, J. S. and Kaur, R. 2008. Parasitisation efficiency of *Trichogramma chilonis* on different *Bt* and non-*Bt* cotton hybrids. Proceedings of *2nd Congress on Insect Science* held at Punjab Agricultural University Ludhiana. Feb. 21-22, 2008, pp 309-10 (Extended Abst).

Virk, J. S., Kaur, R., Brar, K. S. and Mahal, M. S. 2008. Natural enemy complex of all pests including bollworms *Spodoptera* sp., sucking pests and other bugs in *Bt* & Non - *Bt* cotton hybrids. Proceedings of *2nd Congress on Insect Science* held at Punjab Agricultural University Ludhiana. Feb. 21-22, 2008, pp 311-12 (Extended Abst).

Virk, J. S., Kaur, R., Kaur, P., Joshi, N. and Mahal, M. S. 2008. Biological control of major insect pests of field crops: Indian scenario with special reference to Punjab. Souvenir *2nd Congress on Insect Science* held at Punjab Agricultural University Ludhiana. Feb. 21-22, 2008, pp 39-42.

Virk, J. S., Kaur, R., Singh, P. and Kaur, S. 2008. Efficacy of granular insecticides against rice stem borers on *basmati* rice in Punjab. Proceedings of *2nd Congress on Insect Science* held at Punjab Agricultural University Ludhiana. Feb. 21-22, 2008, pp 94-95 (Extended Abst).

SKUAS&T, Srinagar

Sofi, M. A. and Zaki, F. A. 2007. Selectivity of new horticultural mineral oils and some insecticides on parasitoid complex of San Jose scale (*Quadraspidiotus pernicious* Comstock) on apple in Kashmir. Paper presented during *III National Symposium on the Plant Protection in Horticulture*: Emerging Trends and Challenges, held at Indian Institute of Horticultural Research, Bangalore w.e.f 7-9th March, 2007.

Zaki, F. A., Munazah Yaqoob and Sajad Mohi-ud-din. 2007. Insect pests and diseases of temperate fruit crops (Lead paper) presented at *III National Symposium on the Plant Protection in Horticulture*: Emerging Trends and Challenges, at Indian Institute of Horticultural Research, Bangalore held at Indian Institute of Horticultural Research, Bangalore w.e.f 7-9th March, 2007.

Book chapter/Scientific Reviews

PDBC, Bangalore

Azad Thakur, N. S., Shylesha, A. N. and Saikia, Kanchan. 2007. Biopesticides in Organic Farming- Potential and Prospects. In *Advances in Organic Farming Technology in India* (Eds.G. C. Munda, P. K Ghosh, Anup Das, S. V Nagachan and K. M Bujarbaruah). Published by

ICAR Research Complex for NEH Region, Umiam, Meghalaya. pp 403-414.

Ballal, C. R. and Joshi, S. 2008. Mass Production protocols for potential biological control agents. pp. 78-85, In *Proceedings of UGC Refresher Course on Organic Pest Control* (January 21 to February 10, 2008), Department of Entomology, Faculty of Agriculture, Annamalai University, Annamalai Nagar 608 002.

Kumar, P. S. 2007. Biological control of phytophagous mites with fungal pathogens. Lecture Notes provided to the participants of the "Winter School on Biological and Biotechnological Approaches to Insect Pest and Disease Control" organized by the Project Directorate of Biological Control, Bangalore, India, 14 November to 4 December 2007.

Kumar, P. S. 2007. Biological control of weeds with plant pathogens: classical and bioherbicide approaches. Lecture Notes provided to the participants of the "Winter School on Biological and Biotechnological Approaches to Insect Pest and Disease Control" organized by the Project Directorate of Biological Control, Bangalore, India, 14 November to 4 December 2007.

Kumar, P. S. 2007. Quality control aspects in mass production and utilization of fungal pathogens for the control of phytophagous mites. Lecture Notes provided to the participants of the "Model Training Course on Quality Control Aspects on Biological Control Agents" organized by the Project Directorate of Biological Control, Bangalore, India, 11-18 December 2007.

Rao, N. S. and Ballal, C. R. 2007. Techno-economic aspects on the production of biocontrol agents. *In* Status papers during Workshop on *Share your experiences in seed production, marketing, trading, IPR and its implementation.* On 28.04.2007; ICAR Regional Committee No. VIII at SBI, Coimbatore.

Shylesha, A. N. 2007. Beekeeping a source of income in the NEH Region. *In* "Integrated Farming System for hill agriculture" (Eds. N. Prakash, Rajesh Kumar, Brajendra and Rajiv Kumar). pp107-120.

CPCRI, Kayangulam

Chandrika Mohan 2007. Biocontrol methods for pest management in plantation crops In: *Breeding for resistance to diseases and insect pests in plantation crops* (Eds.) R.V. Nair, K. Krishnakumar, Reji .J. Thomas, K. Muralidharan and George, V. Thomas. CPCRI, Kasaragod, Kerala. pp -177-190

Nair, C. P. R., Thajudin, S., Rajan, P. and Chandrika Mohan. 2007. Bibliography on coconut mite *Aceria guerreronis* Keifer. CPCRI, RS, Kayangulam p.35.

Popular article /Technical /Extension Bulletins/Reports

PDBC, Bangalore

Azad Thakur, N. S., Shylesha, A. N., Kumar, D. and Saikia, K. 2006. Bamboo flowering in north-eastern hills. *Indian Farming.* **56** (9): 21-23.

Ballal, C, R., Ramanujam, B. and Joshi, S. 2008. Annual Report of the TMC MM1 3.3 Project on "Development, validation, utilization and/or commercialization of bio-pesticides and bio-inoculants".

Ballal, C. R. 2008. Course Director's Report on the Winter School on "Biological and Bio-technological Approaches to pest and disease control" held from 14th November to 4th December, 2007, 14 pp.

Ballal, C. R., Joshi S., Jalali, S. K., Prashanth Mohanraj and Ramanujam, B 2007. Training Manual for the Winter School on "Biological and Bio-technological Approaches to pest and disease control" from 14th November to 4th December, 2007. 400 pp.

Ballal, C. R., Joshi, S., Sriram, S., Srinivasa Murthy, K and Rabindra, R. J. (Editors and Compilers) Annual Report of AICRP on Biological Control of Crop Pests and weeds for the period 2006-07, Project Directorate of Biological Control, Bangalore, 367 pp.

Ballal, C. R., Prashanth Mohanraj, Joshi, S. and Rao, N. S. 2007. RPF III of the Project entitled Rearing and evaluation of natural enemies with special reference to scelionid, braconid, ichneumonid and anthocorid groups, Project Directorate of Biological Control, 50 pp. + Annexure 138 pp.

Ballal, C. R., Rabindra, R. J., Joshi, S., Sriram, S. and Srinivasa Murthy, K., (Editors and compilers) 2007. Proceedings of the XVI Biocontrol Workers' Group Meeting, Compiled and Edited by Project Technical Document No. 59, Directorate of Biological Control, Bangalore, 110 pp.

Hussaini, S. S. 2007 Entomopathogenic nematodes –a potential biopesticide for insect control, *Green farming* **1(1): 1-8**

Hussaini, S. S. 2007. Insect Pathogenic nematodes : A potential biopesticide SBSI Biopesticide News , Insect Biopesticide Research Centre, Prakash Nagar, Jalandhar 144003, India,2: 3-6.

Hussaini, S. S. and Satender Kumar. 2008. Peedak Niyantran ke liye keet rog sootrakrimi ek mahatvapoorn jaiv keetnaashi (Hindi) *Green Farming.*

Kumar, P. S., Rabindra, R. J. and Usha Dev. 2007. Dossier on the Peruvian isolate (W2102; IMI 393076) of *Puccinia spegazzinii*, a classical biological control agent for *Mikania micrantha* in India. Project Directorate of Biological Control, India (unpublished document), 15 pp.

Kumar, P. S., Bhumannavar, B. S., Joshi, S. and Rabindra, R. J. 2007. Annual Report 2006-07, Project Directorate of Biological Control, 153pp.

Kumar, P. S., Bhumannavar, B. S. and Rabindra, R. J. 2007. Research Highlights 2006-07, Project Directorate of Biological Control, 23pp.

Rabindra, R. J., Joshi S. and Prashant Mohanraj 2007. *Kabbina Bili Henina Jaivika Niyantrana-Ondu Yashogathe*. (In Kannada), Project Directorate of Biological Control, Bangalore, 4pp.

