National Bureau of Agriculturally Important Insects

(Indian Council of Agricultural Research)
Bengaluru 560 024, India

Annual Report 2012-13

National Bureau of Agriculturally Important Insects

भाकृअनुप
ICAR

ANNUAL REPORT
वार्षिक रिपोर्ट 2012-13

National Bureau of Agriculturally Important Insects
राष्ट्रीय कृषि प्रमुख कीट ब्यूरो

NBAII

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch

Annual Report
2012 - 13

वार्षिक रिपोर्ट
2012 - 13

भाकृअनुप
ICAR

National Bureau of Agriculturally Important Insects

(Indian Council of Agricultural Research)
Bengaluru 560 024, India

राष्ट्रीय कृषि प्रमुख कीट ब्यूरो
बेंगलूरू

National Bureau of Agriculturally Important Insects
Bengaluru - 560 024
Telephone : 91-80-23414220, 23511998, 23417930
Fax : 91-80-23411961
E-mail : directornbaii@gmail.com, nbaii.icar@gmail.com
Website : http://www.nbaii.res.in

Published by
Director
NBAII, Bengaluru

Compiled & Edited by
N. Bakthavatsalam
R. Rangeshwaran
P. Sreerama Kumar
K. Srinivasa Murthy
M. Mohan
Sunil Joshi

Hindi text
Satandra Kumar

May 2013

Cover
Front: *Ortalotrypeta isshikii* (Matsumura) and *Microplitis murkyi* Ankita Gupta; Back: *Platensina quadrula* Hardy (Photo credits: Mr. K. J. David and Dr. Ankita Gupta).

Cover design
P. Sreerama Kumar

Citation
NBAII. 2013. Annual Report 2012-13. National Bureau of Agriculturally Important Insects, Bengaluru, India, pp.

Printed at Brilliant Printers Pvt. Ltd, Bengaluru - 560 094
Telephone: 080-27630308

CONTENTS

1. PREFACE

Nearly 70,000 insects have been identified from the Indian sub-continent. Almost the same number potentially occurs and needs to be collected and identified. Of the already identified species, less than 50% only are in some repository or the other. NBAII's urgent target would be to bridge this gap and the last year's ventures were in this direction to enhance the repository collection, arthropod inventory and molecular characterization.

In his book, *The Diversity of Life,* renowned entomologist Edward O. Wilson discusses the importance of insects and arthropods in the ecosystem, saying that "if [they] all were to disappear, humanity probably could not last more than a few months." The relevance of biodiversity has gained immense importance the world over and nations have now come together in evolving strategies for conservation of biological resources. The Indian subcontinent with its diverse geography and flora is a host to rich, vast and varied insect fauna. The National Bureau of Agriculturally Important Insects (NBAII) was christened in 2009 with a core mandate of collecting, cataloguing and documenting the insect fauna of agricultural importance. The multifarious activity of NBAII includes biodiversity, systematics, ecology and molecular entomology. The NBAII is also a recognized centre for excellence in Biological Control and it caters to the needs of the All India Coordinated Research Project on Biological Control (AICRP-BC).

The NBAII is now on the global map and ICAR is looking forward to its valuable contribution in insect biodiversity and systematics. To meet the new challenge, the NBAII has made several strides during 2012-13. Several new collections have now been made from major hot spot ecological regions of the country such as Andaman Islands and North East. Twenty new species have been described besides, several new geographical and host records. Identification services for specimens were provided for institutions from India and abroad for important groups such as Hymenoptera, Diptera, Coleoptera and Hemiptera and several specimens were deposited in the NBAII repository. The NBAII is bestowed with the honour as a national repository for insects which will help scientists to deposit type and voucher specimens. As a part of capacity building, NBAII has organized several training programmes on biosystematics of insects and biological control to researchers, extension workers and developmental officials. Fresh impetus is now put into insect taxonomy with the addition of scientific manpower.

The stakeholders have always been the priority of NBAII and during the year 1009 shipments of parasitoids, predators and microbial agents have been made earning a revenue of 5.17 lakh. Commercialization of one technology and filing of three patents were made during the period under report.

Hard work and success bring laurels and the NBAII was at the helm of affairs in managing the papaya mealybug. This success is listed as one of the achievements of ICAR in its annual report. We are indeed proud to realize that our efforts have saved more than 1500 crores and this called for a celebration. Our honorable Director General **Dr. S. Ayyappan** was happy to be part of it when he inaugurated the meeting on "Success Story of Classical Biological Control of Papaya Mealybug" on 25-10-2012 at NBAII. The Director General honoured six entomologists for their contributions in papaya mealybug management.

Technologies developed have no meaning unless they reach the stakeholders. Biological control technologies generated at NBAII and AICRP centres have been demonstrated through field demonstrations, training and large plot trials. Extension activities through TV telecasts, radio talks and publication of DVDs and bulletins provide wider access to technologies generated by NBAII.

Institute meetings such as RAC, IRC and IMC were conducted at frequent intervals and their suggestions and recommendations were taken for focusing and reorienting our research programs. Quinquennial review team under the chairmanship of **Dr. G. K. Veeresh** made several recommendations to Council for furtherance of research at NBAII and AICRP-BC.

The work carried out by NBAII could not have been more refined but for the timely and critical interventions of the Honourable Secretary, DARE & DG, ICAR, **Dr. S. Ayyappan** and we express our sincere gratitude to him.

The periodical suggestions and reviews expressed by **Dr. Swapan Kumar Datta**, DDG (CS) helped us in the reorientation of our research activities and we are highly grateful to him.

Our sincere thanks are due to **Dr. T. P. Rajendran**, ADG (PP) whose critical comments helped us to improve our performance.

The critical analysis and future road maps for our research programs drawn by RAC headed by **Dr. B. Senapati**, former Vice Chancellor, OUAT and the members are gratefully acknowledged.

The chairman, **Dr. G. K. Veeresh** and the members of QRT deserve a special mention for their contributions in a detailed and exhaustive analysis of NBAII, AICRPs & AINPs.

During the reporting period, **Dr. N. K. Krishna Kumar** [presently DDG (Horticulture)] and Dr. Bhummannavar (Director Acting) guided the research activities of the Bureau.

We are grateful to **Shri. Sujit K. Mitra**, Director (Crop Science), ICAR for all the help given in the progress of the Bureau.

The generous help and support extended to NBAII by **Mr. Siraj Hussain**, Additional secretary, DARE and Secretary, ICAR; **Mr. Pradeep Kumar Pujari**, Additional secretary, DARE & Financial Advisor, ICAR; **Mr. Devendra Kumar**, Director (Finance), ICAR; **Mr. J. Ravi**, Director (Personnel) and **Mr. Sanjay Gupta**, Director (Administration), ICAR is gratefully acknowledged.

The achievements of NBAII could not have been possible but for the support of the scientific, technical, administrative staff and research fellows and I take this opportunity to thank them and wish them more output that is productive in the future.

May 2013

Abraham Verghese
Director

2. EXECUTIVE SUMMARY

The National Bureau of Agriculturally Important Insects (NBAII) is involved in the collection, cataloguing and conservation of insects and related organisms of agricultural importance. Research on all aspects of systematics, ecology and biodiversity of insects is undertaken at this Bureau in the three Divisions of Insect Systematics, Molecular Entomology and Insect Ecology. Training scientists, teachers and other researchers in Biosystematics, Molecular Entomology, Bioinformatics and Biocontrol is also a key function of this Bureau. Detailed below is an overview of the basic research work done at NBAII as well as the applied work undertaken at the various centres of the All India Coordinated Research Project (AICRP) on Biological Control of Crop Pests and Weeds during 2012-2013.

Image Gallery of Insects

An image gallery of agriculturally important insects has been hosted on NBAII's website. This website which is constantly being expanded to include the diverse insect fauna of Indian agro ecosystems currently features 500 species of insects with over 3000 photographs. This along with another website "Featured Insects" on insect bioagents have been included in 'ID Source' hosted by the United States Department of Agriculture and Colorado State University. An interactive LucID Phoenix key to the genera of Mymaridae of India was prepared with fact sheets, diagnostics and illustrations for the 28 genera known so far.

Biosystematics

Trichogramma rabindrai was collected from fallow agricultural fields while, *Trichogrammatoidea bactrae* was recorded on *Prosotas nora* on citrus in Andaman Islands. *Poropoea bella* Hayat & Poorani (Trichogrammatidae) and *Zaplatycerus notialis* Hayat & Poorani (Encyrtidae) were described from Karnataka. *Coccipolipus synonychae* (Acari. Podapolipidae) was described as a parasite of the giant bamboo ladybird, *Synonycha grandis*.

Twelve species of Microgastrinae (Braconidae) were described from India. Among them *Glyptapanteles hypermnestrae* and *Dolichogenidea kunhi* are agriculturally important. Molecular tools were used to resolve the identities of two cryptic species of *Apanteles viz., Apanteles mohandasi* and *Apanteles taragamae*. *A. mohandasi* was placed under *Apanteles* genus instead of *Dolichogenidea*. A catalogue of Microgastrinae fauna of Reunion Island was published with a key for 34 species belonging to 13 genera which includes several species of Indian origin.

Thirty three genera of insects belonging to Telenominae, Teleasinae, Scelioninae, Sceliotrachelinae and Platygastrinae were identified from Andaman Islands. Surveys were conducted for Platygastroidea in five states and union territories. A total of 1850 parasitoids were collected. So far 41 genera under five subfamilies were recorded from India and an additional eleven genera were added, raising the total to 52 genera. A new genus *Dvivarnus* Rajmohana and Veenakumari was described under the subfamily Teleasinae. One new species under this genus, *Dvivarnus punctatus* Veenakumari and Rajmohana was described. Three new species of Sceliotrachelinae *viz., Plutomerus veereshi* Veenakumari, Buhl and Rajmohana, *Fidiobia virakthamati* Veenakumari, Buhl and Rajmohana and *F. nagarajae* Veenakumari, Buhl and Rajmohana were described from S. India. The species of *Fidiobia* is the first representative of the genus from India.

A total of 296 field trips were conducted for the collection of coccids and pseudococcids. A total of 2490 slides of 1298 specimens were made. There were twenty four new records of hemipterans belonging to Coccoidea during these surveys. Species of aphids *viz*., *Pleotrichophorus chrysanthemi* (Theobald) and *Reticulaphis foveolatae* (Takahashi) and a species of invasive mealybug *viz*., *Pseudococcus jackbeardsleyi* Gimpel and Miller were recorded for the first time from India.

Lohiella longicornis (Noyes & Hayat) was recorded for the first time from India parasitizing *Drepanococcus chiton* (Green) which is also a new host association. A total of 260 specimens of hemipterans were identified for different SAUs, ICAR institutes and private organizations.

Surveys were conducted for fruit fly diversity in Karnataka, Kerala, Tamil Nadu, Maharashtra and Andaman and Nicobar islands. Eighty one species were collected and studied in 33 genera and five subfamilies namely, Dacinae, Tephritinae, Trypetinae, Phytalmiinae and Tachiniscinae. About 2400 specimens of fruit flies were added to NBAII collection. Four species of the tribe Adramini namely, *Coelotrypes latilimbatus* (Enderlein), *Dimerinogophrys parilis* (Hardy), *Dimeringophrys pallidipennis* Hardy, *Hardyadrama excoecariae* Lee and an undescribed species of *Coelopacidia* were newly recorded from India. *Ortalotrypeta isohikii* (Matsumura) and subfamily Tachiniscinae was recorded for the first time from India. Four new species of fruit flies, *Euphranta dysoxyli* David, *E. diffusa* David, *E. thandikudi* David and *E. hyalipennis* David & Freidberg were described from India.

Invasive insects

Recurring incidence of papaya mealybug, *Paracoccus marginatus* was observed in a few locations of Karnataka, Andhra Pradesh, Andaman and Nicobar Islands and Tamil Nadu. A total of 43 requests for *Acerophagus papayae* were received from April 2012 to February 2013. *Anagyrus loecki* and *Pseudleptomastix mexicana,* parasitoids of *P. marginatus* were recorded from Salem and Bangalore. A hyperparasitoid, *Marietta lepardiana* (Hymenoptera: Aphelinidae) was recorded from *Acerophagus papayae*. Madeira mealybug, *Phenacoccus madeirensis* Green was found infesting cotton crop near Bandipur (Karnataka). Several parasitoids such as *Allotropa* sp., *Anagyrus* sp., *A. qadrii* and *A. loecki* were found parasitizing *P. madeirensis*.

Entomopathogens

Expeditions to root grub endemic sugarcane areas of north Karnataka, Maharashtra and western Uttar Pradesh helped in the identification of three new isolates of *Heterorhabditis* spp. and *Steinernema abbasi* infecting *Holotrichia serrata, H. consanguinea, Anomala* spp., *Leucopholis lepidophora, Lepidiota mansueta, Phyllophaga calciata* and *Phyllognathus dionysius*.

Development of *H. indica* (strain NBAII 101) was studied *in vivo* on the larvae of *Galleria melonella*. At 28° C, the development was completed in 96–104 hours. The life cycle was shorter with less number of males, females and juveniles in *Spodoptera litura* and *Helicoverpa armigera* compared to *G. mellonella*. Development of *H. indica* on *Leucopholis lepidophora* was completed in 112–136 hours.

Combined application of *H. indica* and *Metarhizium anisopliae* reduced 75 and 67% population of adults and grubs of *Myllocerus subfasciatus*. Around 82 and 80% recovery of *H. indica* (NBAII hi01) and *S. abbasi* (Sa01) strains was made in red lateritic soils after 5 months of application.

Field trials conducted at Varnanagar and Nagaon villages of western Maharastra showed that application of aqueous and cadaver formulations of *H. indica* and *S. abbasi* improved the tiller density and cane height of sugarcane compared to untreated control. *H. indica* and *S. abbasi* performed better than *S. carpocapsae* and *S. glaseri*.

Laboratory studies on the virulence of *S. abbasi*, *H. bacteriophora* and *H. indica* against sod webworm, *Herpetogramma phaeopteralis* infesting turfgrass proved that all the three species were pathogenic to the larvae of *H. phaeopteralis*. *Heterorhabditis indica*, *S. abbasi* and *H. bacteriophaga* were tested against the larvae of coffee stem borer, *Xylotrechus quadripes* and *H. indica* was highly virulent with lowest LC_{50} and LC_{90} of 37.1 and 88.9 IJs, respectively.

Endosymbionts

A total of eighty two culturable bacteria were isolated from *Aphis gossypii, Aphis craccivora* and *Myzus persicae* collected from Bangalore, Malur and Dharwad districts of Karnataka. Based on the 16S rDNA sequence homology search, *Bacillus aryabhattai, B. cereus, B. firmus, B. horikoshii, B. jeotgali, B. massiliensis, B. subtilis, Exiguobacterium indicum, Moraxella osloensis, Paenibacillus lautus, Pseudomonas hibiscicola, Stenotrophomonas maltophilia* and *Zimmermannella faecalis* were found associated with the aphids.

Studies conducted using the minimal salt medium with and without insecticides revealed that *Wickerhamomyces anomalus* was able to grow 3.39 times more in insecticide amended medium than in control after 96 hours of inoculation. The yeast species, *Metschnikowia reukaufii, Pichia ohmeri, Wickerhamomyces anomalus* and *Candida apicola* increased the fitness attributes like per cent parasitism, per cent females and fecundity in *Trichogramma japonicum*. LC–MS studies proved that the *Enterobacter* sp. isolated from *Chrysoperla zastrowi sillemi* larvae was able to degrade acephate 6 times and indoxacarb 11 times compared to control.

The populations of *Cotesia plutellae* fed with *Wolbachia* recorded significantly higher parasitism (74.8 to 91.2%) and adult emergence (64.1 to 82.2%) than the *Wolbachia* cured populations (68.2 to 82.3 and 60.4 to 72.2%, respectively). The populations from Bangalore, Bhubaneshwar and Nawansharar (Punjab) registered higher fitness attributes.

Semisynthetic diet for rearing *Leucinodes orbonalis*

A diet combination containing the nutritional and phagostimulary compounds was developed. It recorded better biological parameters like developmental period and adult life span in *L. orbonalis.* This is crucial for genomic studies.

Database of entomopathogenic nematodes

A database on entomopathogenic nematodes (Steinernematidae and Heterorhabditidae) was developed providing information on the systematics, diagnostic characters, diversity maps, bioecology, mass production techniques, formulation and storage, application and the source of availability of commercial products. The database is user friendly and is available in DVD form.

Anthocorid predators: Diversity, biology and ecology

Anthocorids were collected from different crops/plants during different seasons. *Carayonocoris indicus, Orius dravidiensis, Cardiastethus exiguus, Orius niger, Cardiastethus pseudococci pseudococci, Orius maxidentex, Cardiastethus affinis, Montandoniola indica, Xylocoris* (*Proxylocoris*) *afer, Buchananiella crassicornis* were collected as predators of thrips. An undescribed species of *Montandoniola* was recorded on *Butea monosperma* while *Anthocorini gen. et.* sp. were recorded from

Ficus, *Orius maxidentex* was recorded for the first time from Andaman and Nicobar Islands. *Blaptostethoides* sp. from sugarcane and *Xylocoris afer* were recorded for the first time from India and *Cardiastethus affinis* was for the first time recorded as a predator of *Hemiberlesia lataniae* on agave.

A method was standardized to rear *Montandoniola indica,* a predator of pepper gall thrips, *Liothrips karnyi* using UV irradiated *C. cephalonica* eggs as prey and bean pods as ovipositional substrates. In laboratory studies, each *M. indica* nymph fed on a total of 27.3 *C. cephalonica* eggs, with a per day feeding rate of 1.56 eggs. Each adult male of this species fed on a total of 38 eggs, with a per day feeding rate of 1.67 eggs, while the corresponding figures for the adult female were 56 and 1.79 eggs, respectively.