Rabindra, R. J., Veenakumari, K., Sriram, S. and Bakthavatsalam, N. 2007. EFC Memo – XI plan document for National Bureau of Agricultural important insects, AICRPs and AINPs (2007-2012) 446pp.

Veenakumari, K., Rabindra, R. J., Srinivas Naik, C. D. and Shubha, M. R. 2007. Nucleopolyhedrovirus for the Biological Control of the Red Hairy caterpillar – *Amsacta albistriga*. Technical Bulletin No.37. Project Directorate of Biological Control, Bangalore -560024.

CPCRI, Kayangulam

Chandrika Mohan and Rajan, P. 2008. Coconut leaf eating caterpillar. Extension folder (Malayalam) CPCRI (RS), Kayangulam, Kerala.

Chandrika Mohan, Rajan, P. and Joseph Rajkumar 2008. Black beetle, Extension folder (Malayalam), CPCRI (RS), Kayangulam, Kerala.

Chandrika Mohan, Rajan, P. and Nair, C. P. R. 2008. Many enemies for the coconut palm (Malayalam). *Keerala karshakan*, **539**: 17-21.

Nair, C. P. R., Chandrika Mohan and Rajan, P. 2007. Priority of biological control in coconut pest management (Malayalam) *Karshkan* **15**(10): 31-33.

Rajan, P. and Chandrika Mohan 2008. Coreid bug, Extension folder (Malayalam), CPCRI (RS), Kayangulam, Kerala.

Rajan, P., Chandrika Mohan and Nair, C. P. R. 2007. Coconut Mite (*Aceria guerreronis* Keifer). Technical folder for APCC countries (Eds., S..P. Singh, Romulo N. Arancon Jr., APCC, Jakarta) CPCRI (RS) Kayangulam, Kerala.

IIHR, Bangalore

Krishnakumar, N. K., Krishnamoorthy, P. N., Krishnaprasad, K. S., Krishnamoorthy, A., Verghese, A., Rao, M. S., Jhansi Rani, H. R., Ranghanath, Ganga Visalakshy, P. N., Sridhar, V. and Kkamala Jayanthi, P. D. 2008. Pest management in horticultural crops: fruits, vegetables and ornamaetals. Tech. bulletin.30. IIHR., Bangalore.

Krishnamoorthy, A. and Ganga visalaskhy, P. N. 2008. Vth QRT report of AICRP on Biological Control of Crop Pests and Weeds of IIHR, Bangalore from 2002-2007.

SBI, Coimbatore

Geetha, N. 2007. Bioecology and nature of damage by sugarcane woolly aphid p34-50. In: *Woolly aphid Management in sugarcane (ed* .T. Rajula Shanthy, R. Thiagarajan and D. Puthira Prathap*)* Extension publication No154 (2007) SBI, Coimbatore.

Geetha, N. 2008. Sugarcane pest management in ratoon crop. p. 89-95. In: *Ratoon Management in sugarcane (ed.*T. Rajula Shanthy and D.Puthira Prathap*)* Extension publication No157(2008) SBI, Coimbatore.

Geetha, N. 2008. Cost effective technologies in sugarcane pest management. p.72-79. In.: Low cost production technologies in sugarcane with sustaining productivity *(ed.*T.Rajula Shanthy and D. Puthira Prathap*)* Extension publication No161(2008) SBI, Coimbatore.

GBPUA&T, Pantnagar

U. S. Singh and N. W. Zaidi, 2008. dhd`r uk"khtho izcU/ku *In* Pantnagar Kisan Diary, pp. 265-267.

KAU, Thrissur

Published a brochure in Malayalam entitled "Nelkrishiyil Jaiveeka Keeda Niyanthranam" .

MPKV, Pune

Pokharkar, D. S. 2007. Biological control of insect pests and mites in grapes. Drakshavrutta, August-2007, Souvenier, pp. 56-59.

Chandele, A.G., Nakat, R. V. and Lolage, G. R. 2007. Management of African giant snail, *Achetina fulica*, Poster, pp. 1.

Nakat, R.V. and Pokharkar, D. S. 2008. Management of mealy bugs on custard apple and fig. Agro-Won, March 14, 2008, pp. 8-9.

PAU, Ludhiana

Butter N. S., Virk, J. S. and Sharma, S. 2007. Ganne de hanikarak kireyan di sarvpakhi roktham. *Changi Kheti*. 42(7): 7-9.

12. LIST OF APPROVED ONGOING PROJECTS

Basic research

Project Directorate of Biological Control, Bangalore

1. Taxonomic studies on lesser known Coccinellidae of the Indian Subcontinent
2. Biosystematics of *Trichogramma* and *Trichogrammatoidea*
3. Introduction and studies on natural enemies of some new exotic insect pests and weeds
4. Interaction within the natural enemy guilds of *Ceratovacuna langera* and *Maconellicoccus hirsutus*
5. Development of production protocols and evaluation of anthocorid predators
6. Mass production and field evaluation of *Micromus* sp.
7. Development of novel mass production, storage, and packaging techniques for *C. montrouzieri*
8. Conservation of natural enemies of Rice pests through habitat manipulation techniques
9. Attractants for natural enemies of rice pests for use in the conservation of natural enemies
10. Selection of superior strain of *Chrysoperla carnea* and *Cryptolaemus montrouzieri* from different agro-ecosystems and their molecular characterization
11. Selection of superior strains of certain parasitoids and their characterization
12. *In vitro* cloning of NPV for genetic improvement
13. Inter and Intra specific variation in egg parasitoids, storage and their molecular characterization
14. Identification of pathogens of phytophagous mites and assessment of their potential in microbial control
15. Identification of *Trichoderma* isolates with enhanced biocontrol potential
16. Efficient formulations of *Trichoderma* sp. and entomofungal pathogens with prolonged shelf-life
17. Isolation, characterization and toxicity of indigenous *Bacillus thuringiensis* strains against lepidopterous pests
18. Isolation and characterization of plant growth promoting endophytic bacteria and development of improved formulations
19. Biological control of *Alternaria* leaf blight of tomato
20. Long term Management of red hairy caterpillar (*Amsacta albistriga*) by creating Epizootics of Nuclear polyhedrosis virus
21. Effect of different edaphic factors on EPN activity and refinement of packaging for EPN formulations
22. Data base on entomopathogenic nematodes

Indian Agricultural Research Institute, New Delhi

1. Isolation, characterisation and evaluation of potential *Bt* isolates

Applied research

I BIOLOGICAL CONTROL OF PLANT DISEASES AND NEMATODES USING ANTAGONISTIC ORGANISMS

1. *In vitro* and Green house testing, screening of available isolates of antagonists for their tolerance to abiotic stresses (i.e. cold, drought, salinity) under *in vitro* condition and their performance under rain-fed conditions of hills

and plains (normal & *Usar* soils) (GBPUAT)

2. Field evaluation of promising strains under rain-fed conditions (GBPUA&T)
3. Large scale field demonstration of biocontrol technologies in field (GBPUAT, PAU, AAU(A))
4. Development of non-chemical methods based management strategy for minimizing post harvest losses in mango, litchi and guava (GBPUA&T)
5. To evaluate the potential of selected agents in the management of fruit rot in mango, papaya and guava (PAU, AAU(Anand), GBPUA&T, ANGRAU, MPKV)
   A. Isolation and identification of the potential biocontrol agents (especially yeasts) for the management of post harvest losses

      (GBPUA&T: with *Trichoderma* and *Pseudomonas*, not yeast, (on papaya, mango, guava); AAU (Anand) (on papaya); PAU (on mango), ANGRAU (on mango in collaboration with the plant pathologist at Fruit Research Station at Sangareddy); MPKV (on mango in collaboration with station at Kolhapur)
   B. Evaluation of the biocontrol potential of selected bioagents
6. BIOLOGICAL CONTROL OF PLANT PARASITIC NEMATODES

   (A linkage programme with AICRP on plant parasitic nematodes)

A. Biological control of pigeonpea cyst nematodes and disease complex in redgram (AAU (A)*, TNAU, CS Azad UAT, Kanpur; MPKV, Rahuri)

   (*AAU (A) to develop suitable protocol for their center & communicate to PDBC)
B. Biological control of plant parasitic nematodes on Vegetables and fruits (tomato & pomegranate)

   Tomato: AAU(J), CSKHPKVV, Palampur; BCKVV, Kalyani, CCSHAU, Hisar, UAS, Bangalore. Pomegranate: MPKV, Rahuri, UAS, Bangalore, AAU(A)*

   (*AAU(A) to develop suitable protocol for their center & communicate to PDBC)
C. Biological control of nematodes infesting carnation in polyhouses (UAS, Bangalore)
D. Biological control of plant parasitic nematodes on Citrus (MPKV, Rahuri)

II. BIOLOGICAL SUPPRESSION OF SUGARCANE PESTS

1. Demonstration of *Trichogramma chilonis* against the plassey borer *Chilo tumidicostalis* (AAU(J))
2. Demonstration on use of bioagents for management of sugarcane woolly aphid (MPKV, VSI, Pune, TNAU, UAS, (D), SBI (Coimbatore), ANGRAU)
3. Development of IPM strategies for sugarcane woolly aphid (MPKV, VSI, Pune, TNAU, UAS (D), SBI)
4. Demonstration on the use of *T. chilonis* (temperature tolerant strain) against early shoot borer at one location (In 2007-08= 40 hectares & 2008-09=100ha). (PAU)
5. Large scale demonstration of *T. chilonis* against stalk borer in collaboration with sugar mills of the state. (2007-08= 1000 ha & 2008-09=2000 ha). (PAU)
6. Demonstration on the use of *T. japonicum* against top borer (PAU)
7. To study the influence of plant structural complexity on the behavior of *T. chilonis* (SBI)
8. To study the kairomonal effect of host pheromone on *T. chilonis* (SBI)
9. Field evaluation of *T. chilonis* in combination with pheromones (SBI)
10. To standardize group rearing of the host for mass production of GV of *C. infuscatellus* (SBI)
11. To collect GV isolates from different factory zones and assess the virulence of GV isolates on *Chilo infuscatellus* (SBI)
12. Studies on *Encarsia flavoscutellum* (SBI, AAU(J), TNAU, VSI, MPKV and Navsari Agri University (NAU))

13. Bio-intensive management of stalk borer, *Chilo auricilius* Dudgeon and internode borer, *Chilo sacchariphagus indicus* (Kapur) (IISR)
14. Evaluation of *Metarhizium anisopliae* and EPNs against termites (IISR and VSI, Pune)
15. Termite control with Entomopathogenic Nematodes (VSI, Pune; PDBC)

III. BIOLOGICAL SUPPRESSION OF COTTON PESTS

1. Demonstration of bio-Intensive Pest Management (BIPM) in *Bt* cotton (ANGRAU, AAU (Anand) , PAU, MPKV, TNAU, UAS(D), Raichur)
2. Bio-intensive pest management of pink boll worm, *Pectinophora gossypiella* on cotton (MPKV, ANGRAU, TNAU, AAU, Anand)
3. Enhancement of natural enemies population in cotton by habitat manipulation in rainfed cotton (PAU, ANGRAU, AAU (A), MPKV)
4. Identification of natural enemies of mealy bugs on cotton and evaluation of potential natural enemies (AAU (Anand), ANGRAU, MPKV, TNAU)

IV. BIOLOGICAL SUPPRESSION OF TOBACCO PESTS

1. Studies on the influence of water quality on the efficacy of entomopathogens against tobacco pests. (CTRI)
2. Comparative study of virulence of different isolates of *Spodoptera litura* NPV in tobacco, soybean and chilly ecosystem. (CTRI)
3. Studies on Biological control options for suppression of tobacco stem borer *Scrobipalpa heliopa* Low (Lepidoptera, Gelichidae) (CTRI)
4. Standardization of mass multiplication of *Spodoptera exigua* and *Se*NPV (CTRI)
5. Bio-efficacy of some microbial insecticides against *Spodoptera litura* in tobacco nursery. (AAU, Anand)
6. Popularization of Biocontrol Techniques in farmers fields (CTRI).

V. BIOLOGICAL SUPPRESSION OF PULSE CROP PESTS

1. Demonstration of biocontrol of pests and diseases of Pigeonpea (TNAU, ANGRAU, AAU- Anand)
2. Demonstration of biological control of seed/ soil borne disease of chickpea and *H. armigera* (PAU, Ludhiana)
3. Fixing economic threshold level for NPV application for the control of *Helicoverpa armigera* on chickpea (TNAU, PAU, AAU, Anand)
4. Survey for natural enemies of pigeonpea pod wasp, *Tanaostigmodes cajaninae* and pod fly, *Melanagromyza obtusa* (ANGRAU)
5. Evaluation of EPN (*Heterorhabditis* sp.) against lepidopteran pod borers (ANGRAU)
6. Demonstration of BIPM package for soybean pests (NRCS)
7. Microbial control of *H. armigera* and *Adisura atkinsoni* on *Dolichos lablab* (ANGRAU)

VI. BIOLOGICAL SUPPRESSION RICE PESTS

1. Large-scale demonstration of IPM for rice pests and diseases in the farmer's field (KAU, AAU-Jorhat, PAU)
2. Validation of biointensive pest management practices in organic rice production (PAU, KAU, AAU-Jorhat, NCIPM)

VII. BIOLOGICAL SUPPRESSION OF PESTS OF MAIZE

1. Control of cutworm *Agrotis ipsilon* on maize with EPN (SKUAS&T(J) in collaboration with PDBC)

VIII. BIOLOGICAL SUPPRESSION OF OILSEED CROP PESTS

1. Evaluation of BIPM package for castor pests (ANGRAU, TNAU)
2. Laboratory evaluation of Trichogrammatids against castor capsule borer (ANGRAU)
3. Biological suppression of *Uroleucon carthami* in non spiny safflower varieties (ANGRAU)

4. Biological control of groundnut leaf miner (TNAU)
5. Evaluation of Trichogrammatids against the mustard sawfly (AAU-Jorhat))

IX. BIOLOGICAL SUPPRESSION OF COCONUT PESTS

1. Collection of geographic populations of braconid parasitoids of coconut black headed caterpillar and evaluation of efficiency (CPCRI)
2. Large scale validation on biocontrol of coconut leaf caterpillar *Opisina arenosella* in Kerala (KAU)
3. Evaluation of *Hirsutella thompsonii* for the biocontrol of coconut eriophyid mite (PDBC*, BCKVK, ANGRAU, CPCRI, KAU, NAU, TNAU, UAS(B))
4. Large area demonstration of *Oryctes rhinoceros* management using *Metarrhizium anisopliae* var. *major* and baculovirus in Kerala (KAU, CPCRI*)
5. Field studies on management of *Oryctes* through integration of Green muscardine fungus (GMF), *Oryctes* Baculovirus (OBV) and attractant baited pheromone traps (CPCRI)

X. BIOLOGICAL SUPPRESSION OF PESTS IN TROPICAL FRUITS

1. Evaluation of biological control agents against mango hoppers (IIHR, MPKV, TNAU ANGAU)
2. Demonstration on biological suppression of pink mealy bugs, *M. hirsutus* on custard apple, grapes (NRC on grapes, MPKV, Pune)
3. Survey and record of natural enemies of thrips on pomegranate, grapes (MPKV) and mango (Navsari Agri. University)
4. Effect of off-season release of *Cryptolaemus montrouzieri* to suppress the mealy bug in the main season on custard apple (ANGRAU)
5. Bio control of Guava fruit borer *Conogethes punctiferalis* (RARS, UAS (D) Raichur)

XI. BIOLOGICAL SUPPRESSION OF PESTS OF TEMPERATE FRUITS

1. Development of bio-intensive IPM for San Jose Scale, *Quadraspidiotus perniciosus* in apple ecosystem (SKUAS&T)
2. Field evaluation of *Trichogramma embryophagum* against the codling moth, *Cydia pomonella* on apple (SKUAS&T)
3. A. Evaluation of some microbial pesticides against tree stem borer (*Aeolesthes sata*) (SKUAS&T)
4. Evaluation of fungal pathogens against the apple wooly aphid (*Eriosoma lanigerum*) on apple (YSPUH & F).
5. Laboratory evaluation of some bioagents against the root borer *Dorysthenes hugelii* as pest of apple (YSPUH&F)
6. Studies on the predators of phytophagous mites on apple and beans (YSPUH&F)

XII. BIOLOGICAL SUPPRESSION OF PESTS OF VEGETABLE CROPS

1. Field evaluation of *Trichogramma brassicae* against *Plutella xylostella* on cabbage/ cauliflower (AAU(J), MPKV, TNAU, SDAU & SKUAS&T)
2. Field evaluation of *Trichogramma brassicae* against *Pieris brassicae* on cabbage/ cauliflower (SKUAS&T)
3. Demonstration of biocontrol based IPM module against cabbage pests. (SDAU)
4. Evaluation of *Trichogramma brassicae, B. bassiana* and *S. carpocapsae* against lepidopterous pests of cruciferous crops (cabbage) (IIHR, MPUAT)
5. Evaluation of *Trichogramma chilonis*, EPN and *Bt.* against fruit borer of brinjal and Okra (KAU (on brinjal borer), PAU, AAU (J) and MPUAT)
6. Demonstration of Biological Control of Tomato fruit borer *Helicoverpa armigera* (PAU)
7. Biocontrol of *Aphis craccivora* in cowpea using entomofungal pathogens. (KAU)