Blaptostethus pallescens was evaluated against the pupal stage of the thrips, *Frankliniella schultzei.* In the treatment where *B. pallescens* nymphs and adults were released to target *F. schultzei* pupae in soil, 74.0% and 89.3% mortality were recorded respectively; compared to 41.3% in the control.

Storage of *Corcyra cephalonica* eggs

Storage of *C. cephalonica* eggs for five days at 10°, 12° and 14° C, resulted in a hatching rate of 48, 49 and 77%, respectively; while per cent adult emergence was recorded as 29.2, 67.4 and 90.9, respectively. Eggs of *C. cephalonica* can be safely stored for 5 days at 14° C to obtain more than 70% hatching and 90% adult emergence. Eggs cannot be stored for more than three days at 4° C.

Efficacy of *Trichogramma* spp. reared on eri silkworm eggs (ESW) against rice and sugarcane borers

When *Trichogramma embryophagum,* continuously reared on *C. cephalonica* was exposed to ESW eggs, it initially resulted in low per cent parasitism and adult emergence, the values being 20% and 2%, respectively. Continuous rearing of *T. embryophagum* for 151 generations on ESW eggs however, resulted in 92.2% parasitism and 70.7% adult emergence in rice.

In field trials in rice at Andhra Pradesh, five releases of *T. chilonis* were made @ 10 cards per release at 10 days intervals and comparisons were made between control, biological control and insecticidal control plots. The expenditure in the chemical control plot was Rs. 2000 per acre as compared to Rs. 786 per acre in the biological control plot.

A field experiment in sugarcane was conducted in VC Farm, Mandya to evaluate the relative efficiencies of *T. chilonis* reared on ESW and *C. cephalonica*. Eight releases of *T. chilonis* were made @ 20000 adults per release per acre at weekly intervals. The per cent incidence of infested canes in the control, *T. chilonis* (on ESW) released plot and *T. chilonis* (on *C. cephalonica*) released plot were 92, 76 and 68, respectively.

Akin to the above experiment, another experiment was conducted in a ratoon crop in sugarcane in a farmer's field at Madla, Mandya. Fourteen releases of *T. chilonis* were made @ 40000 adults per release per acre at weekly intervals. The per cent pest incidence in the control, *T. chilonis* (on ESW) released plot and *T. chilonis* (on *C. cephalonica*) released plot were 76, 32 and 20, respectively.

Insect pollinators and their role in pollination

Fifteen species of non *Apis* pollinators belonging to 4 families *viz.* Megachilidae, Apidae, Xylocopidae and Anthophoridae were observed to visit pigeonpea flowers in addition to butterflies and flies. *Apis* (especially *A. dorsata, A. cerana* and *A. florea*) constituted 40% of the total bees observed during flowering. The second largest group, the Megachilidae, constituted 38% of the total sample with *Megachile parietina* (*Chalicodoma* *parietina*) and *M. flavipes* being the most abundant. Although pigeonpea is a self pollinated crop, outcrossing is observed to the extent of 3–40% and 92–100 per cent seed set was observed in the bee visited pods.

In a field trial, pigeonpea and marigold intercrop was found to be effective in enhancing the yield compared to pigeonpea and sunflower but, both intercrops were better than the sole crop. The test weight of 100 seeds of pigeonpea increased from 11.8g to 13.8g in pigeonpea+sunflower and 15.7g in pigeonpea+marigold indicating the role of pollinators in enhancing the yield in pigeonpea.

Collections of *Apis* and non–*Apis* pollinators were made from different crops and wild plants. Dipteran pollinators (Calliphoridae, Syrphidae, Sarcophagidae and Muscidae) and *Apis florea* were the major pollinators in mango. Studies were made on their visitation pattern, duration and time of visit. Non crop plants like *Calotropis* sp. and *Lagerstroemea flos-reginae* support the survival of *Xylocopa* spp. during the off season.

Effect of climate change on diversity of insects of pigeonpea

The effect of climate change, with particular reference to elevated levels of carbon dioxide and temperature on the diversity of insects on pigeonpea was studied in open top carbon dioxide chambers with simulated levels of carbon dioxide and temperature. The incidence of pests like *Maruca vitrata, Aphis gossypii* and *Orgyia leucostigma* did not significantly differ at various levels of CO_2 and temperature. However, the incidence *of Coccidohystrix insolita* was significantly greater in plants grown under elevated levels of CO_2 (500ppm) and temperature (+2°C above ambient).

Semiochemicals for important pests

Two plant based compounds were formulated for attracting fruit flies and *Leptocybe invasa,* respectively. The formulation at different doses was tested in delta traps as attractant for *L. invasa* in eucalypts grooves in Kolar. The traps recorded more adult *L. invasa* than in control. The number of *Bactrocera* were more in the fruitfly traps baited with the blend of plant compounds and was found to be better than methyl eugenol**.**

Biology and mass production of *Anagyrus kamali*

Biology of the endoparasitoid, *Anagyrus kamali* obtained from Andaman islands was studied on pink hibiscus mealybug, *Meconellicoccus hirsutus* cultured on potato sprouts. Although *A. kamali* parasitized 2nd instar nymphs, there was a marked preference towards the 3rd instar and adult female mealy-bugs. The total developmental period of *A. kamali* on the 2nd stage nymph ranged from 25–29 days in males and 30–32 days in females. Development was faster in later stage of nymphs (22 days old) and in adult females (20–21 days old). Longevity of male and female parasitoids varied from 30–32 days and 38–42 days, respectively. Water fed or starved adults could not survive for more than 36–48 hours. Temperature of 22–25°C was found to be optimum for the survival of *A. kamali*.

Selection of superior strain of predators, *viz.*, *Chrysoperla zastrowi sillemi* (Esben–Petersen) and *Cryptolaemus montrouzieri* (Mulsant)

Genetic stocks of twelve different geographical populations of *C. z. sillemi* and 6 populations of *C. montrouzieri* were maintained. Studies on the biological attributes of different populations of *C. montrouzieri* at variable temperatures (32–40ºC) revealed that most of the populations survived for 60 days while Coimbatore and Shimoga populations survived for 70 days. Studies on field release schedule of pesticide tolerant and susceptible strains of *C. z. sillemi* revealed that there was 84% survival in pesticide tolerant strain and 33% in susceptible population and 84%, 98% and 98% on 1, 2 and 3 days after spray, respectively.

Field evaluation of pesticide tolerant strains against sucking pests of cotton revealed that two releases of PTS (Cza–8) at 15 days interval in combination with two sprays of acephate (0.67g/li) (13.4 aphids/plant) were effective against *A. gossypii* and *Thrips tabaci* resulting in highest cotton yield (1533 kg/ha). Pesticide tolerant strain of *C. z. sillemi* (Cza–8) (tolerant to organo phosphates, organo chlorine and synthetic pyrethroids) was mass produced and 12,000 nos. were supplied for field release against sucking pests of capsicum in UP.

Management of pests with pheromone nanogels

Novel nanogels were synthesized in collaboration with the Department of Organic Chemistry, IISc, using supramolecular self-assembly principles to increase the field-life of various nanogel-absorbed pheromones employed to disrupt the lifecycle of harmful crop pests.

Biosafety of nanoparticles in terms of their effects on natural enemies was established. Non-target effects of chitosan-alginate nanoparticles on the biology of *Chrysoperla zastrowi sillemi* were studied through the F1 generation and it was concluded that there were no lethal effects.

Technologies sold

Technologies related to *in vivo* production of *Heterorhabditis indica* strain NBAIIHi1 were sold to three entrepreneurs namely, Camson Biotech Ltd., Bangalore, and FARMER, Ghaziabad, generating a revenue of Rs. 3.5 lakh.

ALL–INDIA COORDINATED RESEARCH PROJECT ON BIOLOGICAL CONTROL

Surveillance for alien invasive pests

Paracoccus marginatus incidence was observed in Thrissur, Ernakulam and Palakkad districts, but the intensity was very low. The parasitoid *Acerophagus papayae* was also present in all the locations.

Surveys conducted in different districts of Punjab revealed that the papaya mealybug *Paracoccus marginatus* attacked different crops including weeds like *Parthenium*, wild okra, *Cassia occidentalis*, *Cassia* sp., *Veronica cineraria*; fruit crops like custard apple, ornamentals like *Diffenbachia*, chrysanthemum and marigold besides papaya. *Maconellicoccus hirsutus* was the predominant species of mealybug on cotton in Punjab.

During a survey for *Paracoccus marginatus* and *Acerophagus papayae* in Sathiyamangalam**,** Tamil Nadu, the short–tailed mealy bug *Pseudococcus jackbeardsleyi* Gimpel & Miller was found together with *P. marginatus* colonizing papaya in two plantations. Four species of mealybugs, *viz*., *Phenacoccus solenopsis*, *Maconellicoccus hirsutus, Ferrisia virgata* and *Paracoccus marginatus* were recorded on cotton. Surveys also indicated that *P. solenopsis* was the predominant species and its hosts included cotton, sunflower, vegetables (brinjal, tomato, bhendi, cucurbits), pulses, *Calotropis, Datura* and *Parthenium.*

Parasitoids of serpentine leaf miner, *Liriomyza trifolii*

Six species of larval and parasitoids one larval–pupal parasitoid were collected. The larval parasitoids were *Neochrysocharis formosa, Chrysocharis* sp., *Diglyphus* sp., *Asecodes delucchii, Asecodes erxias* and *Hemiptarsenus varicornis*, while the larval–pupal parasitoid was *Opius* sp. *Neochrysocharis formosa* was the dominant species (TNAU).

Parasitoids of pea leaf miner, *Chromatomyia horticola*

Biodiversity of parasitoids of pea leaf miner, *Chromatomyia horticola* was studied on peas under mid hill conditions (1300 m AMSL). Two species of larval parasitoids, namely, *Diglyphus* sp. and *Quadrastichus* sp. and one larval-pupal parasitoid, *Opius* sp. were recorded. *Diglyphus* sp. was the dominant species (TNAU).

Surveys for natural enemies in Kerala

Surveys and collection of natural enemies of banana pseudostem weevil, banana aphid, pollu beetle and root mealybug of pepper were carried out in seven agro ecological zones of Kerala. Three different species of earwigs were collected that were found feeding on the eggs of the pseudostem weevil, *Odoiporus longicollis* (Oliv.). *Pseudaspidimerus trinotatus* (Thunberg), *Scymnus pyrocheilus* (Mulsant), *Jauravia soror* Weise, *Scymnus* spp. and hemerobiids (unidentified) were found feeding on the banana aphid, *Pentalonia nigronervosa.* Various predatory spiders collected from leaves were identified as *Araneus bilunifer* (Araneidae), *Argiope pulchella* (Araneidae), *Bavia kairali* (Salticidae), *Clubiona drassodes* (Clubionidae), *Oxyopes javanus* (Oxyopidae), *Charizopes bengalensis* (Araneidae), *Oxyopes birmanicus* (Oxyopidae), *Oxyopes shweta* (Oxyopidae), and *Thiania bhamoensis* (Salticidae) were feeding on pepper pollu beetle, *Lanka ramakrishnai.*

Diversity of natural enemies

Highest species richness was observed for *Neoscona theisi* (133) and *Leucauge* sp. (133) followed by *Cyrtophora cicatrosa* (72), *Argiope* sp. (72), *Tetragnatha javana* (72) *Argiope anasuja* (65) and *Leucauge decorata* (65). Species diversity (H') computed using Shannon-Weiner index of diversity was as 2.43 while species evenness using Kreb's formula was 0.678. Thirty six species of spiders belonging to Araneidae, Oxyopidae, Tetragnathidae, Theridiidae, Lycosidae, Thomisidae and Salticidae were identified.

Natural enemies recorded from five agro-ecological zones of western Maharashtra were *Coccinella septempunctata* Linn., *Cheilomenes sexmaculata* (Fab.), *Hippodamia variegata* (Goeze), *Scymnus* sp., *Chrysoperla zastrowi sillemi* (Esben–Petersen) in cotton, *Dipha aphidivora* Meyrick, *Micromus igorotus* Banks, syrphids, spiders on SWA in sugarcane, *Campoletis chlorideae* Uchida on *H. armigera* and *Cotesia* sp. on *Exelastis atomosa* larvae, *M. sexmaculata* in pigeon pea, *Nomuraea rileyi* and *Sl*NPV in *S. litura* on soybean, *Coccinella transversalis* F., *C. sexmaculata, Brumoides suturalis* (F.) in maize, *Scymnus coccivora* Ayyar, *Triommata coccidivora* and *B. suturalis* on mealybug in custard apple, *Acerophagus papayae* and *Pseudleptomastix mexicana* on papaya mealybug and *Mallada boninensis* (Okam.) on spiralling whitefly on papaya, *Mallada* sp., spiders and anthocorid on mango hoppers and *Illeis cincta* (F.) on mulberry. *C. zastrowi sillemi* was recorded on cotton, maize, pigeonpea and *M. boninensis* on papaya, pomegranate and mango. *Cryptolaemus* grubs were collected from custard apple, papaya and guava orchards. The cadavers of *S. litura* and *H. armigera* infected with *Nomuraea rileyi, Metarhizium anisopliae, Sl*NPV, *Ha*NPV were collected from soybean, potato, pigeonpea and lucerne (MPKV).

Twenty different natural enemies including hyper parasitoids were recorded from San Jose scale, woolly apple aphid, *Eriosoma lanigerum*, an unidentified apple leaf miner and codling moth, *Cydia pomonella* from Ladakh .

Mapping of EPN diversity in Punjab

Out of 200 different samples tested, the samples collected from Amritsar and Sangrur caused mortality of *Galleria* larvae and these were found infected with EPN (PAU).

Monitoring sugarcane woolly aphid (SWA) incidence and impact assessment of natural enemies on its biosuppression

The sugarcane woolly aphid incidence and occurrence of natural enemies (*Dipha aphidivora, Micromus igorotus, Encarsia flavoscutellum,* syrphid, spider) were recorded from five agro–ecological zones of western Maharashtra. The average pest incidence and intensity were 0.44 per cent and 1.39 per cent, respectively. The natural enemies recorded in the SWA infested fields were mainly predators like *D. aphidivora* (0.5–2.3 larvae/leaf), *M. igorotus* (1.2–5.1 grubs/leaf), syrphid, *Eupeodes confrator* (0.03–

1.1 larvae/leaf) and spider (0.02-0.5 per leaf). The parasitoid, *E. flavoscutellum* was observed in Pune and Satara districts. These natural enemies were found to be distributed and established well in sugarcane fields and regulated the SWA in western Maharashtra (MPKV).

Sugarcane woolly aphid incidence and occurrence of natural enemies were recorded from seven major sugarcane growing districts covering different agro–ecological zones of Tamil Nadu. The SWA was noticed in patches and the occurrence of *E. flavoscutellum*, *D. aphidivora* and *M. igorotus* was observed. A maximum of 68.2 *Encarsia* / leaf was observed in Coimbatore during December 2012. SWA incidence was noticed in all the locations from September-October 2012 to January 2013. *Dipha* and *Micromus* populations were also observed during October 2012 to January 2013.

Field evaluation of *Trichogramma chilonis* produced using eri silkworm eggs as factitious host against early shoot borer (internode borer) of sugarcane

Trichogramma reared on eri silkworm eggs or on *Corcyra* eggs were released @ 20,000/ acre. Preliminary laboratory studies showed that difference in parasitization between *Trichogramma* reared on eri silk worm eggs and that reared on *Corcyra* eggs was only 5% (ANGRAU).

There was a significant reduction in the incidence and intensity of damage due to internode borer (INB) infestation by the release of *T. chilonis* reared on eri silkworm eggs @ 20,000/acre and release of *T. chilonis* reared on *Corcyra* moth eggs @ 20,000/ acre than in unreleased fields. After eighth release, release of *T. chilonis* reared on eri silkworm eggs @ 20,000/acre recorded significant reduction of INB (5.4%) as compared to release of *T. chilonis* reared on *Corcyra* eggs @ 20,000/acre (7.2% The untreated control recorded higher INB incidence (21.8%) (TNAU).

Monitoring the diversity and outbreaks of sap sucking pests, mirids and their natural enemies in *Bt* cotton

Among various sucking insect pests, leafhoppers were maximum during September–October and moderate during August on BT cotton in Karnataka. Thrips population peaked during August and was low during December. In general, the population of whiteflies was low during the season. Maximum mirid bug population was recorded in December. Similarly, the activity of mealybug was noticed in first week of December and continued till January and the peak activity of parasitoid was noticed in the second week of January (UAS–Raichur).

Evaluation of IPM for upland rice pests and diseases

Evaluation was done in three locations of East Siang District of Arunachal Pradesh. The incidence of stem borers in the IPM field (2.37 per cent WEH) was comparable with farmer's practice (1.41 per cent WEH). Significantly higher infestation of rice gundhi bug was recorded in untreated control than the other two treatments. The highest grain yield of 46.55q/ ha was recorded in farmer's practice and it was closely followed by IPM practice (43.65q/ ha) at Sille. Similarly, at Mebo also, the grain yield from farmer's practice (42.51q/ha) was comparable with IPM (40.66q/ha). However, at Pasighat, farmers practice gave significantly higher yield (43.84q/ha) than IPM practice (40.37q/ha) (CAU).

Biological suppression of pests of pulses and oilseeds

Evaluation of NBAII liquid formulations (PDBC–BT1 and NBAII-BTG4) and IARI *Bt* against pigeon pea pod borer (*Helicoverpa* *armigera*) and legume pod borer (*Maruca testulalis*) indicated that all the treated plots in 5 centres registered significantly fewer *H. armigera* larvae than the untreated control. All the microbial insecticides were found equally effective in suppressing the pest, however, relatively lesser population of *H. armigera* larvae was found in PDBC–BTG4, PDBC–BTG1 and IARI *Bt* when sprayed at 2% concentration. Pooled results on pod damage also showed the superiority of the above treatments. All the *Bt* based microbial insecticides exhibited grain damage ranging from 7.62 to 10.77% and were found to be on par.

Biological suppression of safflower aphid, *Uroleucon compositae*

Verticillium lecanii was better than *Metarhizium anisopliae* and *Beauveria bassiana* in bringing down populations of aphids. *V. lecanii* was on par with neem oil and together they were on par with the insecticidal check on its lower side in recording minimum aphid population (65–123 aphids/10 plants) and maximum yield (469-509 kg/ha) in Andhra Pradesh. Control recorded maximum aphid number (413–435 aphids/10 plants) and minimum yield (245 kg/ha) (ANGRAU).

Biological control of groundnut pests

Insecticidal treatment recorded the lowest pest population in all cases with 0.7, 0.4 and 0.1 larvae of *S. litura,* leaf miner and hairy caterpillar respectively. In case of *S. litura,* incidence, *Sl*NPV treatment (0.9) was on par with insecticidal treatment (0.7). Against leafminer, Bt treatment (0.9) was again on par with the insecticidal treatment (0.4) and was followed by *Trichogramma* (2.7) and NSKE (2.9). In case of hairy caterpillars, insecticide treatment recorded the lowest pest incidence (0.1) followed by *Bt* (0.4) and NSKE (0.6). The yield was highest in insecticidal treatment (21.17 q/ha) followed by *Bt* (18.97 q/ha). Releases of *Trichogramma* were also responsible for good yield (17.28 q/ha). Control plots yielded 7.98 q/ha (OUAT).

Evaluation of entomopathogens and botanicals against soybean pests complex

Three sprays of *Sl*NPV @ 250 LE/ha (1.5 x 10^{12} POBs/ ha) was significantly superior to botanicals in suppressing the larval population of *S. litura* (3.0 larvae/m row) recording 78.5 per cent mortality due to virus infection and a yield of 21.6 q/ha soybean (MPKV).

Surveillance and need–based control of coconut leaf caterpillar, *Opisina arenosella* in Kerala

Medium level of *Opisina arenosella* incidence was noticed in Puthiyavila (Trivandrum) with leaf infestation of 59.6% and population of 141/100 leaflets. Awareness campaign was conducted in the area in collaboration with Parasite Breeding Station, Trivandrum and Dept. of Agriculture, Kerala. Regular monitoring and release of stage specific parasitoids resulted in 55.7% reduction in leaf damage and 94% reduction in pest population over a period of 8 months. Outbreak of *O. arenosella* was also noticed in Kallara (Kottayam) region during August, 2012 with leaf infestation of 83.4% and pest population of 288/100 leaflets. Systematic monitoring and release of larval parasitoids *viz., Goniozus nephantidis* and *Bracon brevicornis* reduced leaf damage (42%) and pest population (93%) in a period of 7 months (CPCRI).

Field evaluation of *Metarhizium anisopliae* against mango hoppers

Spraying of *M. anisopliae* @ 1 x 10^9 spores/ml during off season in the month of December followed by four sprays of the pathogen mixed with adjuvant (sunflower oil 1 ml/L + Triton–X100 @ 0.1 ml/L) at weekly intervals during flowering was significantly superior to other treatments in suppressing the hopper population and in increasing fruit setting in Andhra Pradesh and Maharastra.

Biological suppression of mealybugs, *Maconellicoccus hirsutus* and *Ferrisia virgata* with *Scymnus coccivora* on custard apple

Two releases of *Scymnus coccivora* @ 10 grubs per infested tree at monthly interval, during July–August 2012 were found to be significantly superior in suppressing the population of *M. hirsutus* (9.8 mealybugs/fruit) and *F. virgata* (3.3 mealybugs/fruit) in custard apple orchards and increased yield of marketable fruits (34.1 kg/tree). It was, however, on par with similar releases of *Cryptolaemus montrouzieri* @ 5 grubs per infested tree. The pest intensity rating was low (1.0–1.1) in orchards with these treatments

Economic analysis of impact of release of *Acerophagus papayae* on papaya production, seed production, papain industry, mulberry and tapioca

Economic analysis showed that the biological control of papaya mealybug with the release of the parasitoid, *Acerophagus papayae* in farmers' fields in papaya, tapioca and mulberry resulted in a saving of Rs 714.55 crores during 2012-13. The savings from papaya, tapioca and mulberry are Rs. 59.95, 514.5 and 140 crores, respectively.

Field evaluation of mass released *Trichogramma embryophagum* against codling moth, *Cydia pomonella* on apple

Average apple fruit damage (on tree + dropped) in plots treated with two sequential release of *Trichogramma* spp. @ 2500-3000 adult wasps/tree and use of pheromone traps @ 4 traps per orchard ranged from 56.8 to 70.2 per cent, as compared to 79.5 per cent in untreated control in Kashmir.

Evaluation of entomopathogenic fungi and EPNs for the suppression of apple root borer, *Dorysthenes hugelii* under field conditions in Himachal Pradesh revealed that chlorpyriphos (0.06%) gave highest grub mortality (86.4%) followed by 74.4% by *Metarhizium anisopliae* (10^6 conidia/cm²). Other biopesticides like *Beauveria bassiana* (10^6 conidia/cm²), *Heterorhabditis indica* and *Steinernema carpocapsae* (80 IJ/cm² each) were moderately effective against apple root borer resulting in 34.0, 45.9 and 34.9 per cent mortality of the grubs, respectively, as against 8.5 per cent in untreated control.

Developing bio intensive IPM package for the pests of cole crops

The population of *Pieris brassicae* and DBM significantly reduced from 2.45 to 1.34 and 4.85 to 1.94 larvae in the BIPM package field at Assam, whereas in farmers practice they were 2.6 to 1.4 and 4.65 to 1.97 larvae, respectively at 55 DAT (third spray). Maximum yield (169.9 q/ha) was registered in IPM package which was significantly superior to farmers' practice (163.7 q /ha)

Comparison of *T. chilonis* and *T. brassicae* in terms of reduction of DBM larvae in Kashmir valley after each release indicated significant difference between the two species used. Overall per cent decline in larval density caused by *T. chilonis* and *T. brassicae* was 33.7 and 20.1, respectively which indicated the supremacy of *T. chilonis* over *T. brassicae* against DBM on Knol khol.

Field evaluation of thelytokous and arrhenotokous strains of *Trichogramma pretiosum* against *Helicoverpa armigera* on tomato in Maharashtra

Six releases of *T. pretiosum* thelytokous strain @ 1 lakh parasitoid/ha at weekly intervals was significantly superior in suppressing *H. armigera* (1.9 larvae/10 plants) and increasing marketable fruit yield of tomato (223.5 t/ha) as compared to the arrhenotokous strain of the parasitoid. Parasitism was higher in thelytokous (56.2%) than in the arrhenotokous (46.5%) strain of the parasitoid

Evaluation of different BIPM modules against shoot and fruit borer, *Leucinodes orbonalis* in brinjal

Three sprays of profenophos (0.05%) at fortnightly intervals were significantly superior in reducing the shoot (9.0%) and fruit (9.6%) infestation and gave maximum marketable yield (228.7 q/ha). However, the BIPM module consisting of the release of *T. chilonis* followed by spraying of NSKE 5% and *Bt* @ 1 Lit./ ha twice at weekly intervals was the next best treatment showing 9.9% shoot and 15.3% fruit infestation with 42.5% parasitism (MPKV).

Least incidence of the shoot borer was recorded in the insecticidal treatment. The incidence of shoot borer ranged from 8.8 to 11.6% in Rynaxypyr 20 SC at various locations. However, BIPM treatment was on par with Rynaxypyr 20 SC in all locations recording 11.4 to 12.8% shoot borer incidence as against 29.3 to 29.9% in untreated control. The control plots recorded 36.0 to 39.7% fruit damage (OUAT).

Evaluation of anthocorid predator *Blaptostethus pallescens* against mite, *Tetranychus urticae* on brinjal and okra

All the doses of *B. pallescens* i.e. @ 10, 20 and 30 nymphs/ plant were on par with one another and better than untreated control in minimizing the population of mites on brinjal in Punjab. With an initial population of 63.5–69.0/plant, the mite population reduced to 14.1–31.3/plant. However, Omite @ 300ml/ plant was found better than *B. pallescens* releases and untreated control. When treated with Omite, the population was reduced to 1.0–1.6 mites/plant. *B. pallescens* along with Omite/ac can be included in the IPM of *T. urticae* on brinjal in polyhouse. In okra, release of *B. pallescens* @ 30 nymphs/plant was found best (11.40 mites/ plant) and it was on par with *B. pallescens* @ 20 nymphs/plant (17.80 mites/plant) in reducing the mites. Both of these bioagent release doses were also on par with Omite (9.53 mites/ plant).

Evaluation of biological control agents against mites in carnation under protected condition

Among biocontrol agents, release of coccinellid beetle, *Stethorus pauperculus* and predatory mite, *Amblyseius* sp. @ 10 beetles and 5 mites/plant were effective in reducing two spotted spider mite, *Tetranychus urticae* which were on par, followed by *Beauveria bassiana* 10^8 CFU/ml spray. However, two sprays of the standard acaricide, abamectin 1.9 EC @ 0.3 ml/litre reduced the mite population (1.3/10 plants) significantly over all other treatments. The untreated check recorded the highest mite population of 78/10 plants at 7 days after second treatment. The highest yield of 2465 numbers of flush/plot was recorded in abamectin treated plot followed by *Stethorus*, *Amblyseius* sp., *and Beauveria bassiana* biocontrol plots. Untreated check recorded the lowest yield of 1540 kg (TNAU).

Evaluation of predatory mite, *Neoseiulus longispinosus* against phytophagus mite in carnation under polyhouse condition

Results indicated that though profenophos (0.05%) was the most effective treatment resulting in 87.5 per cent reduction of mite population over control, it was statistically on par with three releases of *N. longispinosus* at 1:10 predator: prey ratio where the reduction was 73.8 per cent. Other biocontrol agents like, *N. longispinosus* at predator: prey ratio of 1:20 and 1:30 resulted in 62.3, 69 and 62 per cent reduction of mite polulation over control, respectively. All these treatments were statistically on par with each other and also with *N. longispinosus* at 1:10 predator: prey ratio (YSPUHF).

3. निष्पादित सारांश

राष्ट्रीय कृषि प्रमुख कीट ब्यूरो ने कृषि महत्व के कीटों के संग्रहण, केटालोगिंग और संरक्षण का महत्वपूर्ण कार्य किया। प्रमुखतः कीटों के प्रणालियों और जैव विविधता कार्यो के साथ-साथ वैज्ञानिकों, अध्यापकों और अनुसंधानकर्ताओं को प्रशिक्षण प्रदान करने का कार्य किया गया। ब्यूरो के विधिक आदेशों को पूर्ण करने के लिए कीट प्रणालियाँ, आणविक कीटविज्ञान और कीट परिस्थितिकी विज्ञान के रूप में तीन विभागों का सृजन किया गया। निष्पादित सारांश के द्वारा, 2012-13 के दौरान, रा कृ प्र की ब्यू में हो रहे मौलिक कार्यों के साथ-साथ फसल पीडकों और खरपतारों के जैविक नियंत्रण पर अखिल भारतीय समन्वित अनुसंधान परियोजना के अन्तर्गत विभिन्न केन्द्रों पर चल रहे गौण कार्यो की संपूर्ण जानकारी प्रदान करेगी।

कीटों की चित्र गैलरी

रा कृ प्र की ब्यू, की वेबसाईट पर चित्र गैलरी सृजित की गई है अभी तक कीटों की 510 प्रजातियों के 3000 से अधिक फोटो को उनके विवरण सहित स्थापित किया है। इस वेबसाईट को यू एस डी ए और कोलोरेडो स्टेट यूनिवर्सिटी के द्वारा पोषित आई डी स्रोत के तहत अन्य साईट ''फीचर्ड इन्सैक्ट्स'' पर भी शामिल किया गया। अभी तक ज्ञात कीट के 28 वंशों के लिए फेक्ट शीट्स, डायगनोस्टिक्स और इलूस्ट्रेशन्स के साथ भारत के मायमेरीडे वंश का एल यू सी आईडी फीनीक्स कुँजी के द्वारा अंतः क्रिया के तहत तैयार किया गया।

जैवप्रणाली

अंडमान प्राय:द्वीप के खाली पडे खेतों से *ट्रायकोग्रामा रबिन्द्राई* को एकत्रित किया गया। *ट्रायकोग्रामेटॉयडिया बेक्टरे* को *प्रोसोटाज नोरा* पर नीबू वर्गीय बागानों से एकत्र किया गया। *ट्रा. बेक्टरे* एकत्रित करके उनकी आणविक पहचान का कार्य किया गया। *पोरोपोइआ बेल्ला* हयात और पूरणी (ट्रायकोग्रामेटिडे) और *जेपलेटायसेरस नोटीएलिस* हयात और पूरणी (एनसिर्टिडे) को कर्नाटक से वर्णित किया गया। बाँस के बडी लेडीबर्ड, *सायनोनिका ग्रान्डिस* के परजीवी कीट के रूप में *कोक्सीफेलीपस सायनोनिके* (एकरी: पोडेपोलीपिडे) को वर्णित किया गया। बेंगलोर और आस-पास के क्षेत्रों में *अनागायरस कवाड्राई* और *अनागायरस* की एक उपोदघात प्रजाति को मेडेरीआ मिलीबग कीट के परजीवी कीट के रूप मे अभिलेखित किया गया।

भारत से, माइक्रोगेस्ट्रीने (ब्रेकोनीडे) की बारह प्रजातियों को वर्णित किया गया। इनमें से *गिल्पोपेन्टेलस हायमर्मेस्ट्रे* और *डोलीकोजेनीडीआ कुन्ही* को कृषि प्रमुख पाया गया। *एपेन्टेलस मोहनदासी* और *ए. टेरेगामे* की प्रजातियों को सुनिश्चित करने के लिए, आण्विक टूल्स का प्रयोग किया गया। *ए. मोहनदासी* को *डोलीकोजेनीडिआ* के बदले *एपेन्टेलस* वंश में रखा गया। रियूनियन प्राय द्वीप के माइक्रोगेस्ट्रीने जन्तु वर्ग के 13 वशं के अन्तर्गत आने वाली 34 प्रजातियों को, जिसमे भारतीय उद्भव की अनेक प्रजतियाँ शामिल है को, कुँजी के आधार पर प्रकाशित किया गया।

अंडमान प्राय द्वीप से टेलीनोमिने, टेलीएसीनिए, सीलीओनिने, सीलीओट्रकीलीने और प्लेटीगेस्ट्रीने के अन्तर्गत आने वाले कीटों के 33 वशों की पहचान की गई। प्लेटीगेस्ट्रॉयडीए के लिए पाँच राज्यों और केन्द्र शासित प्रदेशों में सर्वेक्षण किए गए। कुल 1850 परजीवी कीटों को एकत्र किया गया, अभी तक पाँच उपकूलों के अन्तर्गत आने वाले 41 वंशो और इनके अतिरिक्त 11 वंश और शामिल किए गए,

इस प्रकार कुल 52 वंशों को भारत वर्ष में अभिलेखित किया गया। उपकुल टेलीएसीने के अन्तर्गत आने वाले एक नए वंश *डवीवार्नस* राजमोहन और वीनाकुमारी, को वर्णित किया गया। इसी वंश के अन्तर्गत एक नई जाति *डवीवार्नस पन्कटेटस* वीनाकुमारी और राजमोहन, वर्णित की गई। उपकुल सीलीओट्रेकीलीने के अन्तर्गत तीन नई प्रजातियों को वर्णित किया गया। *प्लूटोमेरस विरेशी* वीनाकुमारी, ब्युहल और राजमोहन, *फिडीओबिआ विर्कतामठी* वीनाकुमारी, ब्युहल और राजमोहन और *फि. नागराजाए* वीनाकुमारी, ब्युहल और राजमोहन, वर्णित की गई। *फिडीओबिआ* प्रजाति को, भारत में पहली बार इस वंश को प्रदर्शित करते पाया गया।

कुल 296 क्षेत्रीय सर्वेक्षण किए गये और 1298 प्रतिदर्शों के 2490 स्लाईडस बनाई गई। इन सर्वेक्षणों के दौरान कोकसोयडिआ के अन्तर्गत आने वाले होमोप्टेरन्स के चौबीस नए अभिलेखन किए गए। भारत में, माहू की प्रजातियाँ जैसे *प्लेओट्रायकोफोरस क्रायसेन्थेमी* (थीओबाल्ड) और *रेटीक्यूलेफिस फोवीओलेटे* (ताकाशाही) और एक परदेशी मिलीबग, *स्यूडोकोकस जैकबेयर्डस्लेई* गिमपेल और मिलर को भारत में पहली बार अभिलेखित किया गया।

लोहीएल्ला लोन्गिकॉर्निस (नॉयेस और हयात) को *ड्रेपेनोकोकस चिटॉन* को परजीवित करते हुए भारत में पहली बार पाया गया जो कि एक नया पोषक कीट के रूप में शामिल हुआ। विभिन्न रा कृ वि, भा कृ अनु प सस्थानों और निजी संगठनों से भेजे गए 260 प्रतिदर्शों की पहचान की गई।

कर्नाटक, केरल, तमिल नाडू, महाराष्ट्र, अण्डमान और निकोबार द्वीप समूहों में सर्वेक्षण किए गए। 33 वंशों और पाँच उपकुलों जैसे डेकीने, टेफरीटिने, फाइटेलमीने और टेकीनीस्किने की 81 प्रजातियाँ एकत्र/अध्ययन किए गए। रा कृ प्र की ब्यू के संग्रहण में फल मक्खी की लगभग 2,400 प्रतिदर्श शामिल किए गए। अड्रामीनाई जनजाति की चार प्रजातियाँ, *कोयलोट्रीपेस लेटीलीम्बेटस* (एन्डर्लिन), *डाइमेरीनोगेफ्रीस पेरीलिस* (हार्डी), *डाइमेरीनोगफ्रीस पेलीडीपेनिस* हार्डी, *हार्डीएड्रामा एकसकोएकेरीए* ली और *कोएलोपेसीडिआ* की एक नई अवर्णित प्रजाति भारत में अभिलेखित की गई। *ओरटेलोट्रीपेटा इशीकी* (मत्सयूमुरा) और टेकीनिस्किने उपकुल को भारत में, पहली बार अभिलेखित किया गया। फल मक्खी की चार नई प्रजातियों- *यूफ्रेन्टा डायसेक्सीलाई* डेविड, *यू. डाईफ़ुसा* डेविड, *यू. थेन्डीकुडी* डेविड और *यू. हायएलीपेनिस* डेविड और फ्रीडबर्ग को भारत में वर्णित किया गया।