8. Demonstration of Potato Tuber Moth suppression by releasing *Copidosoma koehleri* (MPKV, AAU - Jorhat)
9. Effectiveness of various microbial pesticides and a summer oil against *Pieris brassicae* on kale / Knol khol. (SKUAS & T)
10. Biological control of cabbage aphids (*Brevicoryne brassicae*) (SKUAS & T)
11. Study on natural enemies of the serpentine leaf miner, *Liriomyza trifolii* on tomato and their possible exploitation for its suppression (YSPUH&F)
12. Demonstration of bio-intensive package for the pests of cole crops (YSPUH & F)
13. Biocontrol of greenhouse whiteflies (GHWF) on beans/cucumber/tomato (YSPUH&F)

XIII. BIOLOGICAL SUPPRESSION OF WHITE GRUBS

1. Biological Control of white grubs on turf grass (YSPUH&F)
2. Biological suppression of white grubs

a) Potato and tomato (GBPUA&T, Ranichauri Centre)

b) Potato (YSPUH&F, MPKV)

c) Sugarcane

i) *Leucopholis* (COA, Kolhapur)

ii) *Holotrichia* (VSI, MPKV)

3. Mass Production of *B. brongniartii* and *B. bassiana* using adult white grubs (MPKV, Kolhapur)
4. Suppression of Cardamom root grub, *Basilepta fulvicorne* with Entomopathogenic Nematodes (Voluntary Centre: Cardamom Res. Station, Pampadampara, Idukki)

XIV. BIOLOGICAL SUPPRESSION OF PESTS IN POLYHOUSES

1. Evaluation of biological control agents against sucking pests of vegetables and ornamentals under polyhouse conditions KAU: Gerbera/ capsicum/ tomato/ rose MPKV: Rose and Chillies/capsicum IIHR: Rose/Carnation/Chilli/capsicum
2. Evaluation of anthocorid predator, *Blaptostethus pallescens* against spider mites on carnation in polyhouses (KAU, MPKV, PDBC)

XV. BIOLOGICAL SUPPRESSION OF WEEDS

1. A) Survey of natural enemies of *Cyperus rotundus* (AAU-Jorhat)

   B) Biocontrol of *Cyperus rotundus* (KAU)
2. Biocontrol of *Chromolaena odorata* using *Cecidochares connexa* (KAU, AAU-Jorhat)
3. Monitoring of populations of *Cyrtobagous salviniae* released in the Kolhapur lake (Entomology Dept., College of Agriculture, Kolhapur)
4. Investigations on the differential performance of *Cyrtobagous salviniae* against *Salvinia* (KAU)

XVI. ESTABLISHMENT OF MASS PRODUCTION UNITS (AT ALL THE AICRP CENTRES)

13. CONSULTANCY, PATENTS AND COMMERCIALISATION OF TECHNOLOGY

- Quality test for several biopesticides
- EAG and GC-MS analysis for samples received from various organizations
- Bioassay of *Bt* proteins against lepidopterous pests
- Mass production and supply of *Goniozus nephantidis* for the biological control of *Opisina arenosella* on coconut

14. MEETINGS HELD AND SIGNIFICANT DECISIONS MADE

Institute Research Council Meeting held from 7-8 May 2007

The Institute Research Council Meeting of PDBC, Bangalore was held from 7-8 May 2007 under the Chairmanship of Dr.R.J.Rabindra, Project Director. The Project Director advised the scientists to complete all the objectives and technical programme so that no objections are raised by the audit. He advised the scientists to initiate action on the recommendation of the previous IRC immediately on priority basis. All the scientists were advised to ensure that research programmes are formulated as per projection of the perspective plan. Research focus should be on refining technologies of mass production so that quality biocontrol agents will be registered. The scientists were asked to identify field trials and include them as adhoc programmes to their research projects.

After the detailed discussion on the presentation on the achievements as per the targets given in their respective projects following points emerged out as recommendation for action.

- ❖ Supply of *Cecidochares connexa* may be made during July-August, 2007-08 to the Co-ordinating centres located in Assam and Kerala along with the protocols for field establishment and impact assessment. (Action: Dr. S. Ramani)
- ❖ The preparation of the distribution maps for common species of coccinellids should be completed by November, 2007. A presentation on visit of Australian laboratory on sabbatical leave may be done within 30 days. (Action: Dr. J. Poorani)
- ❖ Studies on the occurrence of *Anagyrus kamali* needs to be intensified. The prospects of *A. kamali* as a biocontrol agent for *Maconellicoccus* should be explored under *Encarsia-Dipha* interaction, emergence of *Encarsia* from normal looking SWA may be studied. Also predation by *Dipha* on bald aphids (*Encarsia* parasitized) may be investigated. Work on the import of *Heteropsylla spinulosa* should be expedited before the expiry of the import permit. Mimosa plants to be raised and kept ready. (Action: S. Ramani)
- ❖ Alternate hosts of new species of *Trichogramma* and *Trichogrammatoidea* need to be identified. The work on semisynthetic diet should be intensified for *Dipha* (Action: Dr. Prashanth Mohanraj)
- ❖ *Tr. armigera* to be tried on *H. armigera* on pigeon pea. Maintenance of culture of *Telenomus remus* may be transferred to mass production unit. In the new project on Development of production protocol and evaluation of anthocorid predators, Dr. P. Mohanraj name can be included in place of Dr. N. S. Rao Susceptibility of anthocorids to acarophagous fungi may be studied in collaboration with Dr. P. Sreerama Kumar (Action: Dr. CRB)
- ❖ Cost of production of *S. cerealella, Cryptolaemus* and *Micromus* has to could be worked out. Rearing parameters for *Micromus* has to be standardized in terms of area/ volume/ larva or per pair of adults. (Action: Dr. S. Joshi)

- Shelf life studies on NPV formulations beyond 9 months up to 18 months has to be done (Action: Dr. K. Veenakumari)
- Efforts need to be made to collect antagonists for *Alternaria* spp. from different geographical regions of the country. A large number of naturally occurring antagonists from the phyloplane should be isolated and tested against *Alternaria*. The mechanism of action of *Trichoderma* against *Alernaria* may be studied. Promising *Trichoderma* isolates can be tested against *Alernaria* spp. on tomato (Action: Dr. Ramanujam)
- Testing the pathogenicity of different *Bt*. isolates against important lepidopteran pests like okra fruit borer, brinjal fruit borer and rice leaf folder has to be completed by October, 2007. Dr. K. Veenakumari will associate in this work. (Action: Dr. Rangeswaran)
- Efforts should be made to start the concurrent trial on the efficacy of *H. thompsonii* along with adjuvants in multi-location trials by June/ July, 2007. (Action: Dr. Sreerama kumar)
- Suitable methods for assessing the bio-efficacy of formulation in storage need to be standardized and suitable packaging materials to be identified and work to be intensified on *Trichoderma* isolates. After six months of storage, quality parameters can be tested at monthly intervals. Research on solid-state formulation and fabrication of semi-automation gadgets may be initiated. (Action: Dr. S. Sriram)
- A road map may pleased be prepared for future studies using synomonal compounds (Action: Dr. P.L. Tandon)
- Different brands of sponge with different density may be tried for formulation of EPN. (Dr. S.S.Hussaini)
- Efforts may be made to increase the geographical locations while collecting *C. carnea* and other Neuropteran for strain evaluation. Since *Mallada boninensis* is also found along *Chrysoperla* on cotton, the predatory potential of *M. boninensis* against the sucking pests of cotton may be studied. (Action: Dr. T. Venketasan)
- Arrangements may be made to release the CD on biological suppression of rice pests by July, 2007. (Action: Dr. N. S. Rao)
- The activity mile-stone may be included in all the RPF I for new projects submitted by different scientists (Action: All scientists)
- The scientists should re-submit RPF-I incorporating the suggestions given by the Project Monitoring and Evaluation Cell (Action: All scientists).

15. PARTICIPATION OF SCIENTISTS IN CONFERENCES, MEETINGS, WORKSHOPS, SYMPOSIA, ETC. IN INDIA AND ABROAD

International

Project Directorate of Biological Control, Bangalore

Dr. R.J.Rabindra

International Symposium on coastal Agriculture at Science City, Kolkata on 28-10-2007.