परदेशी कीट

पपीते के मिलीबग, *पेराकोकस मार्जिनेटस* को कर्नाटक, आन्ध्र प्रदेश, अण्डमान और निकोबार द्वीप और तमिल नाडू राज्यों में देखा गया। अप्रैल, 2012 से फरवरी 2013 तक *एसीरोफेगस पपाये* के कुल 43 आग्रह प्राप्त हुए। सेलम और बेंगलोर में *पे. मार्जिनेटस* के परजीवी कीट *अनागायरस लोएकी* और *स्यूडलेप्टोमेस्टिकस मेक्सिकाना* को अभिलेखित किया गया। *एसीरोफेगस पपाये* के ऊपर अति परजीवी कीट के रूप में *मेरीएटा लेपोर्डिआना* (हायमेनोप्टेरा: एफलीनिडे) अभिलेखित किया गया। बाँदीपुर (कर्नाटक) के समीप कपास की फसल में मेडईरा मिलीबग, *फीनेकोकस मादेईरेन्सिस* ग्रीन का ग्रसन पाया गया। *फी. मादेईरेन्सिस* के अनेक परजीवी कीट जैसे *एलोट्रोपा* स्पे., *अनागरस* स्पे., *अ. क्वाड्री* और *अ. लोएकी* अभिलेखित किया गया।

कीटरोगाणु

उत्तरी कर्नाटक, महाराष्ट्र और पश्चिमी उत्तर प्रदेश के सफेद लट ग्रसित गन्ना उगाने वाले क्षेत्रों में *हेटेरोरहाब्डिटिस* स्पे. और *स्टेईनर्नेमा अब्बासी* के तीन नए पृथककरणों की पहचान में सहायता की गई जो कि *होलोट्रीकीया सेरेटा, हो. कोन्सेन्गुयीना, अनोमोला* स्पे., *लियूकोफोलिस लोपिडिफोरा, लेपिडिओटा मेन्सुएटा, फायलोफेगा केल्सिएटा* और *फायलोग्नेथस डाईओनीसिअस* से ग्रसित पाए गए।

इन विवो में *गेलेरीआ मेलोनेल्ला* के लारवों पर *हे. इन्डिका* (विभेद एन बी ए आई आई 10) के विकास का अध्ययन किया गया। 28°C तापमान पर विकास 96-104 घन्टों में पूर्ण हुआ। *गे. मेलोनेल्ला* की तुलना में, *स्पो. लिट्यूरा* और *हे. आर्मिजेरा* में इनका जीवन चक्र कम के साथ-साथ नर, मादाओं और ज्युवेनाईल्स की सँख्या कम पाई गई। सफेद लट, *लियूकोफोलिस लेपिडिफोरा* पर, *हे. इन्डिका* का विकास 112-136 घन्टों में पूर्ण हुआ।

हे. इन्डिका और *मेटारहाईजिएम एनाईसोप्लिए* का मिश्रित उपयोग करने पर *मायलोसेरस सबफेसीकेटस* के प्रौढ और ग्रब का क्रमशः 75 और 67% सँख्या कम किया। लाल लेटेराईट मृदा में 5 महीनों के प्रयोग के बाद *हे. इन्डिका* (एन बी ए आई आई एच आई 01) और *स्टे. अब्बासी* (एस ए 01) विभेदों की क्रमशः लगभग 82 और 80% पुनः प्राप्ति हुई।

पश्चिमी महाराष्ट्र के वारानगर और नागाँव में क्षेत्रीय परीक्षण दर्शाते हैं कि *हे. इन्डिका* और *स्टे. अब्बासी* के द्रवीय एवं कडावर नियमनों का प्रयोग करने पर, अनोपचारित की अपेक्षा गन्ने की उगने और ऊँचाई में अधिक सुधार पाया गया। *हे. इन्डिका* और *स्टे. अब्बासी* को *स्टे. कार्पोकेप्से* और *स्टे. ग्लेसेरी* की अपेक्षा उत्तम कार्य करने वाला पाया गया।

टर्फघास को ग्रसित करने वाली सॉड वेबवॉर्म, *हर्पेटोग्रामा फेओप्ट्रेलिस* के प्रति *स्टे. अब्बासी, हे. बेक्टेरिओफोरा* और *हे. इन्डिका* के विषालुपन के प्रयोगशाला अध्ययन में पाया गया कि ये सभी तीनों जातियाँ *ह. फेओप्टेरेलिस* के लारवों के प्रति रोगाण्विक हैं। कॉफी के तना बेधक, *जाइलोट्रेकस क्वाड्रीपस* के लारवों के प्रति *हेटेरोरहाब्डिटिज इन्डिका, स्टे. अब्बासी* और *हे. बेक्टेरिओफोरा* का परीक्षण किया गया और *हे. इन्डिका* की न्यूनतम एल सी$_{50}$ और एल सी$_{90}$ क्रमशः 37.1 और 88.9 आई जे के रूप में अति घातक पाया गया।

अन्तः सहजीवी

कर्नाटक राज्य के बेंगलोर, मालूर और धारवाड जिलों से एकत्र *एफिस गोसीपी, एफिस क्रेकसीवोरा* और *माईजस पर्सिके* से कुल 82 संवर्धन लायक जीवाणु पृथक किए गए। 16 एस आर डी एन ए सीक्वेन्स होमोलोजी खोज के आधार पर *बेसीलस आयभिट्टाई, बे. मेरेअस, बे. फर्मस, बे. होरीकोसाई, बे. जेओटगाली, बे. माजीलिएन्सिस, बे. सबटिलिस, एग्जिगुओबेक्टेरिअम इन्डिकम, मोरेक्सेल्ला ओसलोएन्सिस, पाएनिबेसीलस लाउटस, स्यूडोमोनाज हिबीसीकोला, स्टेनोट्रोफोगोनाज माल्टोफिलिआ* और *जिम्मेरमानेल्ला फाएकेलिस* को माहुओं के सहयोजी होने के पहचान की गई।

न्यूनतम साल्ट मीडियम और बिना कीटनाशकों का अध्ययन किया गया इसमें पाया कि 96 घन्टों के बाद *विकेरहेमोमायसस एनोमालस* अनोपचार की अपेक्षा सुधारे गए मिडियम कीटनाशी में इनका विकास या वृद्धि 3.39 गुणा अधिक पाई गई। यीस्ट प्रजातियाँ, *फोटस्कनिकोविआ रियुकॉई, पिकीआ ओहमेरी, विकेरहामायसस एनोमालस* और *केनेडिडा एपिकोला* के प्रयोग करने से *ट्राइकोग्रामा जेपोनिकम* में सही अनुरूपता जैसे परजीवीकरण क्षमता प्रतिशत, मादा और जनन क्षमता की प्रतिशतता बढी पाई गई। एल सी-एम एस अध्ययन में पाया गया कि अनोपचार की तुलना मे, *क्राईसोपरला जेस्ट्रोवी सिलेमी* के लारवों से प्रथक किए गए *एन्टेरोबेक्टर* स्पे., एसीफेट को 6 गुणा और इन्डोक्साकार्ब 11 गुणा अवक्षित करने के योग्य पाया गया।

कोटेसिआ प्लुटेल्ले को विभिन्न भौगोलिक क्षेत्रों से एकत्र करके *वोल्बेशिआ* का लक्षण कराने पर परजीवीकरण महत्वपूर्ण रूप से अत्यधिक (74.8 से 91.2%) और प्रौढ़ निकलने की दर भी अत्यधिक (64.1 से 82.2%) प्राप्त हुई जबकि *वोल्बेशिआ* से उपचारित संख्या में यह क्रमशः 68.2 से 82.3 और 60.4 से 72.2% ही पाई गई। बेंगलोर, भुवनेश्वर और नवाँशहर (पंजाब) में अनुकूल अनुरूपता अत्यधिक दर्ज की गई।

लियूसीनॉयड्स ओरबोनेलिस पालने के लिए अर्द्धसंश्लेषित आहार

पोषक तत्व और फेगोस्टीमुलरी यौगिक अवयवों के संयोगी एक आहार तैयार की गई। *लि. ओरबोनेलिस* के वृद्धि विकास और प्रौढ़ जीवन काल जैसे जैव मापन के लिए इस आहार को अत्युत्तम पाया। यह जिनोमिक अध्ययन के लिए उत्तम है।

कीटरोगाण्विक सूत्रकृमियों का आँकडा सूची

कीटरोगाण्विक सूत्रकृमियों का आँकडा आधारित डिवाईस तैयार की गई जो कि स्टेईनर्नेमेटिडे और हेटेरोरहाब्डिटिडे के प्रणालिक, विशिष्ट गुणों, जैवविविधता मानचित्र, जैवपरिस्थितिकी, बहुगुणन तकनीकों, नियमनों और संग्रहण, प्रयोग तथा व्यवसायिक उत्पादों के उपलब्धता संबंधी जानकारी प्रदान करती है।

एन्थोकोरिड परभक्षी कीट: उनकी विविधता, जैविकी और परिस्थितिकी विज्ञान

विभिन्न मौसमों में विभिन्न फसलों/पौधों से एन्थोकोरिड्स एकत्र किए गए। थ्रिप्स प्रजातियों के प्रति *केरायोनोकोरिस इन्डिकस, ओरीयस ड्रेवीडिएन्सिस, कार्डियास्टेथस एग्जिगुअस, ओरीअस नाईगर, कार्डिआस्टेथ्स स्युडोकोकी स्युडोकोकी, ओरीयस मेक्सिडेन्टेक्स, कार्डिआस्टेथस एफीनिस, मोन्टेडोनिओला इन्डिका, जाईलोकेरिस (प्रोक्सीलोकोरिस) आफर* और *बुचेनेनिएल्ला क्रेसीकोर्निस* परभक्षी कीट एकत्र किए गए। फाइकस से *ब्यूटिआ मोनोस्पर्मा, एन्थोकोरीनी* वंश. एट. स्पे. पर *मोन्टेन्डोनिओला* की एक अवर्णित प्रजाति पाई गई, *ओरीअस मेक्सिडेन्टेक्स* अण्डमान और निकोबार द्वीप समूहों से पहली बार अभिलेखित की गई। गन्ने की फसल में *ब्लाप्टोस्टेथॉयड्स* स्पे. की एक अवर्णित प्रजाति अभिलेखित की गई और *जाइलोकोरिस आफर* को भारत में, पहली बार अभिलेखित किया गया, अगेव पर *हेमिबर्लेसिआ लेंटेनिए* के परभक्षी कीट के रूप में *कार्डियास्टेथस एफिनिस* को पहली बार अभिलेखित किया गया।

काली मिर्च के गॉलथ्रिप्स, *लॉयोथ्रिप्स कार्नाई* के परभक्षी कीट *मोन्टेन्डोनिआला इन्डिका* को पालने की एक मानक विधि तैयार की गई, इस विधि में अल्ट्रा वॉयलेट उपचारित *को. सीफेलोनिका* के अण्डों को अधोस्तर के रूप में बीन्स की फली पर भक्षण के लिए प्रयोग किए जाते हैं। प्रयोगशाला अध्ययन में *मो. इन्डिका* के निम्फ, *को. सीफेलोनिका* के प्रतिदिन 1.56 अण्डे प्रतिदिन की दर के साथ कुल 27.3 अण्डों का भक्षण करता है। *मो. इन्डिका* का प्रौढ़ कीट 1.67 अण्डे प्रतिदिन की दर के साथ कुल 38 अण्डों का भक्षण करता है, जबकि प्रौढ़ मादा प्रतिदिन 1.79 अण्डे की दर के साथ कुल 56 अण्डों का भक्षण करते पाए गए।

थ्रिप्स, *फ्रेंकलिनिएल्ला स्कूल्टजी* के प्यूपा अवस्था के प्रति *ब्लाप्टोस्टेथस पेलेसेन्स* का मूल्यांकन किया गया। जब मृदा में, *फ्रे. स्कूल्टजी* के प्यूपों को नियंत्रित करने के लिए *ब्ला. पेलेसेन्स* के निम्फ और प्रौढ़ छोडे गए तब, घातकता क्रमशः 74.0% और 89.3% जबकि अनोपचारित दशा में घातकता 41.3% ही पाई गई।

कोरसेरा सीफेलोनिका के अण्डों का संग्रहण

को. सीफेलोनिका के अण्डों को 10,12 और 14° से.ग्रे. पर पाँच दिनों के लिए संग्रहण करने पर उनके सेने की दर क्रमशः 48, 49 और 77% पाई गई; जबकि उनके अन्दर से प्रौढ़ निकलने की दर क्रमशः 29.2, 67.4 और 90.9 पाई गई। यह परीक्षण दर्शाते हैं कि *को. सीफेलोनिका* के अण्डों में 14° सेग्रे. पर 5 दिनों के लिए सुरक्षित रूप से संग्रहित किया जा सकता है, इससे अण्डों में 70% से अधिक सेनेयोग्य और प्रौढ़ निकलने की दर 90% से अधिक पाई जाती है।

धान और गन्ने के बेधक कीटों के प्रति एरी सिल्कवॉर्म (ईएसडब्ल्यू) के अण्डो पर पाले गए *ट्राइकोग्रामा* स्पे. की दक्षता

को. सीफेलोनिका पर लगतार पाले जाने वाले *ट्रायकोग्रामा एम्ब्रियोफेगम* को जब शुरूआत में एरी सिल्कवॉर्म के अण्डों पर उदभासित किया गया तो परजीवीकरण और प्रौढ़ निकलने की दर कम मात्रा में क्रमशः 20 और 2% प्राप्त हुई। *ट्रा. एम्ब्रियोफेगम* को लगातार 151 पीढीयों तक एरी सिल्कवॉर्म के अण्डों पर पालने के परिणामस्वरूप परजीवीकरण 92.2% और प्रौढ़ निकलने की दर 70.7% पाई गई।

आन्ध्र प्रदेश के क्षेत्रीय परीक्षणों में, *ट्रा. किलोनिस*, को 10 कार्ड प्रति बार की दर से 10 दिनों के अंतराल पर पाँच बार छोडने का, अनोपचारित प्लॉट, जैविक नियंत्रण प्लॉट और कीटनाशी उपचारित प्लॉट के बीच तुलना की गई। रासायनिक नियंत्रण वाले प्लॉट में खर्चा 2000 रूपये प्रति एकड़ और जैविक नियंत्रण प्लॉट खर्चा 786 प्रति एकड़ पाया गया।

वी सी फार्म, मान्डया पर एक अन्य क्षेत्रीय परिक्षण में एरी सिल्कवॉर्म और *को. सीफेलोनिका* पर पाले गए *ट्रा. किलोनिस* की दक्षता का मूल्यांकन किया गया। *ट्रा. किलोनिस* के 20,000 प्रौढ़ प्रति एकड़ की दर से, साप्ताहिक अन्तराल पर 8 बार छोडे गए। अनोपचारित, *ट्रा. किलोनिस* (एरी सिल्कवॉर्म पर) छोडे गए प्लॉट और *ट्रा. किलोनिस* (*को. सीफेलोनिका* पर) छोडे गए प्लॉट में, पोरियों के ग्रसन की प्रतिशतता क्रमशः 92, 76 और 68 पाई गई।

उपरोक्त परीक्षण को बल देने के लिए माडला, मान्डया में किसान के खेत में एक अन्य परीक्षण गन्ने की फसल में किया गया। *ट्रा. किलोनिस* के 40000 प्रौढ़ प्रति एकड, प्रति बार की दर से साप्ताहिक अन्तराल पर चौदह बार छोडा गया। अनोपचारित, *ट्रा. किलोनिस* (एरी सिल्कवॉर्म पर) छोडे गए प्लॉट और *ट्रा. किलोनिस* (*को. सीफेलोनिका* पर) छोड़े गए प्लॉट में पीड़क ग्रसन की प्रतिशतता क्रमशः 76, 32 और 20 पाई गई।

कीट परागणकर्ता और इनका परागण में महत्व

मधुमक्खी रहित परागणकर्ताओं के 4 कुलों जैसे मेगाचिलीडे, एपीडे, जाईलोकोपिडे और एन्थोकोरिडे की अरहर की फसल में फूलों के ऊपर तितलियों और मक्खियों के साथ पंद्रह प्रजातियाँ पाई गई। फूल आने के समय कुल मधुमक्खियों में से *एपिस* (विशेषतः *ए. डोर्सेटा*, *ए. सीरेना* और *ए. फ्लोरीआ*) की 40% पाई गई। इसके बाद दूसरे बडे समूह में मेगाचिलिडे कुल में आने वाली *मेगाचिले पेरीएटिना* (*केलीकोडोमा पेरीएटिना*) और *मे. फ्लेविपस* को कुल प्रतिदर्शों में से 38% पाया गया। यद्यपि, अरहर एक स्वपरागण वाली फसल है, बाहरी मिलान 3-40% पाया गया और मक्खी उपलब्ध होने वाली फलियों में बीज बनने की दर 92-100 प्रतिशत पाई गई।

एक क्षेत्रीय परीक्षण में पाया गया कि अरहर के साथ अन्तः फसल के रूप में सूर्यमुखी को जगह गेंदा उगाने पर उपज अधिक, किन्तु अकेले अरहर उगाने की जगह इन दोनो को अन्तः फसल के रूप में उगाना श्रेष्ठ पाया गया। अरहर के 100 बीजों का भार 11.8 से 13.8 ग्राम (अरहर +सूर्यमुखी) और 15.7 ग्राम (अरहर + गेंदा) बढ़ना अरहर की फसल में उपज बढ़ाने के लिए परागणकर्ताओं की भूमिका का द्योतक है।

विभिन्न फसलों और जंगली पौधों से मधुमक्खी और मधुमक्खी रहित परागणकर्ताओं को एकत्र किया गया। आम में, डिप्टेरन परागणकर्ता (केलीफोरिडे, सिरफिडे, सेरकोफेगिडे, मस्किडे) और *एपिस फ्लोरीआ* प्रमुख परागणकर्ता पाए गए। उनके आने का तरीका, दौरा काल और दौरे का समय का अध्ययन किया गया। अफसलीय

जैसे *केलोट्रोपिस* स्पे. और *लेगेरस्ट्रोमिआ फ्लोस-रेजिने* फसल के उपलब्ध न होने पर *जाईलोकोपा* स्पे. के जीवनयापन के लिए मदद देते हैं।

अरहर में कीटों की विविधता पर मौसम के बदलाव का प्रभाव

ऊपर से खुले कार्बन डाईऑक्साईड चैम्बरों में कार्बन डाईआक्साईड और तापक्रम को नियंत्रित करने वाले उपकरण के माध्यम से अरहर की फसल में, मौसम के बदलाव के प्रभाव, मुख्य रूप से कार्बन डाईआक्साईड और तापक्रम के बढने का अरहर के कीट विविधताओं पर होने वाले प्रभाव का अध्ययन किया गया। और तापक्रम के अनेक स्तरों का *मेरूका विट्रेटा, एफिस गोसीपी* और *ओरीजिआ लियूकोस्टिग्मा* कीटों के ग्रसन पर कोई महत्वपूर्ण अन्तर नहीं पाया गया। यद्यपि, बढाए गए (500 पी.पी.एम) और तापक्रम (सामान्य से 2° से.ग्रे. अधिक) पर उगाए गए पौधों पर *कोक्सीडोहायस्टिक्स इन्सोलिटा* की सँख्या महत्वपूर्ण रूप से अधिक पाई गई।

प्रमुख पीड़कों के लिए अर्द्धरासायनिक

फल मक्खियों और *लेप्टोसाईबे इनवेसा* को आकर्षित करने के लिए दो पौधो से आधारित यौगिक बनाया गया। कोलार में, यूकेलिप्टस के बाग में नियमन की विभिन्न मात्राओं को डेल्टा प्रपंचों के माध्यम से *ले. इनवेसा* को आकर्षित करने के लिए परीक्षण किया गया घोल के साथ अनोपचारित की तुलना में प्रपंचों में *ले. इनवेसा* के प्रौढ़ अधिक सँख्या में अभिलेखित किए गए। पौधे यौगिको वाले ब्लेन्ड युक्त प्रपंचों में, *बेक्ट्रोसीरा* स्पे. अधिक सँख्या में पकडे गए और इसको मिथाईल यूजेनोल से श्रेष्ठ पाया गया।

अनागायरस कमाली की जैविकी और बहुगुणन

गुडहल के मिलीबग, *मेकोनेलीकोकस हिर्सुटस* के अन्तः परजीवी कीट, *अनागायरस कमाली* की जैविकी का अध्ययन किया गया। अध्ययन करने के लिए अंडमान द्वीपों से प्राप्त संवर्धन का प्रयोग किया गया। *मे. हिर्सुटस* को अंकुरित आलुओं और कद्दू पर पाला गया। यद्यपि, *अ. कमाली* दूसरे निरूपीय निम्फों को परजीवित करता है, फिर भी तीसरे निरुपीय और प्रौढ़ मादा मिलीबग के प्रति भी प्राथमिकता देता है। *अ. कमाली* का वृद्धिकाल दूसरे निरूपीय नर की दशा में 25-29 दिनों और मादा की दशा में 30-32 दिनों का पाया गया। निम्फ की अंतिम दशा में वृद्धि काल (22 दिन) और प्रौढ़ मादा की दशा में वृद्धि काल (20-21 दिन) तेजी से होता है। परजीवी कीट के नर और मादा की जीवन क्षमता क्रमशः 30-32 दिन और 38-42 दिन की होती है। पानी भक्षण या भूखे प्रौढ़ कीट 36-48 घंटों से अधिक जीवित नहीं रह सकते हैं। इस परजीवी कीट को जीवित रहने के लिए 22-25° से. ग्रे. तापक्रम उचित पाया गया।

परभक्षी कीटों, *क्रायसोपर्ला जेस्ट्रोवी सिलेमी* (एस्बन पेटर्सन) और *क्रिप्टोलीमस मोन्ट्रयूजिएरी* (मुलसेन्ट) के उत्कृष्ट विभेद का चयन

क्रा. जे. सिलेमी के बारह विभिन्न भौगोलिक सँख्याओं और *क्रि. मोन्ट्रयूजिएरी* की 6 विभिन्न सँख्याओं का आनुवांशिक संग्रहण का रखरखाव किया गया। *क्रि. मोन्ट्रयूजिएरी* की विभिन्न सँख्याओं के जैविक मापन के लिए विभिन्न तापक्रमों (32-40° से.ग्रे.) पर पाया कि अधिकांशतः सँख्यायें 60 दिनों तक जीवित रहती हैं और कोयम्बटूर तथा शिमोगा से एकत्र की गई सँख्याये 70 दिनों तक जीवित रहती हैं। *क्रा. जे. सिलेमी* के क्षेत्र में छोडने पर कीटनाशी सहिष्णु विभेद 84% और ग्रहणीय सँख्यायें 33% जीवित रहती हैं और छिड़काव के 1,2 और 3 दिनों के बाद क्रमशः 84%, 98% और 98% पाई गई।

कपास में चूसने वाले कीटों के प्रति कीटनाशी सहिष्णु विभेदों के क्षेत्रीय मूल्यांकन में पाया गया कि एसीफेट

(0.67 ग्रा./ली.) के दो छिड़काव और पी टी एस (सी जेड ऐ - 8) को 15 दिनों के अन्तराल बार दो बार संयोजी रूप में प्रयोग करना *ए. गोसीपी* (13.4 माहू/पौधा) और *थ्रिप्स टेबेसी* के प्रति प्रभावी पाया गया और कपास की अत्यधिक उपज (1533 किग्रा./हे.) प्राप्त हुई। *क्रा. जे. सिलेमी* (सी जेड ए - 8) के कीटनाशी सहिष्णु विभेद (ओरगेनो फॉस्फेटस, ओरगेनो क्लोरीन और संश्लेषित पायरेथ्रॉयडस के सहिष्णु) का बहुगुणन किया गया और उ. प्र. में, शिमला मिर्च में चूसने वाले कीटों के प्रति क्षेत्र में छोड्ने के लिए 12,000 भेजे गए।

फेरोमोन नैनोजैल के साथ पीड़कों का प्रबंधन

फसलों के हानिकारक कीटों के जीवन चक्र को विचलित करने के लिए कई नैनोजैल-अवशोषित फेरोमोनों का उपयोग करके उनकी क्षेत्रीय-जीवन बढ़ाने के लिए स्वतः सिद्धान्तिक सुपरमोलिक्यूलर का प्रयोग कर भारतीय विज्ञान संस्थान के कार्बनिक रसायन विभाग के सहयोग से एक उत्कृष्ट नैनोजैल संश्लेषित किया गया।

नैनोपार्टिकल्स की जैवसुरक्षा प्राकृतिक शत्रु कीटों पर उनके प्रभाव की दृष्टि को ध्यान में रखकर स्थापित की गई। *क्रायसोपर्ला जेस्ट्रोवी सिलेमी* की जैविकी पर काईटोसेन-एल्जिनेट नैनोपार्टिकलों के अलक्षित प्रभावों का एफ-1 पीढियों तक अध्ययन किया और पाया कि इनका उनके उपर कोई हानिकारक प्रभाव नहीं है।

प्रौद्योगिकीयों का विक्रय

हेटेरोरहाब्डिटिस इन्डिका के एन बी ए आई आई एच आई 1 के *इन विवो* उत्पादन संबंधी प्रौद्योगिकीयों को, तीन उद्योग जगत केमसन बायोटेक लि., बेंगलोर और फार्मर, गजियाबाद को बेचकर 3.5 लाख रूपयों का राजस्व प्राप्त किया।

जैविक नियंत्रण पर अखिल भारतीय समन्वियत अनुसंधान परियोजना

विदेशी हानिकारक पीडकों का अनुवीक्षण

पेराकोकस मार्जिनेटस का ग्रसन थ्रिसूर, एरनाकुलम और पालकाड जिलों में देखा गया, किन्तु इनकी तीव्रता बहुत कम पाई गई। परजीवी कीट *एसीरोफेगस पपाये* को सभी जगहों पर उपस्थित पाया गया।

पंजाब राज्य के विभिन्न जिलो में किए गए सर्वेक्षण में पाया कि पपीते के मिलीबग *पेराकोकस मार्जिनेटस* को खरपतवारों सहित विभिन्न फसलों जैसे *पार्थेनियम,* जंगली भिण्डी, *केशिआ आक्सीडेन्टेलिस, केशिआ* स्पे., *वेरोनिका सीनेरेरिआ;* पपीते के साथ फल वाली फसलों जैसे शरीफा, अलंकृत पौधे जैसे *डाइफनबेचिआ,* क्रायसेन्थिमम और गेंदा पर ग्रसन पाया गया। पंजाब में कपास की फसल में, *मेकोनेलीकोकस हिर्सुटस* को मिलीबग की सर्वाधिक पायी जाने वाली जातियों में पाया।

तमिल नाडू के सत्यामंगलम में, *पेराकोकस मार्जिनेटस* और *एसीरोफेगस पपाये* के सर्वेक्षण के दौरान पपीते के दो उद्यानों में पपीते की कालोनी में *पे. मार्जिनेटस* के साथ-साथ एक छोटी पूँछ वाले मिलीबग, *स्यूडोकोकस जैकबेयर्डस्लेई* गिम्पल और मिलर पाई गई। मिलीबग की चार जातियों, *फीनेकोकस सोलेनोप्सिस, मेकोनेलीकोकस हिर्सुटस, फेरीसिआ विरगेटा* और *पेराकोकस मार्जिनेटस* को कपास की फसल मे पाया गया। सर्वेक्षण से यह भी ज्ञात हुआ कि, *फी. सोलेनोप्सिस* इन सब में सर्वाधिक पाई जाने वाली प्रजाति थी और इसके परपोषी पौधो में कपास, सूर्यमुखी, सब्जियाँ (बैंगन, टमाटर, भिण्डी, कुकुरबिट लोकी कुल), दाले, *केलोट्रोपिस, धतुरा* और *पार्थेनियम* शामिल थे।

पत्ती के सर्पिलाकार सुरंगी कीट, *लिरीयोमाईजा ट्रायफोली* के परजीवी कीट

लारवा परजीवी कीट की छः और लारवा-प्यूपा परजीवी कीट की एक प्रजाति एकत्रित की गई। लारवा कीट की पहचान *नीओक्रायसोकेरिस फोरमोसा, क्रायसोकेरिस* स्पे., *डिगलीफस* स्पे., *एसीकोडस डेलुकी, एसीकोडस एरक्सिआज* और *हेमिपटेर्सीनस वेरीकोर्निस* के रूप में जबकि, लारवा-प्यूपा परजीवी कीट के रूप में *ओपिअस* स्पे. की पहचान की गई। *नी. फोरमोसा* प्रजाति का प्रभुत्व पाया गया (त कृ वि)।

मटर की पत्ती सुरंगी कीट *क्रोमेटोमायईआ होर्टिकोला* के परजीवी कीट

मटर पर, मध्यम पहाडी दशा (1300 मीटर एम एस एल) के अन्तर्गत मटर की पत्ती सुंरगी कीट *क्रोमेटोमायईआ होर्टिकोला* के परजीवी कीटों की जैवविविधता अध्ययन किया गया। लारवा परजीवी कीटों की *डिग्लीफस* स्पे. और *क्वाड्रेस्टिकस* स्पे. के रूप में दो प्रजातियाँ तथा लारवा-प्यूपा परजीवी कीट के रूप में *ओपिअस* स्पे. प्रजाति अभिलेखित की गई। *डिग्लीफस* स्पे. प्रजाति का प्रभुत्व पाया गया (त कृ वि)।

केरल में, केले के तना विविल, केले के माहू, पोलू बीटल और काली मिर्च के जड़ में लगने वाले मिलीबग का सात कृषि पारिस्थितिकी क्षेत्रों में प्राकृतिक शत्रु कीटों के एकत्रण और सर्वेक्षण का कार्य किया गया। केले के तना विविल, *ओडोईपोरस लोन्गिकोलिस* (ओलाईव.) के अण्डों का भक्षण करते हुए ईअरविग्स की तीन विभिन्न जातियों को एकत्रित किया गया। केले के माहू, *पेन्टालोनिआ नाइग्रोनेर्वोसा* पर भक्षण करते हुए *स्यूडेस्पाईडिमेरस ट्राईनोटेटस* (थंगबर्ग), *स्किमनस पायरोकीलस* (मूलसेन्ट), *जोरेवीआ सोरोर* वाईजे, *स्किमन्स* स्पे. और हेमेरोबीड्स (बिना पहचान के) को पाया गया। काली मिर्च पर, पोलू बीटल, *लंका रामकृष्णाई* पर भक्षण करते हुए पत्तियों के ऊपर अनेक परभक्षी मकडियाँ एकत्रित की गई और उनकी पहचान *एरेनीअस बाईलुनीफर* (अनेनीअडे), *अर्गीओपे पुलचेल्ला* (अरेनीअडे), *बेवीआ कैरेली* (साल्टीसीडे), *क्लबीओना ड्रेसोड्स* (क्लबोनीडे), *ओक्सीओपस जेवेनस* (ऑक्सीओपिडे), *केरीजोपेस बेन्गालेन्सिस* (अरेनीअडे), *ओक्सीओपस बाईर्मेनीकस* (ऑक्सीओपिडे), *ओक्सीओपस श्वेता* (ऑक्सीओपिडे) और *थाईएनिआ भेमोएन्सिस* (साल्टीसीडे) के रूप में हुई।

प्राकृतिक शत्रु कीटों की विविधता

अधिकांश पाए जाने वाली प्रजातियों में *निओस्कोना थिएसी* (133) और *लियूकाउज* स्पे. (133) इनके बाद *सिरटोफोरा सीकेट्रोसा* (72), *आर्जिओपे* स्पे. (72), *टेट्राग्नेथा जेवेना* (72), *आर्जिओपे एनासूजा* (65) और *लियूकाउज डेकोरेटा* (65), प्रजातियाँ पाई गई। विविधता को शेनॉन-वियनर इन्डैक्स के द्वारा प्रयोग कर प्रजाति विविधता (एच) की गणना 2.43, जबकि क्रेब का फार्मूला प्रयोग कर प्रजाति संयोजन की गणना 0.678 पाई गई। अरेनेईडे, आक्सीओपीडे, टेट्राग्नेथिडे, थेरीडिडे, लायकोसिडे, थोमिसिडे और साल्टीसीडे से संबंधित कुल 36 विभिन्न प्रजातियों की पहचान की गई।

पश्चिमी महाराष्ट्र के पाँच कृषि-पारिस्थितिकी क्षेत्रों में प्राकृतिक शत्रु कीट अभिलेखित किए गए। *कोक्सीनेल्ला सेपटेमपंकटेटा, मीनोकीलस सेक्समेकुलेटा, हिप्पोडेमिआ वेरीएगेटा, स्किमनस* स्पे., *क्रायसोपर्ला जेस्ट्रोवी सिलेमी* कपास में, *डाइफा एफिडिवोरा, माइक्रोमस इगोरोटस, सिरफिड्स*, और मकडियाँ गन्ने के वूली माहू में, *हे. अर्मिजेरा* पर *केम्पोलेटिस क्लोरीडिए, एकिजलेस्टिस एटोमोसा* लारवों पर *कोटेशिआ* स्पे., *मी. सेक्समेकुलेटा* अरहर में, *नोम्यूरेईआ रिलेई* और *स्पो.* एन पी वी का संक्रमण *स्पो. लिट्यूरा* में सोयाबीन पर, *कोक्सीनेल्ला ट्रान्सवर्सेलिस, मी. सेक्समेकुलेटा, ब्रुमॉयडस सुचुरेलिस* मक्का

में, *स्किमनस कोक्सीवोरा, ट्रायोमेटा कोक्सीडीवोरा* और *ब्रु. सुचुरेलिस* को शरीफा के मिलीबग पर, *एसीरोफेगस पपाये* और *स्यूडलेप्टोमेस्टिकस मेक्सिकाना* पपीते के मिलीबग पर और *मलाडा बोनिनेन्सिस* पपीते की सर्पिलाकार सफेद मक्खी पर *मलाडा* स्पे. मकडियाँ और एन्थोकोरिड, आम के फूदकों पर तथा *ईलेईस सिन्कटा* शहतुत पर, *क्रा. जेस्ट्रोवी सिलेमी* को कपास, मक्का, अरहर तथा *म. बोनिनेन्सिस* को पपीता, अनार और आम पर पाया गया। *क्रिप्टोलीमस* ग्रबों को शरीफा, पपीता और अमरूद के उद्यानों से एकत्र किया गया। सोयाबीन, आलू, अरहर, रिजका में *नोम्यूरिआ रिलेई, मेटारहाईजियम एनाईसोप्लिए, स्पो* एन पी वी, *हे* एन पी वी से ग्रसित *स्पो. लिट्यूरा* और *हे. आर्मिजेरा* के लारवों को एकत्र करके प्रयोगशाला में पृथककरण किया गया (म फु कृ विद्या)।

लद्दाख में, अतिपरजीवीयों के साथ-साथ बीस विभिन्न प्राकृतिक शत्रु कीटों को सेन जोस स्केल, सेब के वुली माहू, *एरीओसोमा लेनिजेरम,* अनभिज्ञ सेब की पत्ती के सुरंगी कीट और कॉडलिंग मौथ *सायडिआ पोमोनेल्ला* से अभिलेखित किया गया।