Dr. P. Sreerama Kumar

Workshop on the coconut mite, Salalah Agricultural Research Station, Salalah, Dhofar region, Sultanate of Oman, 21-10-2007 to 24-10-2007.

Dr. M. Nagesh

International Conference on Biotechnology", VIT, Vellore, (6-2-2008 to 8-2-2008).

Gobind Ballabh Pant University of Agriculture & Technology, Pantnagar

Dr. U. S. Singh

Dhaka, Bangladesh to participate in the policy and planning workshop of The Global Plant Clinic (GPC), managed by CABI, UK, and Indian and Bangladesh partners from the 5-12-2007 to 6-12-2007.

Dr. N. W. Zaidi

Dhaka, Bangladesh to participate in the policy and planning workshop of The Global Plant Clinic (GPC), managed by CABI, UK, and Indian and Bangladesh partners from the 5-12-2007 to 6-12-2007.

Interview on BBC World Service in the programme *One Planet: From the Ground up: Part 1* that covers environmental, development and agriculture stories, dealing with the impact of humankind on the natural world. (Broadcast in January 2008)

Kerala Agricultural University, Thrissur

Dr. S. Pathummal Beevi

International symposium on Agrometeorology and Food Security, 18-2-2008 to 21-2-2008 at CRIDA, Hyderabad.

National

Project Directorate of Biological Control, Bangalore

Dr. R.J.Rabindra

- QRT meeting of the IIVR, Varanasi at Krishi anusandhan Bhawan-II, New Delhi on 25-5-2007.
- First Training-cum-workshop on IP and Technology Management in ICAR system at NAARM, Hyderabad from 28-5-2007 to 30-5-2007, called by ADG (IPM and Policy), ICAR.
- National workshop on Integrated Management of white grubs in sugarcane: Current Trends and Future Strategies held at VSI, Pune on 14-6-2007.
- Review meeting on the management of grape vine mealy bug at NRC Campus, Pune on 20-6-2007.
- QRT meeting of NRC for Weed Science from 1-7-2007 to 4-7-2007 at HPKVV, Palampur.
- Fifth RAC meeting of Central Institute for Tropical Horticulture, Srinagar from 7-7-2007 to 8-7-2007 at Reginal Station, Mukteshwar, Nainital District.
- Directors' Conference of ICAR institutes from 16-7-2007 to 18-7-2007 at NASC Complex, New Delhi.
- Symposium organized by the Entomology Academy at Chennai and delivered a lecture on "Current Status and Prospects of Classical Biological Control of Exotic Pest Species" on 18-8-2007.

- CIBRC Expert Committee Meeting at ICAR, New Delhi on 30-10-2007.
- NAIP meeting held at NAARM, Hyderabad on 28-11-2007.
- Training programme on IPM in *Bt* cotton organized by NCIPM at RRS, LAM, Guntur on12-12-2007.
- DBT task force meeting on 10-1-2008 at DBT Office, New Delhi.
- XXI Meeting of ICAR Regional Committee No. VIII at CTCRI, Thiruvananthapuram on 11-1-2008.
- UGC-SAP programme of the Anna University from 18-2-2008 to 19-2-2008.

Dr. Veenakumari

- NAIP project (Production to Consumption) proposal meeting with partners from private sector personnel of KVK, AME foundation, ATMA and others on 15-12-2007 at PDBC, Bangalore.
- Special interactive workshop on "Administrative and Financial Matters' for the ICAR Institutes placed under southern/ western zone held at NIANP, Bangalore on 26-10-2007 to 27-10-2007.

Dr. Chandish. R. Ballal

- National Workshop on Women in Agriculture from 10-4-2007 to 12-4-2007 at GKVK, Bangalore
- UGC sponsored Refresher course on "Organic Pest Control" (21-1-2007 to 10-2-2008) and delivered a lecture on "Mass Production Protocols for potential biocontrol agents" at Annamalai University, Chidambaram on 08.02.2008.
- DBT Rural Bio-resources Complex Project Meeting at Karnada Village on 4-7-2007, Doddaballapur (organized by ISRO-UAS Bangalore).
- Institute Research Council Meeting on 7-5-2007 at PDBC, Bangalore
- XVI Biocontrol Workers Group Meeting held on 18-5-2007 to 19-5-2007 at ANGRAU, Hyderabad.
- National Symposium on "Thrust areas in Entomological Research" organised by the Entomology Academy of India on 18-8-2007.

Dr. J. Poorani

- Review meeting of the Network Project on Insect Biosystematics held at IARI, New Delhi, on 17-12-2007 and presented the report for PDBC centre.

Dr. S.K.Murthy

- Meeting on "ICAR Information and Publication Services" organized by the Directorate of Information and Publication of Agriculture at IIHR, Bangalore, 29-9-2007.
- All India Convention on the Right to Information Act, 15-6-2007 to16-6-2007 and 15-10-2007 to 16-10-2007 at Hotel Capitol, Rajbhavan Road, Bangalore.

Dr. S. S. Hussaini

- National Symposium on "*Emerging Trends of Bioinoculants in Forestry*", April, 26-4-2007 to 27-4-2007, TFRI, JABALPUR.
- National Symposium on "*Ecofriendly insect Pest Management* ",Chennai, Feb, 7-2-2007 to 8-2-2007.
- Refresher Course in Organic Pest Control, held at Dept. of Entomology/Faculty of Agriculture, Annamalai University, January 21-1-2008 to 10-2-2008.
- National Symposium on Molecular Biology held at CMC,Vellore, Feb,2008.
- Winter School, Maharana Pratap University of Agriculture and Technology, Udaipur

Dr. B. Bhumannavar

- XVI Biocontrol Workers Group Meeting on Biological control of Crop Pests and Weeds from 18-19, May, 2007 at ANGRAU, Hyderabad.

Dr. A. N. Shylesha

- Work shop on Agricultural Biosecurity at

NASC complex New Delhi. 25th March 2008

Dr. R. Rangeshwaran

- Stake holders meeting organized by NAIP for the PDBC project titled "Production and Uptake of Quality Biological Control Agents for Enhancing Productivity of Agri-Horticultural Farming Systems" on
- Stake holders meeting organized by NAIP for the PDBC project titled "Effect of abiotic stresses on the natural enemies of crop pests: *Trichogramma, Chrysoperla, Trichoderma* and *Pseudomonas* and mechanism of tolerance to these stresses" held at PDBC on

Dr. Sunil Joshi

- Meeting on "Present status of sugarcane woolly aphid in Karnataka" at the chamber of Director of Agriculture, Bangalore on 29.02.08
- Meeting on "National scenario on management of sucking pests" on 7.03.08 at IIHR, Bangalore

Dr. P. Sreeramakumar

- Institute Research Council Meeting at PDBC, Bangalore, on 7-8 May 2007.
- Meeting of the Project Application of Microorganisms in Agriculture and Allied Sectors (AMAAS) (South Zone), Indian Institute of Spices Research, Marikunnu, Calicut, 3-4 August 2007.
- National Symposium in Acarology: Acari-Globalisation and Climate Change), Acarological Society of India, University of Agricultural Sciences, GKVK Campus, Bangalore, 24-26 November 2007.

Dr. S. Sriram

- DBT task force on 31st August and 1st Sept. at IIHT, Palampur and presented the first year report with respect to the DBT sponsored project on development of invert-emulsion formulation of *Trichoderma*.
- NAIP stakeholders meeting with respect to NAIP proposal on Production to uptake of biological control agents under component II at PDBC, 15th Dec 2007. The participants included private sector partners, Programme organizers from different KVKs, scientists from collaborating SAUs and ICAR institutes.
- Brainstorming session on "Establishment of National Genomic Research Repository" at NBPGR on 27th Dec 2007.
- NAIP workshop on developing the full proposals held at NASC complex and organized by NAIP on 28th Dec 2007.
- Network meeting on wilt and Phytophthora diseases of plants on 16th Jan 2008. Component with respect to biological control has been included in which PDBC will be a partner.
- TAG meeting and presented the proposal with respect to NAIP component II proposal at New Delhi on 11th March 2008.
- RPC meeting with respect to proposal under component IV (Basic and Strategic Research) at New Delhi on 19th March 2008.