पंजाब में ई पी एन विविधता का मानचित्र

एकत्रित किए 200 प्रतिदर्शों के परीक्षण में से अमृतसर और संगरूर जिलों से एकत्र प्रतिदर्शों ने *गेलेरीआ* के लारवों में घातकता दर्शायी और इनको ई पी एन से ग्रसित पाया गया (पं कृ वि)।

गन्ने के वुली माहू के ग्रसन की निगरानी और इनके जैविक नियंत्रण पर प्राकृतिक शत्रु कीटों के प्रभाव का मूल्यांकन

पश्चिमी महाराष्ट्र के पाँच कृषीय - परिस्थितिकी क्षेत्रों में गन्ने के वुली माहू का ग्रसन और प्राकृतिक शत्रु कीटों (*डाईफा एफिडिवोरा, माइक्रोमस इगोरोटस, एनकार्सिआ फ्लेवोस्कूटेलम,* सिरफिड, मकड़ी) को अभिलेखित किया गया। पीड़कों के ग्रसन और तीव्रता क्रमशः 0.44 प्रतिशत और 1.39 पाई गई। गन्ने के वूली माहू से ग्रसित क्षेत्रों से मुख्यतः *डा. एफिडिवोरा* (0.5-2.3 लारवा/पत्ती), *मा. इगोरोटस* (1.2-5.1 ग्रब/पत्ती), सिरफिड, *यूपिओडेस कान्फ्रेटीओर* (0.03-1.1 लारवा/पत्ती) और मकडी (0.02-0.5 प्रति पत्ती) परभक्षी कीट पाए गए। परजीवी कीट, *ए. फ्लेवोस्कूटेलम* को पुणे और सतारा जिलों में देखा गया। ये प्राकृतिक शत्रुकीट पश्चिमी महाराष्ट्र के गन्ने के क्षेत्रों में फैल गये और स्थापित होकर गन्ने के वूली माहू का सफलतापूर्वक नियंत्रित करते पाए गए (म फु कृ विद्या)।

तमिल नाडू के विभिन्न कृषीय-परिस्थितिकी क्षेत्रों के, सात प्रमुख जिलों में गन्ना उगाने वाले क्षेत्रों में गन्ने के वूली माहू के ग्रसन और उनके प्राकृतिक शत्रु कीटों का उपलब्धता अभिलेखित की गई। गन्ने के वूली माहू को छोटे-छोटे धब्बों के रूप में देखा गया तथा *ए. फ्लेवोस्कूटेलम, डा. एफिडिवोरा* और *मा. इगोरोटस* पाए गए। दिसम्बर, 2012 के दौरान कोयम्बटूर में 68.2 *एनकार्सिआ*/पत्ती अधिकतम पाए गए। सितम्बर-अक्टूबर, 2012 से जनवरी, 2013 के तक गन्ने के वूली माहू का ग्रसन सभी जगहों पर देखा गया। अक्टूबर, 2012 से जनवरी 2013 के दौरान *डाईफा* और *माइक्रोमस* की सँख्यायें भी देखी गई।

एरी सिल्कवॉर्म अण्डों पर अध्य परपोषी के रूप में उत्पादित *ट्राइकोग्रामा किलोनिस* का गन्ने के अगेती अगोला बेधक के प्रति क्षेत्रीय मूल्यांकन

एरी सिल्कवॉर्म के अण्डों या *कोरसेरा* के अण्डों पर पाले गए *ट्राइकोग्रामा* को 20,000/एकड़ की दर से गन्ने के पोरी बेधक के प्रति क्षेत्रीय मूल्यांकन किया गया। प्रयोगशाला के प्राथमिक अध्ययन दर्शाते हैं कि एरी सिल्कवॉर्म के अण्डों या *कोरसेरा* के अण्डों पर पाले गए *ट्राइकोग्रामा* के परजीवीकरण का अन्तर केवल 5% पाया गया (आ एन जी रंगा कृ वि)।

अनोपचारित खेतों की अपेक्षा एरी सिल्कवॉर्म के अण्डों पर पाले गए *ट्रा. किलोनिस* को 20,000/एकड़ या *कोरसेरा* मौथ के अण्डों पर पाले गए *ट्रा. किलोनिस* को 20,000/एकड़ की दर से छोड़ने पर पोरी बेधको के कारण होने वाले ग्रसन और क्षति की मात्रा को महत्वपूर्ण रूप से कम पाया गया। एरी सिल्कवॉर्म के अण्डों पर पाले गए *ट्रा. किलोनिस* को 20,000/एकड़ की दर से छोडने पर पोरी बेधक ग्रसन महत्वपूर्ण रूप से कम (5.4%) पाया गया जबकि *कोरसेरा* के अण्डो पर पाले गए *ट्रा. किलोनिस* को 20,000 एकड़ की दर से छोडने पर पोरी ग्रसन (7.2%) पाया गया। अनोपचारित क्षेत्र में पोरी बेधक का ग्रसन अधिक (21.8%) पाया गया (त कृ वि)।

विविधिता निगरानी और *बीटी* कपास में रस चूसने वाले पीड़कों, मिरिडों और उनके प्राकृतिक शत्रु कीटों की उपलब्धता

कर्नाटक में *बीटी* कपास की फसल में, चूसने वाले अनेक कीट पीडकों में से पर्णफूदकों की अधिकतम सँख्या सितम्बर-अक्टूबर के दौरान और अगस्त के दौरान सामान्यतः कम पाई गई। थ्रिप्स की सँख्या अगस्त में अत्यधिक और दिसम्बर के दौरान न्यूनतम पाई गई। मौसम के दौरान सामान्यतः सफेद मक्खियों की सँख्या कम पाई गई। दिसम्बर में, मिरिडबग की सँख्या अधिकतम पाई गई। इसी प्रकार, दिसम्बर के पहले सप्ताह मे मिलीबग की सक्रियता पाई गई और जनवरी तक लगातार सक्रियता देखी गई तथा परजीवी कीटों की अत्यधिक सक्रियता जनवरी के दूसरे सप्ताह में देखी गई (कृ वि वि-रायचूर)।

धान के पीडकों और रोगों के प्रति आई पी एम का मूल्यांकन

अरूणाचल प्रदेश के ईस्ट सिआंग जिले के तीन स्थानों पर मूल्यांकन किया गया। आई पी एम अपनाए गए खेत में तना बेधकों का ग्रसन (2.37 प्रतिशत सफेद बाली शीर्ष) की तुलना किसान के द्वारा अपनाई प्रकिया (1.41 प्रतिशत सफेद बाली शीर्ष) से की गई। दो उपचारों की तुलना में, अनोपचारित क्षेत्र में धान के गंधी बग का ग्रसन महत्वपूर्ण रूप से अधिक पाया गया। सीले में, किसान द्वारा अपनाई गई प्रक्रिया में दानों की अत्यधिक उपज 46.55 कु./हे. और यह आई पी एम अपनाए क्षेत्र की उपज के काफी नजदीक उपज (43.65 कु./हे.) पाई गई। इसी प्रकार मेबो मे भी, किसान द्वारा अपनाई गई प्रक्रिया में दानों की उपज (42.51 कु./हे.)को आई पी एम अपनाई गई प्रक्रिया की उपज (40.66 कु./हे.) के तुल्य पाया गया। यद्यपि, पासीघाट में, आई पी एम अपनाई प्रक्रिया में उपज (40.37 कु./हे.) प्राप्त हुई जबकि किसान द्वारा अपनाई गई प्रक्रिया में महत्वपूर्ण रूप से उपज अत्यधिक (43.84 कु./हे.) प्राप्त हुई (केन्द्रीय कृ वि)।

दलहनी और तिलहनी फसलों के पीड़कों का जैविक नियंत्रण

एन बी ए आई आई द्रवीय नियमनों (पीडीबीसी-बीटी 1 और एन बी ए आई आई - बी टी जी 4) और आई ए आर आई *बीटी* का अरहर के फली बेधक (*हेलीकोवपा आर्मिजेरा*) और दलहनी फली बेधक (*मेरूका टेस्टुलेलिस*) के प्रति मूल्यांकन में ज्ञात हुआ कि, अनोपचारित प्लॉट की अपेक्षा 5 केन्द्रों पर सभी उपचारित प्लॉटों मे *हे. आर्मिजेरा* के लारवों की सँख्या महत्वपूर्ण रूप से न्यूनतम पाई गई। पीडकों के ग्रसन को नियंत्रण करने के लिए सभी सूक्ष्मजीवी कीटनाशकों को एकसमान, प्रभावी पाया गया, यद्यपि, जब पी डी बी सी - बी टी जी 4, पी डी बी सी - बी टी जी 1 और आई ए आर आई *बीटी* को 2% सान्द्रता के साथ छिड़काव किया गया तब तुलना में *हे. आर्मिजेरा* के लारवों की सँख्या उनसे भी कम पायी गयी। सभी परिणामों को मिलाकर देखने पर उपरोक्त उपचारों में फली क्षति के हिसाब से उत्कृष्ट परिणाम मिले। सभी *बीटी* आधारित सूक्ष्मजीवी कीटनाशक के प्रयोग से दानों की क्षति का

विस्तार 7.62 से 10.77% पाया और इसको एक समान पाया गया।

कुसुम के माहू, *यूरोल्यूकोन कम्पोजिटे* का जैविक नियंत्रण

आन्ध्र प्रदेश में, माहू की सँख्या को कम करने के लिए *मेटारहाजियम एनाईसोप्लिए* और *ब्यूवेरिआ बेसीआना* की अपेक्षा *वर्टिसिलियम लेकेनी* के प्रयोग को श्रेष्ठ पाया गया। आन्ध्र प्रदेश में, *व. लेकेनी* को नीम के तेल के समान प्रभावी पाया और इन दोनों को मिलाकर प्रयोग करने पर कीटनाशकों के समान पाया गया, जिसके परिणाम स्वरूप माहू की सँख्या न्यूनतम (65-123 माहू/10 पौधे) तथा उपज अत्यधिक (469-509 किग्रा./हे.) प्राप्त हुई। अनोपचारित प्लॉट में, माहू की सँख्या अधिकतम (413-435 माहू/10 पौधे) और उपज न्यूनतम (245 किग्रा./हे.) प्राप्त हुई (आ एन जी रंगा कृ वि)।

मूँगफली के पीडकों का जैविक नियंत्रण

कीटनाशकों के उपचार करने पर सभी दशाओं में *स्पो. लिट्यूरा*, पत्ती सुरंगी कीट और बालों वाली सूँडी का क्रमशः 0.7, 0.4 और 0.1 लारवों के साथ पीड़कों की सँख्या न्यूनतम अभिलेखित की गई। *स्पो. लिट्यूरा* के मामले में *स्पो.* एन पी वी के उपचार में (0.9) जबकि कीटनाशी उपचार में (0.7) पाया गया और उपचार एक समान पाया। पत्ती सुरंगी कीट के प्रति *बीटी* उपचार (0.9), कीटनाशी उपचार (0.4) के साथ पुनः एक समान पाया तथा इसके बाद *ट्राइकोग्रामा* (2.7) एवं नीम बीज कर्नेल अर्क (2.9) पाए गए। बालों वाली सूँडी के मामले में, कीटनाशी के उपचार में पीडक ग्रसन न्यूनतम (0.1) इसके बाद *बीटी* (0.4) और नीम बीज कर्नेल अर्क (0.6) अभिलेखित किए गए। कीटनाशी उपचार में उपज अत्यधिक (21.17 कु./हे.) इसके बाद *बीटी* से उपज (18.97 कु./हे.) प्रप्त गई। *ट्राइकोग्रामा* को खेत में छोड़ने से भी अच्छी उपज (17.28 कु./हे.) पाई गई। अनोपचारित प्लॉटो से उपज केवल 7.98 कु./हे. प्राप्त हुई (ओ कृ प्रौ वि)।

सोयाबीन पीडकों के प्रति कीटरोगाण्विकों और वानस्पतिकों का मूल्यांकन

स्पो एन पी वी का 250 एल ई/हे. (1.5 x 10^{12} पी ओ बी/हे.) की दर से प्रयोग करने पर *स्पो. लिट्यूरा* (3.0 लारवे/मी. पंक्ति में) में विषाणु के संक्रमण के कारण 78.5 प्रतिशत घातकता के द्वारा महत्वपूर्ण रूप से लारवों की सँख्या को नियंत्रित किया और सोयाबीन की अत्याधिक उपज 21.6 कु./हे. प्राप्त हुई।

केरल में, नारियल की पत्ती की सूँडी, *ओपीसिना एरेनोसेल्ला* का अनुवीक्षण और आवश्यकता अनुसार नियंत्रण

पुथियाविला (त्रिवेन्द्रम) में *ओपीसीना एरेनोसेल्ला* का 59.6% पत्ती पर ग्रसन के साथ मध्यम स्तर का ग्रसन पाया गया तथा इनकी संख्या 141/100 पत्रक पायी गई। परजीवी प्रजनन केन्द्र, त्रिवेन्द्रम और कृषि विभाग, केरल के सहयोग से क्षेत्र में जागरूकता अभियान आयोजित किया गया। निरंतर निगरानी और परजीवी कीट छोड़ने के परिणाम स्वरूप 7 महीनों में, पत्तीक्षति 55.7% की कमी और पीडकों की सँख्या में 94% तक की कमी पाई गई। कल्लारा (कोट्टायाम) क्षेत्र में अगस्त 2012 के दौरान 83.4% पत्ती ग्रसन और पीड़क सँख्या 288/100 पत्रकों के माध्यम से *ओ. एरेनोसेल्ला* की उपस्थिति क्षेत्र में देखी गई। क्रमवार निगरानी और परजीवी कीटों जैसे *गोनीओजस निफेन्टिडिस* और *ब्रेकोन ब्रेविकोर्निस* को क्षेत्र में छोड़ने के परिणाम स्वरूप सात महीनों में पत्ती की क्षतिग्रस्तता कम (42%) और पीड़क सँख्या कम (93%) करने में सफलता पाई (के फ रो अनु सं)।

आम के फूदकों के प्रति *मेटारहाईजियम एनाईसोप्लिए* का क्षेत्रीय मूल्यांकन

आन्ध्र प्रदेश और महाराष्ट्र राज्यों में, बिन मौसम में दिसंबर माह के दौरान *मे. एनाईसोप्लिए* को 1 x 10^{9} बीजाणु/मिली. की दर छिडकाव इसके बाद रोगाणु को

आलंगन (सूरजमुखी का तेल 1 मिली/ली + ट्रायटोन - x 100 को 0.1 मिली./ली. की दर से) मिलाकर फूल आने के समय साप्ताहिक अन्तरालों पर चार बार छिडकाव करने पर फूदकों की सँख्या को नियंत्रण और फल लदान बढाने के लिए अन्य उपचारों की अपेक्षा उत्कृष्ट पाया गया।

शरीफा पर मिलीबग, *मेकोनेलीकोकस हिर्सुटस* और *फेरीसिआ विरगेटा* का *स्किमनस कोक्सीवोरा* द्वारा जैविक नियंत्रण

जुलाई-अगस्त 2012 के दौरान शरीफा उद्यान में *स्किमनस कोक्सीवोरा* को 10 ग्रब प्रति ग्रसित वृक्ष की दर से मासिक अन्तराल पर दो बार छोड़ने पर *मे. हिर्सुटस* (9.8 मिलीबग/फल) और *फे. विरगेटा* (3.3 मिलीबग/फल) की सँख्या को नियंत्रण करने के लिए महत्वपूर्ण रूप से उत्कृष्ट पाया गया तथा फलों की बाजार योग्य उपज भी बढ़ी (34.1 किग्रा./वृक्ष) पाई गई। यद्यपि, ये परिणाम *क्रिप्टोलीमस मोन्ट्रयूजिएरी* को 5 ग्रब प्रति ग्रसित वृक्ष की दर के समान पाए गए। इन उपचारों के परिणाम स्वरूप उद्यानों में पीडकों की तीव्रता दर न्यूनतम (1.0-1.1) अभिलेखित की गई।

पपीता उत्पादन, बीजोत्पादन, पपेन उद्योग, शहतुत और टेपिओका पर *एसीरोफेगस पपाऐ* के छोड़ने के प्रभाव का आर्थिक विश्लेषण

2012-13 के दौरान किसान के खेत में, पपीते, टेपीओका और शहतुत पर पपीते के मिलीबग का नियंत्रण करने के लिए परजीवी कीट *एसीरोफेगस पपाऐ* द्वारा जैविक नियंत्रण के आर्थिक विश्लेषण में 714.55 करोड रूपये की बचत होने के परिणाम प्राप्त हुए। यह बचत पपीते, टेपिओका और शहतुत में क्रमशः 59.95, 514.5 और 140 करोड रूपए पाई गई।

सेब के कोडलिंग मौथ, *सायडिआ पोमोनेल्ला* के प्रति *ट्राइकोग्रामा एम्ब्रियोफेगम* के अधिक मात्रा में छोड़ने का क्षेत्रीय मूल्यांकन

कश्मीर में *ट्राइकोग्रामा* स्पे. को 2500-3000 प्रौढ़ कीट/वृक्ष की दर से दो बार क्रमवार छोड़ना तथा फेरोमोन प्रपंच को चार प्रपंच प्रति उद्यान की दर से दो बार प्रयोग करने पर उपचारित प्लॉट में सेब की फल क्षति (पेड़ पर + टूट कर गिरे) की औसत विस्तार 56.8 और 70.2 प्रतिशत के बीच पाई गई जबकि अनोपचारित प्लॉट में, यह प्रतिशत 79.5 पाया गया।

हिमाचल प्रदेश में, सेब के जड बेधक, *डोरीस्थेनस ह्यूजेलाई* का क्षेत्रीय दशाओं में कीटरोगाण्विक कवक और ई पी एन द्वारा नियंत्रण के मूल्यांकन में पाया गया कि क्लोरपायरीफॉस (0.06%) द्वारा ग्रब की घातकता अत्यधिक (86.4%) इसके बाद *मेटारहाईजियम एनाईसोप्लिए* (10^6. कोनिडिआ/सेमी^{2}) द्वारा घातकता (74.4%) पाई गई। अन्य जैवकीटनाशक जैसे *ब्यूवेरिआ बेसीआना* (10^6 कोनिडिआ/सेमी^{2}), *हेटेरोरहाब्डिटिज ईन्डिका* और *स्टेईनर्नेमा कार्पोकेप्से* (80 आई जे/सेमी^{2} प्रत्येक) काफी हद तक सेब के जड बेधक के प्रति प्रभावी पाए गए, इसके परिणामस्वरूप ग्रबों की घातकता क्रमशः 34.0, 45.9 और 34.9 प्रतिशत पाई गई जबकि अनोपचारित क्षेत्र में केवल 8.5 प्रतिशत ही पाई गई।

कोल फसलों के पीड़कों के लिए जैव प्रबल आई पी एम पैकेज का विकास

असम में, बी आई पी एम पैकेज अपनाए गए क्षेत्र में रोपाई के 55 दिनों के बाद (तीसरे छिड़काव) *पीएरिस ब्रेसीके* और डी बी एम की सँख्या को 2.45 से 1.34 और 4.85 से 1.94 लारवे तक महत्वपूर्ण रूप से कम किया गया जबकि किसान द्वारा अपनाई गई प्रक्रिया में क्रमशः 2.6 से 1.4 और 4.65 से 1.97 लारवे पाए गए। आई

पी एम पैकेज वाले क्षेत्र में अत्यधिक उपज (169.9 कु./हे.) जो कि किसान प्रक्रिया वाले क्षेत्र से (163.7 कु./हे.) महत्वपूर्ण रूप से उत्कृष्ट पाई गई।

कश्मीर की घाटी में गाँठ गोभी में, डी बी एम के प्रति *ट्रा. किलोनिस* और *ट्रा. ब्रेसीके* के प्रयोग से डी बी एम के लारवों में कमी का दोनों प्रयोग की गई प्रजातियों के प्रत्येक बार में छोड़ने पर महत्वपूर्ण रूप से अन्तर दिखाई दिया। सबकुछ मिलाकर *ट्रा. किलोनिस* और *ट्रा. ब्रेसीके* के कारण लारवो की सघनता में क्रमशः 33.7 और 20.1 प्रतिशत की कमी पाई गई जो इस बात का सूचक है कि *ट्रा. किलोनिस* की प्रधानता *ट्रा. ब्रेसीके* से अधिकतम है।

महाराष्ट्र में टमाटर की फसल पर *हे. आर्मिजेरा* के प्रति *ट्राइकोग्रामा प्रेटीओजम* के विभेदों थेलाईटोकोअस और आरहेनोटोकोअस का क्षेत्रीय मूल्यांकन

परजीवी कीट के आरहेनोटोकोअस विभेद की तुलना में, *ट्रा. प्रेटीओजम* थेलाईटोकोअस विभेद को 1 लाख परजीवी कीट/हे. की दर से साप्ताहिक अन्तराल पर छः बार छोडने पर *हे. अर्मिजेरा* को नियंत्रित (1.9 लारवे/10 पौधे) करने के लिए महत्वपूर्ण रूप से उत्कृष्ट पाया गया और टमाटर की बाजार योग्य फल उपज (223.5 टन/हे.) को बढ़ाया। परजीवी कीट के विभेद थेलाईटोकोअस द्वारा परजीवीकरण अत्यधिक (56.2%) जबकि विभेद आरहेनोटोकोअस द्वारा परजीवीकरण कम (46.5%) पाया गया।

बैंगन के शाखा और फल बेधक *लियुसिनोड्स ओरबोनेलिस* के प्रति विभिन्न बी आई पी एम मोड्यूल्स का मूल्यांकन

प्रोफेनोफॉस (0.05%) का पन्द्रह दिनों के अन्तराल पर तीन छिडकाव करने पर शाखा (9.0%) और फल (9.6%) ग्रसन को कम करने के लिए महत्वपूर्ण रूप से उत्कृष्ट पाया गया और बाजार योग्य उपज (228.7 कु./हे.) अधिकतम प्राप्त हुई। यद्यपि, बी आई पी एम के दूसरे अन्य मोड्यूल में, *ट्रा. किलोनिस* छोडने के बाद एन एस के ई 5% और *बीटी* को 1 ली./हे. की दर से साप्ताहिक अन्तराल पर दो बार प्रयोग करना पहले मोडयूल के बाद श्रेष्ठ उपचार पाया गया जिसके माध्यम से शाखा 9.9% और फल 15.3% ग्रसित के साथ-साथ परजीवीकरण 42.5% पाया गया (म फु कृ विद्या)।

शाखा बेधकों का ग्रसन सबसे कम कीटनाशी उपचार में अभिलेखित किया गया। अनेक स्थानों पर रैनाक्सीपायर के द्वारा उपचार करने पर शाखा बेधक का ग्रसन विस्तार 8.8 से 11.6% पाया गया। यद्यपि, बी आई पी एम उपचार का सभी स्थानों पर शाखा बेधक ग्रसन विस्तार 11.4 से 12.8% के साथ रैनाक्सीपायर के समान ही पाया, जबकि अनोपचारित प्लॉट में, यह ग्रसन विस्तार 29.3 से 29.9% पाया गया। अनोपचारित प्लॉट में, फल क्षति 36.0 से 39.7% अभिलेखित की गई (ओ कृ प्रौ वि)।

बैंगन और भिण्डी में माईट, *टेट्रानिकस उर्टिके* के प्रति एन्थोकोरिड परभक्षी कीट *ब्लाप्टोस्टेथस पेलेसेन्स* का मूल्यांकन

पंजाब में, बैंगन की फसल में माइट की सँख्या को न्यूनतम रखने के लिए *ब्ला. पेलेसेन्स* को 10, 20 और 30 निम्फ/पौधा की दर से छोड़ने की सभी मात्राओं को एक समान और अनोपचारित क्षेत्र की तुलना मैं श्रेष्ठ विधि पाया गया। प्रारम्भ में माइट की सँख्या 63.5-69.0/पौधा थी, जिसको घटाकर 14.1-31.3/पौधा तक किया गया। यद्यपि, ओमाईट को 300 मिली./पौधा की दर से प्रयोग करना, *ब्ला. पेलेसेन्स* को प्रति पौधा छोड़ने और अनोपचारित प्लॉट से श्रेष्ठ पाया गया। ओमाईट से उपचारित क्षेत्र में माईट की सँख्या 1.0-1.6 माईट/पौधा तक कम किया। पोलीहाऊस में बैंगन पर *टे. उर्टिके* के नियंत्रण के लिए आई पी एम के अन्तर्गत *ब्ला. पेलेसेन्स* के साथ ओमाईट/ए. को

भी शामिल किया जा सकता है। भिण्डी में माईट की सँख्या कम करने के लिए *ब्ला. पेलेसेन्स* को 30 निम्फ/पौधा की दर से छोड़ना उत्कृष्ट (11.40 माईट/पौधा) और यह *ब्ला. पेलेसेन्स* को 20 निम्फ/पौधा की दर से छोड़ने के समान ही परिणाम (17.80 माईट/पौधा) पाए गए। इन दोनों जैव कारको को छोड़ना, भी ओमाईट (9.53 माईट/पौधा) के समान महत्वपूर्ण पाया गया।

संरक्षित दशा में कार्नेशन फसल में माईट के प्रति जैविक नियंत्रण कारकों का मूल्यांकन

जैवनियंत्रण कारकों में से कोक्सीनेलिड बीटल, *स्टेथोरस पाउपेरकुलस* और परभक्षी माईट, *एम्बलीसीअस* स्पे. को क्रमशः 10 और 5 माईट/पौधा की दर से छोड़ने पर दो धब्बेदार वाली मकड़ी माईट, *टेट्रानीकस उर्टिके* को प्रभावी ढ़ंग से कम करती है और दोनों को लगभग एक समान प्रभावी पाया गया, इसके बाद *ब्यूवेरिआ बेसीआना* का 10^8 सी एफ यू/मिली. का छिड़काव प्रभावी पाया गया। यद्यपि, जितने भी अन्य उपचारों का मूल्यांकन किया गया उनमें से मानक एकेरीसिडे, एबेमेसीटिन 1.9 ई सी का 0.3 मिली./लीटर की दर से दो छिड़काव करने पर माईट की सँख्या को महत्वपूर्ण रूप से कम (1.3/10 पौधे) किया गया। दूसरे उपचार के 7 दिनों के बाद अनोपचारित दशा में माईट की सँख्या 78/10 पौधों के रूप में अत्यधिक अभिलेखित की गई। एबेमेसीटिन से उपचारित प्लॉट में 2465 पुष्पक्रम की संख्या/प्लॉट प्राप्त हुई, इसके बाद *स्टेथोरस, एम्बलीसीअस* स्पे., *ब्यूवेरिआ बेसीआना* जैवनियंत्रण उपचारित प्लॉट से प्राप्त हुई। अनोपचारित प्लॉट से न्यूनतम उपज, केवल 1540 किग्रा. प्राप्त हुई (त कृ वि)।

पॉली हाऊस में कार्नेशन फसल पर फाईटोफेगस माईट के प्रति परभक्षी कीट माईट, *नीओसेईयुलस लोन्गिस्पाईनोसस* का मूल्यांकन

परिणाम दर्शाते हैं कि, अनोपचारित की अपेक्षा प्रोफेनोफॉस (0.05%) का उपचार अत्यन्त प्रभावी है जिसके परिणाम स्वरूप माईट की सँख्या 87.5% प्रतिशत कम पाई गई, जो कि साँख्यिकी रूप में *नी. लोन्गिस्पाईनोसस* को 1:10 परभक्षी कीटः भक्षित के अनुपात में तीन बार छोडने पर 73.8 प्रतिशत तक कम कर देता है। अन्य जैवनियंत्रण कारकों जैसे नीम बाण (3 मिली./ली.) और *नी. लोन्गिस्पाईनोसस* को 1:20 तथा 1:30 परभक्षी कीटः भक्षित के अनुपात में छोड़ने के परिणाम स्वरूप अनोपचारित की अपेक्षा माइट की सँख्या अनेपचार की अपेक्षा क्रमशः 62.3, 69 और 62 प्रतिशत की कमी करता है। साँख्यिकी रूप से इन सभी उपचारों को आपस में एक दूसरे के समान पाया गया और *नी. लोन्गिस्पाईनोसस* का 1:10 परभक्षीः भक्षित के अनुपात को भी इन्हीं के समान ही पाया गया (य सि प बा वा वि)।

4. INTRODUCTION

Brief History

The All India Co-ordinated Research Project on Biological Control of Crop Pests and Weeds was initiated in the year 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 (1979), 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 period with the up-gradation of the centre to Project Directorate of Biological Control (PDBC) with headquarters at Bangalore with effect from 19th October 1993. In the XI plan, the PDBC has been reoriented into National Bureau of Agriculturally Important Insects (NBAII) on the 25th June, 2009. The AICRP has centres based in 15 agricultural universities and 7 ICAR institutes.

Notable achievements in the past

Basic Research

- Many species of ladbird beetles are efficient predators of aphids, mealybugs and scales. *Henosepilachna verriculata* Pang & Mao, a phytophagous species was recorded for the first time from Manipur. *Synonychimorpha chittagongi* (Vaziran) (Tripura), *Ortalia vietnamica* Hong (Himachal Pradesh), *Illeis confusa* Timberlake (Manipur and Jammu & Kashmir) and *Serangium chapini* (Kapur) (Assam) were recorded from several parts of India.
- A coccinellid beetle, *Sticholotis magnostriata* Poorani was described from Assam.
- *Trichogramma achaeae* and *Trichogrammatoidea bactrae* were recorded from Andaman islands. A single specimen of *Trichogramma* belonging to the *nomlaki/ drepanophorum* group was collected from Bhubaneshwar.
- *Microterys chaetococci* Hayat & Poorani (Encyrtiade) a parasitoid of *Chaetococcus* sp. on bamboo was described from Karnataka.
- Two new species of *Trichogrammatoidea, viz., T. rufomaculata* Nagaraja & Prashanth and *T. brevicaudata* Nagaraja & Prashanth were described from Karnataka.
- *Odontacolus markadicus* Veenakumari and Rajamohana was described from southern India.
- DNA barcodes were generated for *Trichogramma rabindrai, T. japonicum, Trichogrammatoidea armigera, T. agriae, Apanteles galleriae, Apanteles hyposidrae* and *Fornicia ceylonica.*
- One thousand two hundred and thirty six specimen of insects belonging to orders such as Thysanoptera, coccids, Aphididae, Syrphidae, Tachinidae, Tepritidae, Coccinellidae and parasitic Hymenoptera were identified during 2011–12.
- Insect germplasm information system, an online computer tool was developed for providing information about live insect genetic resources and the insectaries maintaining those cultures.
- The culturable microflora from the guts of *Plutella xylostella*, *Trichogramma* spp., *Chrysoperla zastrowi sillemi* and *Cotesia plutellae* were identified using 16s RNA.
- Ninety-four exotic natural enemies (NEs) have been studied for utilization against

alien pests, out of which 62 could be successfully multiplied in the laboratory, 52 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, *Acerophagus papayae*, introduced from Peurto Rico in 2010, has successfully controlled the papaya mealybug, *Paracoccus marginatus* infesting papaya, tapioca, mulberry, sunflower, cotton and several crops plants in south India. The economic benefits accrued through the introduction was estimated to be around Rs. 1500 crores.
- *Trichogramma brassicae*, an egg parasitoid, introduced from Canada was successfully quarantined and found suitable for the biological control of *Plutella xylostella* on cole crops recording more than 90% parasitization.
- The sugarcane woolly aphid, *Ceratovacuna lanigera* has been successfully managed by the deployment of two predators, *Dipha aphidivora* and *Micromus igorotus* and one parasitoid, *Encarsia flavoscutellum*.
- The eulophid parasitoid. *Quadrastichus mendeli* introduced from Israel in 2009 has successfully established and is suppressing populations of the eucalyptus gall wasp, *Leptocybe invasa.*
- The chrysopid predator, being reported as *Chrysoperla carnea* from India has now been identified as *Chrysoperla zastrowi sillemi* through acoustic analysis of mating calls.
- DNA barcode for the invasive pest, coconut leaf beetle *Brontispa longissima* was generated for the first time in the world for the rapid identification of the pest in the event of invasion into our country.
- URL: http://www.nbaii.res.in/Featured%20 insects/featured–insects.html-Factsheets on agriculturally important insects. (for 155 species of common bioagents, invasives, and pests)
- URL: http://www.nbaii.res.in Introductions/ Insects/index.htm-Biocontrol introductions. (for ~185 species of introduced bioagents in India)
- 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 – Web photo album on aphids of Karnataka was hosted - URL: aphids www.aphidweb.com.
- Improved laboratory techniques were developed for the multiplication of 27 egg parasitoids, 7 egg–larval parasitoids, 42 larval/nymphal parasitoids, 25 predators and 7 species of weed insects.
- *Sitotroga cerealella* eggs proved to be the most suitable for rearing *Orius tantillus* and *Corcyra cephalonica* eggs for *Blaptostethus pallescens*.
- 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 *Helicoverpa 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. The technology was 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. Field tests have shown encouraging results.
- Kairomones from scale extracts of *H. armigera* and *C. cephalonica* increased the predatory potential of chrysopids.
- Talc-based formulation of *Bacillus megaterium* has been developed for the management of bacterial wilts of tomato and brinjal caused by *Ralstonia solanacearum*.
- Isolates of *Trichoderma harzianum* tolerant to carbendazim and salinity with good biocontrol potential against four important plant pathogens have been identified.
- 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.
- The bacterial antagonist, *Pseudomonas cepacia* (strain N 24), successfully suppressed *Sclerotium rolfsii* in sunflower rhizosphere as seed inoculum.
- 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.
- *Bacillus thuringiensis* isolate PDBC-BT1 caused 100% mortality of first instars of *Plutella xylostella*, *Chilo partellus* and *Sesamia inferens*. *Bacillus thuringiensis* isolate PDBC-BNGBT 1 caused complete mortality of *Helicoverpa armigera*.
- DVD films of short duration were produced on classical biological control of papaya mealybug, management of sugarcane woolly aphid, management of rice insect pests and diseases through BIPM module, management of coconut black headed caterpillar, mass production and use of predatory coccinellids, mass production and delivery of *Trichoderma* spp., mass production and use of trichogramma egg parasitoids.
- Licensing of know how/product of *in–vivo* production, downstream processing and development of wettable powder formulation of entomopathogenic nematode, *Heterorhabditis indica* strain NBAII Hi1 and field use for biological control of white grubs to three companies each for 2 lakhs on non-exclusive basis.

- Licensing of know-how/product of technology for liquid formulation of *Bacillus thuringiensis* to one company for 2 lakhs on non-exclusive basis.

Successes in Biocontrol

- 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 effective against sugarcane white grubs.
- *Encarsia flavoscutellum, Micromus igorotus* and *Dipha aphidivora* effectively controlled the sugarcane woolly aphid, which is adequatly kept under suppression.
- Application of *Heterorhabditis indica* @ 2.0 billion IJs/ha resulted in minimum population of white grubs in sugarcane.
- Biocontrol-based IPM (BIPM) modules consisting of use of moderately resistant variety, *Trichoderma 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 yield and net profit in the Kerala.
- IPM module comprising of need-based use of insecticide 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. zastrovi sillemi* and *Nomuraea rileyi* (@ 10^{13} spores/ha) for the management of *Helicoverpa armigera* on tobacco were effective.
- *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, *Pulvinaria psidii, Ferrisia virgata* on guava*, Maconellicoccus hirsutus* on grapes and *Rastrococcus iceryoides* on mango.
- Efficacy of *Trichogramma, Cryptolaemus, C. zastrowi sillemi, Ha*NPV and *Sl*NPV has been successfully demonstrated in Punjab, Andhra Pradesh, Karnataka, Maharashtra, Gujarat and Tamil Nadu.