Ms. M. Pratheepa

- Training programme on Senior Programme on E-Learning from 20-08-2007 to 25-08-2008 at NAARM, Hyderabad
- Training programme on GIS Based Decision Support Systems for Sustainable Agriculture from 01-02-2008 to 21-02-2008 at NAARM, Hyderabad

Central Plantation Crops Research Institute, Regional Station, Kayangulam

Dr. Chandrika Mohan

- The brain storming session on "Field level utilization of technologies and research/ technology gap to address the field problems in coconut, arecanut and cocoa" held at CPCRI, Kasaragod during 18/02/2008.
- The national level group discussion on diseases of phytoplasmal and complex etiology of coconut and arecanut held at CPCRI, Regional Station, Kayangulam during 28/01/2008.
- The 3rd Annual meeting cum Terminal Review of the CFC/DFID/ APCC/ FAO funded project

on Coconut Integrated Pest Management held at Kochi during 2nd to 5th May 2007.

Central Tobacco Research Institute, Rajahmundry

Dr. S. Gunneswara Rao

- Participated in XVI Biocontrol Working Group Meeting held at ANGRAU, Hyderabad during 18.5.07 to 19.5.07.
- Participated in IRC meeting 2007 of CTRI, Rajahmundry during July, 2007.
- Delivered guest lecture to High School children of Sri Gouthami (EM) High School, Rajahmundry on 28.2.2007.
- Delivered lecture on ‘Role of biocontrol in IPM’ to Management Trainees of M/s Godfrey Phillips (India) Limited on 11.1.2008 at CTRI, Rajahmundry.
- Participated and presented the report for QRT (2002-07) of AICRP Biological Control of Tobacco Pests at ANGRAU, Hyderabad on 21st November 2007.

Indian Institute of Horticultural Research, Bangalore

Dr. P. N. Ganga visalskhy

- National symposium on ecofriendly insect pests management held at loyal college, chennai, from 7-8 feb.2008
- Biennial conference on weed management in modern agriculture: Emering challenges and oppurtunities held at patna from 27th to 28th feb.2008
- XVI AICRP on crop pests and weeds at APAU, Hyderabad, during 18-5-07 to 19-5-07.

Dr. A. Krishnamoorthy

- XVI Biocontrol workers’ group meeting on biological control of crop pests and weeds at ANG Ranga Agricultural University, Hyderabad, 18-19 May 2007
- Group meeting to discuss the formulation of the proposed National Bureu of Agril. Arthropod Resources at PDBC Bangalore 0n 22 /1/2008
- National Consultation on Mealy bug Management held at CICR, Nagpur 28 – 29 January, 2008
- Workshop on biocontrol of crop pests held at NPPTI, Hyderabad on 30 – 31 January 2008 – Strategy for sustainable Biocontrol Programme in India and gave a talk on Biocontrol programme for exports of fruits and vegetables.
- Gave lecture on Biological control of pests in Horticultural ecosystems on 31st January 2008 in Organic pest control – At Annamalai University, Chidambaram, Tamilnadu
- Attended a group meeting on National scenario on Management of sucking pests at IIHR, Bangalore on 7/3/2208

Indian Institute of Sugarcane Research, Lucknow

Dr. Arun Baitha

- The National Symposium on Seed Cane at IISR, Lucknow, 27-28th Sept.2007.

Assam Agricultural University, Jorhat

Dr. A. Basit

- XVI Biocontrol workers Group Meeting held at ANGRAV, Hyderabad on 18th & 19th May 2007.

Dr. D.K. Saikia

- XVI Biocontrol workers Group Meeting held at ANGRAV, Hyderabad on 18th & 19th May 2007.

Kerala Agricultural University, Thrissur

Dr. S. Pathummal Beevi

- XVI Biocontrol workers group meeting held at Acharya N.G. Ranga Agricultural University, Hyderabad on 18th and 19th May 2007.
- Stakeholder’s workshop on ‘Biological control of crop pests’ 29th to 30th January, 2008 at NPPTI, Hyderabad.
- International symposium on Agrometeorology and Food Security, 18-21 February, 2008 at CRIDA, Hyderabad.

Dr. K. R. Lyla

- XVI Biocontrol workers group meeting held at Acharya N.G. Ranga Agricultural University, Hyderabad on 18th and 19th May 2007.

Mahatma Phule Krishi Vidyapeeth, Pune

Dr. D.S. Pokharkar

- XVI Biocontrol Workers Group Meeting on Biological Control of Crop Pests and Weeds at ANGRAU, Hyderabad on May 18-19, 2007.
- Research Review Committee meeting of Plant Protection and Basic Sciences for the year 2007-08 on April 15, 2007 at MPKV, Rahuri.
- 59th Meeting of Board of Studies in Agril. Entomology including Sericulture, Zoology and Nematology on April 23-24, 2007 at MPKV, Rahuri.
- National Workshop on Integrated Management of White grubs in Sugarcane: Current Trends and Future Strategies at Vasantdada Sugar Institute, Manjari (Bk.), Pune on 14th June 2007.
- The meeting on 'Strategies for mealy bug management in grape orchard' at NRC Grape, Pune on 20th June 2007.
- National Symposium on Recent Trends in Organic Farming at College of Agriculture, Pune on September 11-12, 2007.
- National Seminar on 'A Step Towards Prevention of Global Warming: Integrated Management of Early Shoot Borer in Sugarcane' at VSI, Manjari (Bk), Pune on 31st January 2008.

Dr. R. V. Nakat

- National Symposium on Recent Trends in Organic Farming at College of Agriculture, Pune on September 11-12, 2007.

Punjab Agricultural University, Ludhiana

Dr. Maninder Shenhmar

- XVI All India Biocontrol Worker's group meeting held at ANGRAU, Hyderabad from May 18-19, 2007.

Dr. Jaspal Singh Virk

- XVI All India Biocontrol Worker's group meeting held at ANGRAU, Hyderabad from May 18-19, 2007.
- Agricultural Officer's Workshop for *Rabi* crops August 13-14, 2007 at PAU, Ludhiana.
- *Kisan Mela* at PAU, Ludhiana on Sept. 13-14, 2007.
- Symposium on "Pesticides and Environment" held at PAU, Ludhiana on 29th Nov, 2007.
- The XVI Annual Workshop on "All India Network Project on Pesticide Residue" held at PAU, Ludhiana on 15 Dec, 2007.
- The 2nd Annual workshop on "Monitoring of Pesticides Residues at National Level" held at PAU, Ludhiana on 16 Dec, 2007.
- Seminar on 'High Resolution Imaging in Agricultural Research" held at PAU, Ludhiana on 9th January 2008.
- Agricultural Officer's Workshop for *Kharif* crops, PAU, Ludhiana on Feb. 12-13, 2007.
- Second Congress on Insect Science from February 21-22, 2008 held at PAU, Ludhiana.
- *Kisan Mela* at PAU, Ludhiana on March 13 –14 2008.

Dr. Neelam Joshi

- XVI All India Biocontrol Worker's group meeting held at ANGRAU, Hyderabad from May 18-19, 2007.
- Agricultural Officer's Workshop for *Rabi* crops August 13-14, 2007 at PAU, Ludhiana.
- *Kisan Mela* at PAU, Ludhiana on Sept. 13-14, 2007.
- Symposium on "Pesticides and Environment" held at PAU, Ludhiana on 29th Nov, 2007.
- The XVI Annual Workshop on "All India Network Project on Pesticide Residue" held at PAU, Ludhiana on 15 Dec, 2007.
- Second Annual workshop on "Monitoring of Pesticides Residues at National Level" held at PAU, Ludhiana on 16 Dec, 2007.

- Seminar on 'High Resolution Imaging in Agricultural Research" held at PAU, Ludhiana on 9th January 2008.
- Agricultural Officer's Workshop for *Kharif* crops, PAU, Ludhiana on Feb. 12-13, 2007.
- Second Congress on Insect Science from February 21-22, 2008 held at PAU, Ludhiana.

Ms. Ramandeep Kaur

- Agricultural Officer's Workshop for *Rabi* crops August 13-14, 2007 at PAU, Ludhiana.
- *Kisan Mela* at PAU, Ludhiana on Sept. 13-14, 2007.
- Symposium on "Pesticides and Environment" held at PAU, Ludhiana on 29th Nov, 2007.
- The XVI Annual Workshop on "All India Network Project on Pesticide Residue" held at PAU, Ludhiana on 15 Dec, 2007.
- Second Annual workshop on "Monitoring of Pesticides Residues at National Level" held at PAU, Ludhiana on 16 Dec, 2007.
- Seminar on 'High Resolution Imaging in Agricultural Research" held at PAU, Ludhiana on 9th January 2008.
- Agricultural Officer's Workshop for *Kharif* crops, PAU, Ludhiana on Feb. 12-13, 2007.
- Second Congress on Insect Science from February 21-22, 2008 held at PAU, Ludhiana.

Dr. Rabinder Kaur

- XVI All India Biocontrol Worker's group meeting held at ANGRAU, Hyderabad from May 18-19, 2007.
- Agricultural Officer's Workshop for *Rabi* crops August 13-14, 2007 at PAU, Ludhiana.
- *Kisan Mela* at PAU, Ludhiana on Sept. 13-14, 2007.
- Symposium on "Pesticides and Environment" held at PAU, Ludhiana on 29th Nov, 2007.
- The XVI Annual Workshop on "All India Network Project on Pesticide Residue" held at PAU, Ludhiana on 15 Dec, 2007.
- Second Annual workshop on "Monitoring of Pesticides Residues at National Level" held at PAU, Ludhiana on 16 Dec, 2007.
- Seminar on 'High Resolution Imaging in Agricultural Research" held at PAU, Ludhiana on 9th January 2008.
- Agricultural Officer's Workshop for *Kharif* crops, PAU, Ludhiana on Feb. 12-13, 2007.
- Second Congress on Insect Science from February 21-22, 2008 held at PAU, Ludhiana.

Sher-e-Kashmir University of Agriculture Science & Technology, Srinagar

Dr. F.A. Zaki

- xvi workshop on Biological control of crop pests and Diseases at Hyderabad on 18-19 May 2007

Tamilnadu Agricultural University, Coimbatore

Dr.R.Balagurunathan

- VIII Agricultural Science Congress 2007, TNAU.

Dr. M.Kalyanasundaram

- National Termite Group Meet at Mumbai during February 2008.

16. WORKSHOPS, SEMINARS, SUMMER INSTITUTES, TRAINING, ETC.

Organized at PDBC

- XVI Biocontrol Workers' Group Meeting: 18-5-2007 to 19-5-2007
- Winter school on Biological and Biotechnological Approaches toIinsect Pest and Disease Control from 14-11-2007 to 4-12-2007
- Model Training Course on Quality Aspects of Biological Control Agents from 11-12-2007 to 18-12-2007 and 28-1-2008 to 2-2-2008
- Recent trends in biological control of pests and diseases from 17-3-2008 to 26-3-2008

Celebrated

- Hindi Pakhwada from 14-9-2007 to 30-9-2007
- Vigilance awareness week, 12-11-2007 to 16-11-2007

17. DISTINGUISHED VISITORS

Project Directorate of Biological Control, Bangalore

Dr. Mangala Rai, Secretary (DARE), Director General, ICAR, New Delhi, visited PDBC Research Farm during June, 2007

Dr. M. Mahadevappa, Former Chairman, ASRB, ICAR, New Delhi visited PDBC Research Farm during June, 2007

Dr. P. G. Chengappa, Vice-chancellor, UAS, GKVK, Bangalore, Dr. A. M. Krishnappa and Dr. G.K.Veeresh, former VCs of UAS visited PDBC Research Farm during June, 2007

Acharya N. G. Ranga Agricultural University, Hyderabad

Dr. T. Nageswara Rao, Associate Director of Research, RARS, Palem on 7.12.2007

QRT visit 21-22, November, 2007

Central Plantation Ccrops Research Institute, Kayangulam

Mr. Romulo N. Arancon Jr., Executive Director, Asian and Pacific Coconut Community, Jakarta

Dr. S. P. Singh, Project Coordinator IPM, Asian and Pacific Coconut Community, Jakarta

Mr. Peter Thones, Secretary, Intergovernmental Group on Oilseeds, Oils, and Fats, FAO Commodities and Trade Division, Rome, Itally

Mr. W. K. N. Shanthichandra, Assistant Director, Asian and Pacific Coconut Community, Jakarta

Ms. Sri Utami Widya Lestari, Administrative & Finance Officer, Asian and Pacific Coconut Community, Jakarta

Mr. Gerd Walter Echoles, FAORAP, Thailand

Ms. Cynthia E. Gallego, Project Scientist and Division Chief III, Crop Protection Division, Philippine Coconut Authority, Philippines.

Dr. L.C. Priynathie Fernando, Head Crop Protection Division, Coconut Research Institute, Sri Lanka.

Dr. Meldy L. A. Hosang, Entomologist, Indonesian Research Institute for Coconut and Palmae, Indonesia

Dr. A. Sivapragasam, Deputy Director, Rice and Industrial Crops Center, MARDI, Malaysia.

Dr. Zuberi S. K. Seguni, Entomologist, Mikocheni Agricultural Research Institute, Tanzania.

Ms. Yupin Kasinkasaempong, Plant Pathologist, Chumpon Horticultural Research Centre, Thailand

Dr. Shantanu Mathur, Technical Advisor, IFAD

Dr. Maria Luz George, Coordinator, COGENT

Dr. Alessandro Meschinelli, Research Officer, IFAD

Dr. H.T.R. Wijesekhara, Plant Pathologist, CRI, Sri Lanka

Gobind Ballabh Pant University of Agriculture & Technology, Pantnagar

Dr. Elan Chet Professor, University of Jerusalem, Israel (Former President Weisman Institute of Science, Israel and Wolf Prize Winner) (Dec. 2007)

Dr. Eric Boa, Director Global Plant Clinic, CABI, UK (Dec. 2007)

Dr. Yaima Arocha Rossette, Scientist, Rothamsted Research, UK (Dec. 2007)

Mahatma Phule Krishi Vidyapeeth, Pune

Dr. Danilo P. Padua, Visiting Scientist, Knowledge Management and Sharing, ICRISAT, Patancheru, Andhra Pradesh visited on 13-04-2007.

Prof. M. C. Varshneya, Vice-Chancellor, AAU, Anand, Dr. A. M. Shaikh, Dean, F/A, and Dr. A. D. Patel, Research Scientist Bidi Tobacco Project, AAU, Anand visited on 08-5-2007.

Dr. J.A.U.T. Seneviratne, Principal Research Scientist, Sugarcane Research Institute, Sri Lanka, an international delegate approved by the Department of Agricultural Research and Education, Govt. of India, New Delhi and arranged by the Project Director, PDBC, Bangalore visited this centre on November 13-15, 2007 for studying problems of sugarcane woolly aphid and technology developed by this centre for its management.

Dr. S.N. Talekar, Scientist, College of Plant Protection, Yunnan Agricultural University, Kunming, Yunnan 650 201, China visited the Biological control laboratory and field experiments on 01-2-2008 and suggested to include socio-economic component in each biocontrol and IPM projects.

Punjab Agricultural University, Ludhiana

Dr Raj Khosla, University of Louisania, USA, on 5-12-2007

Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar

Lt. General S.K. Sinha, Governor of J & K

Dr. C.B. Singh, Asstt. Prof. Instt. Of Agricultural Sciences, Bundel Khand University

Tamilnadu Agricultural University, Coimbatore

Dr. Tabone Elisaleeth & Co scientists from France visited on 24-09-2007 to get training on sugarcane biological control especially use of various species of *Trichogramma* for sugarcane pest management.

Shrowan K. Adhekany and 10 colleague, Ministry of Agriculture and co-operation, Kathmandu, Nepal as a team visited Biocontrol laboratory on 10-12-2007 to learn the methods of mass production of Biocontrol agents and their field efficacy studies.

The Prochancellor and Honourable Minister for Agriculture visited the Biocontrol Laboratory on 17-03-2008.

18. PERSONNEL

Project Directorate of Biological Control, Bangalore

Dr. R. J. Rabindra	Project Director
Dr. P. L. Tandon	Principal Scientist
Dr. N. S. Rao	Principal Scientist
Dr. S. S. Hussaini	Principal Scientist
Dr. B. S. Bhumannavar	Principal Scientist
Dr. N. Bakthavatsalam	Principal Scientist
Dr. B. Ramanujam	Principal Scientist
Dr. Prashanth Mohanraj	Principal Scientist
Dr. (Ms.) Veena Kumari	Principal Scientist
Dr. (Ms.) J. Poorani	Principal Scientist
Dr. (Ms.) Chandish R. Ballal	Senior Scientist
Dr. S. Ramani	Senior Scientist
Dr. S. K. Jalali	Senior Scientist
Dr. M. Nagesh	Senior Scientist
Dr. T. Venkatesan	Senior Scientist
Dr. P. Sreerama Kumar	Senior Scientist
Dr. Sunil Joshi	Senior Scientist
Dr. K. Srinivasa Murthy	Senior Scientist
Dr. A. N. Shylesh	Senior Scientist
Dr. S. Sriram	Senior Scientist
Dr. R. Rangeshwaran	Senior Scientist
Ms. M. Pratheepa	Scientist (SS)
Dr. (Ms.) Deepa Bhagat	Scientist (SS)

Central Tobacco Research Institute, Rajahmundry

Mr. S. Gunneswara Rao	Scientist (SG)

Central Plantation Crops Research Institute, Regional Station, Kayangulam

Dr. (Ms.) Chandrika Mohan	Senior Scientist

Indian Agricultural Research Institute, New Delhi

Dr. G. T. Gujar	Principal Scientist

Indian Institute of Sugarcane Research, Lucknow

Dr. Arun Baitha	Scientist (SS)

Indian Institute of Horticultural Research, Bangalore

Dr. A. Krishnamoorthy	Principal Scientist
Dr. (Ms.) P. N. Ganga Visalakshy	Senior Scientist

Sugarcane Breeding Institute, Coimbatore

Dr. J. Srikanth	Senior Scientist
Dr. N. Geetha	Senior Scientist

Anand Agricultural University, Anand

Dr. D. M. Korat	Principal Research Scientist
Dr. Babubhai H. Patel	Associate Research Scientist
Dr. J. J. Jani	Assistant Research Scientist
Achrya N. G. Ranga Agricultural University, Hyderabad	
Dr. N. Hariprasada Rao	Principal Scientist
Dr. S. J. Rahman	Senior Scientist
Assam Agricultural University, Jorhat	
Dr. A. Basit	Principal Scientist
Dr. D. K. Saikia	Senior Scientist
Dr. Y. S. Parmar University of Horticulture & Forestry, Solan	
Dr. P. R. Gupta	Senior Entomologist
Dr. Usha Chauhan	Entomologist
Govind Ballabh Pant University of Agricultural Science & Technology, Pantnagar	
Dr. U. S. Singh	Professor
Dr. (Ms.) Nijam Waris Zaidi	Assistant Professor
Kerala Agricultural University, Thrissur	
Dr. (Ms.) S. Pathummal Beevi	Associate Professor
Dr. (Ms.) K. R. Lyla	Associate Professor
Mahatma Phule Krishi Vidyapeeth, Pune	
Dr. D. S. Phokharkar	Assistant Entomologist
Dr. R. V. Nakat	Assistant Entomologist
Punjab Agricultural University, Ludhiana	
Dr. Jaspal Singh Virk	Professor
Dr. (Ms.) Neelam Joshi	Microbiologist
Ms. Ramandeep Kaur	Assistant Entomologist
Dr. (Ms.) Rabinder Kaur	Assistant Entomologist
Sher-e-Kashmir University of Agriculture and Technology, Srinagar	
Dr. M. Jamal Ahmad	Associate Professor
Dr. Sajad Mohi-ud-din	Assistant Professor
Tamilnadu Agricultural University, Coimbatore	
Dr. P. Karuppuchamy	Professor
Dr. M. Kalyanasundaram	Professor

19. INFRASTRUCTURE DEVELOPMENT

Equipment

The laboratories were further strengthened with the acquisition of several equipment, including, viscometer, BioCV 16 Lid for Bioassay tray, digital camera attachment, optima UV visible spectrophotometer, digital bench top incubated/refrigerated shaker, thermo forma upright single door freezer, water purification system, fax machine, latest xerox machines, latest tft monitors, UPS, latest desktop computers and printers.

Library

The library has a collection of 1,847 books, 1,421 volumes of journals, 55 bulletins and several miscellaneous publications including several reprints on various aspects of biological control. Twelve foreign and 14 Indian journals were subscribed for. CD-ROM - abstracts upgraded up to November 2007.

Aris Cell

Computer systems have been upgraded with Windows XP operating system in ARIS Cell. The software Corel DRAW X3 Graphics Suite and MS-Office 2007 has been procured. Database on entomopathogenic nematodes is developed at PDBC and it is available in the CD. Project Directorate of Biological Control domain name has been registered with ERNET India, New Delhi and hosted its own web site. The institute web site address is www.pdbc.res.in. The mail server also has been configured in the ARIS Cell and our official E-mail id is: pdbc@mail.pdbc.res.in

National Insect Reference Collection

The PDBC has 4,225 authentically identified species belonging to 235 families under 18 orders. A sizeable reference collection of Thysanoptera with 1000 slides has been added. The collection includes representatives of the orders Hymenoptera, Coleoptera, Hemiptera, Orthoptera, Strepsiptera, Thysanoptera, Neuroptera, Diptera, Lepidoptera, etc., encompassing crop pests, parasitoids and predators. The information is available in the form of a catalogue. PDBC's reference collection of insects has been electronically catalogued in a retrievable form.

Land and buildings

The following civil and other works were taken up. Fixing of chequered tiles on concrete entrance road, construction of under-ground sump with 40,000 liters capacity, construction of Monkey-proof she4d with flooring of pavers tiles, painting of main and pathology buildings, construction of security cabin, construction of new compound wall, standby transformer and shifting of existing transformer and its accessories.

Farm development

Completion of compound wall construction, central road and poly-houses and provision of irrigation facility for the whole farm.

20. EMPOWERMENT OF WOMEN

During 2007-08, the participation of women in different training programmes was as follows:

Mass production of trichogrammatids, chrysopids & coccinellids (16-04-2007 to 25-04-2007)

Ms. Archana Chatterjee, Vivekananda Institute of Biotechnology, Nimpith Ashram, South 24 - Parganas, West Bengal.

Ms. Nitu Maity, Vivekananda Institute of Biotechnology, Nimpith Ashram, South 24 - Parganas, West Bengal.

Ms. Deepika Biswas Vivekananda Institute of Biotechnology, Nimpith Ashram, South 24 - Parganas, West Bengal.

Entomopathogenic Nematodes (10-09-2007 to 14-09-2007)

Ms. Syeda Humera Ambreen, Qumar Colony, Gulbarga

Techniques for Semiochemical Research (17-09-2007 to 25-09-2007)

Dr. P. G. Padmaja, Scientist (Senior Scale), N. R. C. Sorghum, Rajendranagar, Hyderabad

Ms. G. Chaya, Research Fellow, Vittal Malya Scientific Research Foundation, Vasantpura, Bangalore.

Winter School on "Biological and Biotech-nological Approaches to Insect Pest and Disease Control" (14-11-2007 to 04-12-2007)

Ms. Gandhi Gracy, Division of crop protection, Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh.

Dr (Ms.). Alice, R. P. Sujeetha, J., Department of Entomology, Pajancoa & RI, Karaikal, U.T. of Puducherry.

Dr (Ms.). Sireesha Kukkapalli, Scientist (Entomology), AINP on Betelvine, Bapatla, Guntur (Dt.), A.P.

Ms. Toktel Boko, Subject Matter Specialist (Plant Protection) Krishi Vigyan Kendra, Dirang, Arunachal Pracdesh.

Dr (Ms.). P. M. Beebi Razeena, Lecturer (Selection Grade) in Botany, Dept. of Post Graduate Studies and Research in Botany, Sir Syed College, Taliparamba, Kerala.

Ms. Prameela H. A., Assistant Professor (Sel. Grade), Department of Plant Pathology, Agriculture College, GKVK, Bangalore.

"Model Training Course on Quality Control Aspects on Biological Control Agents" (11-12-2007 to 18-12-2007)

Mrs. Michi Mamung, Agriculture Development Officer, State Bio-control Laboratory, Directorate of Agriculture, Arunachal Pradesh, Naharlagun.

Smt. Geeta S. Kadapatti, Agriculture Officer, State Biocontrol Laboratory, Asst. Director of Agriculture, Dharwad, Karnataka

Smt. B. Kharshandy, Research Assistant, State Biological Control Laboratory, Upper Shillong, Meghalaya

Mass production and Quality Control Aspects of Biological Control Agents (28-01-2008 to 02-02-2008)

Miss. Pallavi, D. Suryawanshi, Agricultural Assistant, Biocontrol laboratory, Aurangabad

Recent trends in biological control of pests and diseases (17-03-2008 to 26-03-2008)

Dr. A. Shanthi, SMS (Plant Protection), Krishi Vigyan Kendra, Dharmapuri.

Dr. B. Geetha, SMS-Plant Protection (Entomology), Krishi Vigyan Kendra, Sandhiyur, Salem

Ms. Lavanya, Programme Assistant (Technical), Krishi Vigyan Kendra, Sandhiyur, Salem