- *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.
- *Trichogramma brassicae* 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 the potato tuber moth in storage.

Mandate

National Bureau of Agriculturally Important Insects
To act as a nodal agency for collection, characterization, documentation, conservation, exchange and utilization of agriculturally important insect resources (including mites and spiders) for sustainable agriculture.
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 NBAII is organized into three divisions *viz.,* Division of Insect Systematics, Molecular Entomology and Insect Ecology. Research on microbial biocontrol is being addressed under the coordinating cell of the AICRP on Biological Control (Fig. 1).

Financial Statement (2012-13) (Rs. in lakhs)

National Bureau of Agriculturally Important Insects, Bangalore

Head	Plan	Non-plan	Total
Pay & allowances	---	525.15	525.15
TA	11.99	3.58	15.57
Other charges including equipment-Lib.	142.23	95.82	238.05
Information Technology	----	2.75	2.75
Works/petty works	3.00	14.00	17.00
HRD	**0.77**	**----**	**0.77**
Pension	----	2.26	2.26
Loan	------	1.05	1.05
Total	**157.99**	**644.61**	**802.60**

AICRP Centres (ICAR share only) expenditure (2012-13)

Name of the centre	Expenditure (Rs. in lakhs)
AAU, Anand	44.73
AAU, Jorhat	34.80
ANGRAU, Hyderabad	33.93
Dr.YSPUH&F, Nauni, Solan	26.03
GBPUA&T, Pantnagar	0.00
KAU, Thrissur	25.43
MPKV, Pune	32.80
PAU, Ludhiana	46.24
SKUAS&T, Srinagar	21.58
TNAU, Coimbatore	29.84
PC Cell, Bangalore	9.76
MPUAT, Udaipur	1.50
JNKVV, Jabalpur	0.00
OUAT, Bhubaneshwar	3.82
CAU, Manipur	0.93
Total	**311.39**

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 budget of the institutes.

ORGANISATIONAL CHART

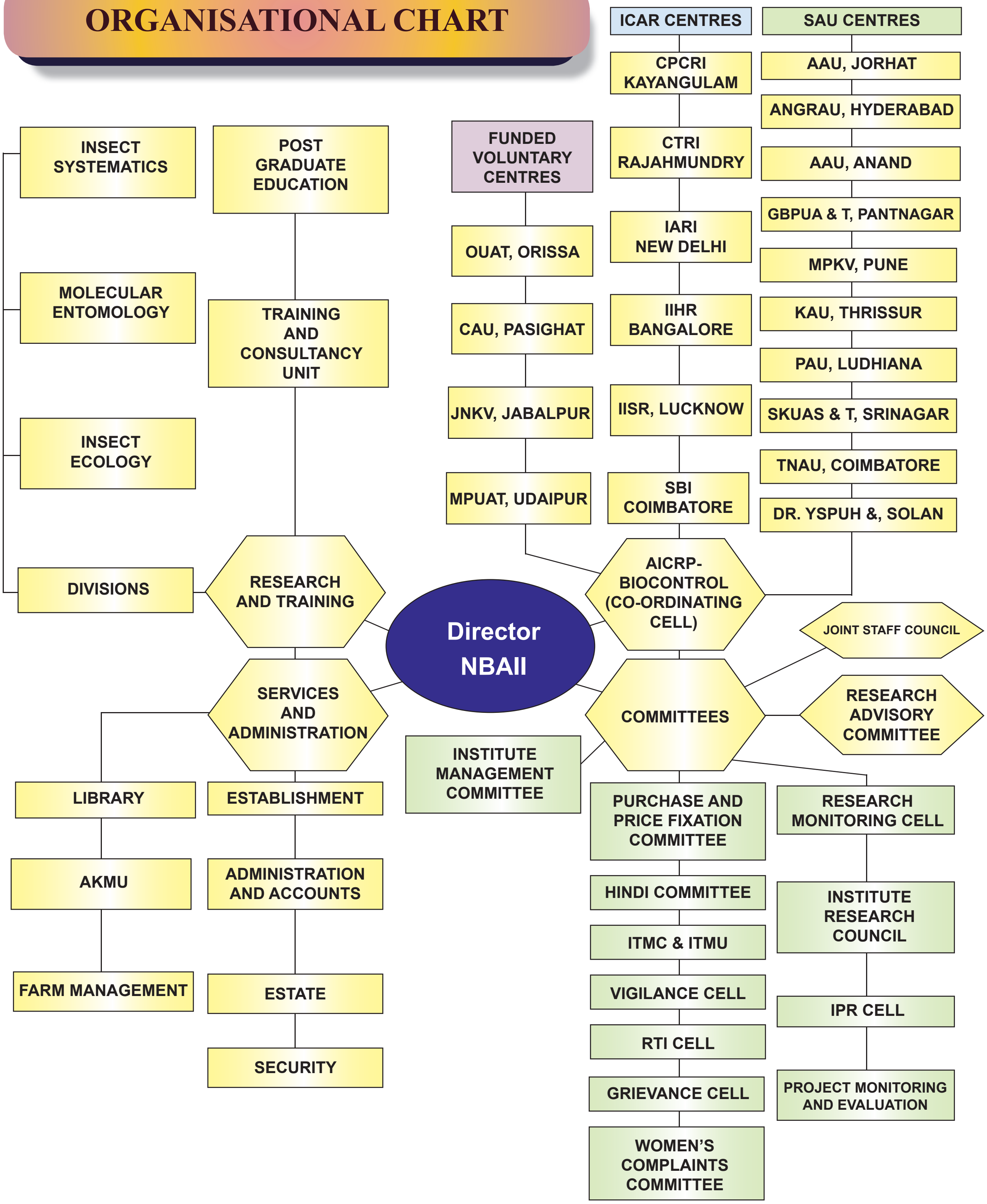


Fig. 1. The Organisational Chart of NBAII

5. RESEARCH ACHIEVEMENTS

National Bureau of Agriculturally Important Insects

Division of Insect Systematics

Systematizing knowledge on the systematics and diversity of important species of insects is a major mandate of NBAII. The Division of Insect systematics created with the mandate of augmenting the collection and cataloguing the insect diversity of specified groups of insects has been carrying out taxonomic studies and cataloguing insects in orders such as Hymenoptera, Coleoptera, Hemiptera and Diptera. The division has not only developed taxonomic expertise in these groups but also provided identification services of insects belonging to selected groups to both national and international institutes.

Survey

Explorative surveys were carried out in different parts of the country, with emphasis on less explored areas like Andaman & Nicobar Islands, southern & western India as well as other parts of India with the specific objective of documenting insects belonging to Hymenoptera, Coleoptera, Hemiptera and Diptera. The areas surveyed in these regions were (i) South India: Andhra Pradesh (Hyderabad), Tamil Nadu (Kotagiri and Ootacamund) and Karnataka (Balehonnur, Mudigere, Chikkabelegere, Kudregundi, Tumkur, Anekal, Mandya, Bengaluru, Mysore, Chintamani, Chikkaballapur, Nandi Hills, Chintamani and Doddaballapur), (ii) Western India: Maharashtra (Nasik, Kohlapur, Panhala). Urban areas were surveyed for these insects.

New distribution records

Order Hymenoptera

The order Hymenoptera comprises important groups of parasitic insects as well as pollinators. Collections of insects belonging to Trichogrammatidae, Pteromalidae, Eucharitidae and Braconidae were made during 2012–13.

Family: Trichogrammatidae

Collection of host insect eggs, laying of sentinel cards, yellow pan traps and pit fall traps was done for the collection of trichogrammatids.

Several species of trichogrammatids were recorded from Andaman Islands, Karnataka and Maharashtra. *Trichogramma rabindrai* from fallow agricultural fields and *Trichogrammatoidea bactrae* from citrus orchards were collected from the Andaman Islands. This is the first record of *Trichogramma rabindrai* from outside Karnataka / Madhya Pradesh. This is also the first record of *T. bactrae* from the eggs of *Prosotas nora* (Lepidoptera: Lycaenidae) on citrus. In addition to morphological studies, *Trichogramma rabindrai* and other new species were studied from a molecular perspective (Fig. 2).

A total of 132 crosses were made to determine the specific status of species of *Trichogramma* which were morphologically similar. Two cultures which failed to interbreed are being studied taxonomically.

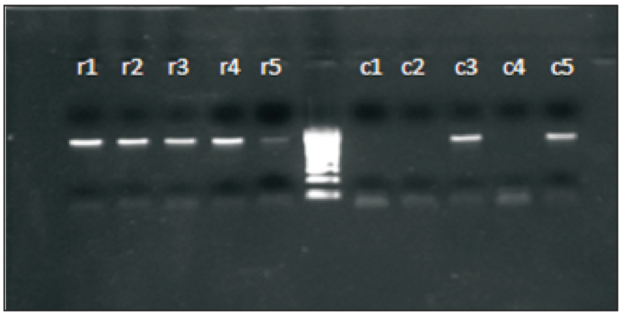


Fig. 2. PCR products of CO1 gene of *Trichogramma rabindrai* (Lanes r1r5) and *Trichogramma* sp. nov. (Lanes c1-c5)

Biosystematics and diversity of economically important Indian Microgastrinae (Braconidae) supported by molecular phylogenetic studies

Species belonging to the subfamily Microgastrinae (Braconidae) are larval endoparasitoids of different lepidopteran insect pests. During 2012–13, 12 new species belonging to Microgastrinae were described, amongst them three were of Indian origin and nine were Afro-tropical. Twelve new taxa described include: *Microplitis murkyi* Ankita Gupta 2013, *Glyptapanteles hypermnestrae* Gupta and Pereira 2012, *Dolichogenidea kunhi* Gupta & Kalesh 2012, *Apanteles minatchy* Rousse & Gupta 2013, *Distatrix yunae* Rousse & Gupta 2013, *Dolichogenidea lumba* Rousse & Gupta 2013, *Dolichogenidea uru* Rousse & Gupta 3013, *Exoryza safranum* Rousse & Gupta 2013, *Glyptapanteles chidra* Rousse & Gupta 2013, *Nyereria ganges* Rousse & Gupta 2013, *Nyereria mayurus* Rousse & Gupta 2013, and *Wilkinsonellus narangahus* Rousse & Gupta 2013. The parasitic wasp, *Cotesia erionotae* (Wilkinson) obtained from parasitized caterpillars of *Udaspes folus* (Cramer) is a new distribution record of the species (Fig. 3).

Fig. 3. Parasitic wasp *Cotesia erionotae* (Wilkinson) from parasitized caterpillar of *Udaspes folus* (Cramer)

The new species, *Dolichogenidea kunhi* Gupta & Kalesh 2012 (Hymenoptera: Braconidae) was reared from *Thoressa evershedi* (Evans) (Lepidoptera: Hesperiidae), a rare skipper species from Western Ghats, Kerala. The parasitic wasp, *Glyptapanteles hypermnestrae* was reared from parasitized caterpillar of *Elymnias hypermnestra* (L.) on coconut from Maharashtra. Extensive studies on parasitic wasp fauna associated with Hesperiidae caterpillars from Western Ghats, Kerala were conducted. Eight species of parasitoids from various life stages of several skippers were documented and published.

International catalogue on Micro-gastrinae

A catalogue of revised Microgastrinae (Hymenoptera: Braconidae) fauna of Reunion Island (Indian Ocean) was published. The catalogue contains several species which are also reported from India. A key to all genera and species was provided. Thirty four species belonging to 13 genera were recorded along with description of nine new species and new distribution records for 12 species were given. New combination was given for four species, which are reassigned from the traditionally defined *Apanteles* genus to respective genera. The species with new combination include *Glyptapanteles antsirabensis* (Granger), *Glyptapanteles ficus* (Granger), *Glyptapanteles subandinus* (Blanchard) and *Venanides curticornis* (Granger).

Revision of Indian *Microplitis* Foerster

The genus *Microplitis* Foerster (Hymenoptera: Braconidae: Microgastrinae) is revised from India. The wasp species of the genus *Microplitis* are larval endoparasitoids of economically important agricultural pests, particularly lepidopteran species of *Helicoverpa* and *Spodoptera* spp. A new species, *Microplitis murkyi* Ankita Gupta was described from Karnataka (Fig. 6). Two species, *M. bageshri* Sathe, Inamdar & Dawale and

M. dipika (Bhatnagar) were considered *incertae sedis* in the publication. New combination given for *Snellenius maculipennis* (Szepligeti) which is placed into synonymy with *Microplitis.*

Molecular tools used to resolve the correct identity of two cryptic species of hymenopteran wasps

Resolved the correct identity of two cryptic species of parasitic wasps, *Apanteles mohandasi* Sumodan & Narendran and *Apanteles taragamae* Viereck combining traditional taxonomy and molecular characterization. Both are solitary endoparasitoids of *Pammene* (*Grapholita*) *critica* Meyrick on *Cajanus cajan* (L.). Taxonomic studies confirmed correct placement of *A. mohandasi* Sumodan & Narendran (1990) in the genus *Apanteles* instead of *Dolichogenidea* (Fig. 4).

A

B

C D

Fig. 4. ***Apanteles mohandasi*** **Sumodan & Narendran**

Chalcidoidea: Family Pteromalidae & Eucharitidae

The family Pteromalidae is a very large family of parasitic wasps, with some 3,450 described species in about 640 genera, the number was greater, but many species and genera have been reduced to synonymy in recent years. Eucharitid wasps are members of the superfamily Chalcidoidea and consist of three subfamilies: Oraseminae, Eucharitinae, and Gollumiellinae. During 2012–13, specimens under 17 genera and 24 species were sorted, identified and added to NBAII collection. Seven new distribution records and one first record from India with description of one female was completed.

Fig. 5. ***Glyptapanteles hypermnestrae*** **Gupta & Pereira**

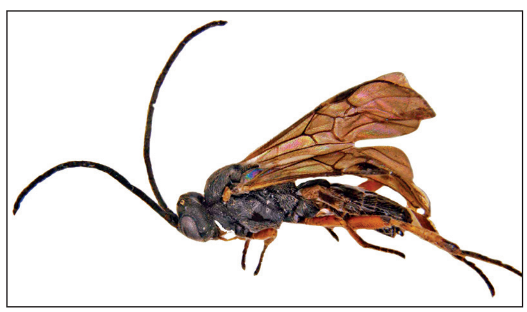


Fig. 6. ***Microplitis murkyi*** **Ankita Gupta**

Biodiversity of oophagous parasitoids with special reference to Platygastridae (Hymenoptera)

Expeditions were conducted for Platygastroidea in five States and Union territories, *viz.*, Andaman and Nicobar Islands (South Andaman, Middle Andaman and Little Andaman), Andhra Pradesh (Hyderabad), Maharashtra (Nasik, Kohlapur, Panhala), Tamil Nadu (Kotagiri and Ooty) and Karnataka. Egg parasitoids belonging to different genera were collected from 248 egg masses of different orders of insects such as Hemiptera (16), Lepidoptera (123), Arachnida (72) Diptera (12), Neuroptera (Chrysopidae) (18) and Dictyoptera.

In Karnataka, collections were made extensively from six different districts, *viz.,* Chikkamagalur (Balehonnur, Mudigere, Kudgregundi, Chikkabelegere) Ramanagara (Magadi), Mandya, Bengaluru (Kengeri, Hebbal, Hessaraghatta, Attur, Devanahalli) and Chikkabalapur (Nandi Hills, Chintamani). Different crops *viz.*, sugarcane, rice, maize, pulses, vegetables and fruits in addition to forest and uncultivated fields were surveyed for insect eggs. A total of 1850 parasitoids were collected, curated and preserved for future studies. So far 41 genera under five subfamilies were recorded from India and an additional eleven genera are added (Table 1), raising the total to 52 genera. A new genus *Dvivarnus* Rajmohana and Veenakumari was described under the subfamily Teleasinae. One new species under this genus *Dvivarnus punctatus* Veenakumari and Rajmohana was described. Under the subfamily Sceliotrachelinae three new species were described. *Plutomerus veereshi* Veenakumari, Buhl and Rajmohana*, Fidiobia virakthamati* Veenakumari, Buhl and Rajmohana and *F. nagarajae* Veenakumari, Buhl and Rajmohana were described. The species of *Fidiobia* are the first representatives of the genus from India.

So far only two genera of Platygastroidea, *viz*. *Telenomus* and *Gryon* were known from the Andaman Islands. During recent expeditions and collections in 2012 and 2013, 33 additional genera were collected under five subfamilies (Table. 1).

Table 1. New genera of Platygastroidea recorded from a biodiversity hot spot, Andaman & Nicobar Islands

Mainland	Andaman & Nicobar Islands
Telenominae *Protelenomus (*New record for India) **Scelioninae** *Leptoteleia* (New record from Karnataka) *Habroteleia* (New record for Karnataka) *Aradophagus* **Platygastrinae** *Trichacoides* (New record from South India) *Platygaster* *Synopeas* *Leptacis* (Previously recorded from Karnataka) **Sceliotrachelinae** *Fidiobia* (New record from India)	**Telenominae** *Paratelenomus* *Trissolcus* *Psix* **Teleasinae** *Trimorus* *Xenomerus* **Scelioninae** *Baeus* *Baryconus* *Calliscelio* *Calotelea* *Ceratobaeus* *Cremastobaeus* *Dicroscelio* *D oddiella*

Plutomerus (New record from South India) *Isolia* (New record from Karnataka)	*Duta* *Dyscritobaeus* *Fusicornia* *Habroteleia* *Idris* *Macroteleia* *Opisthacantha* *Palpoteleia* *Paridris* *Platyscelio* *Probaryconus* *Psilanteris* *Scelio* *Sparasion* *Triteleia* **Sceliotrachelinae** *Allotropa* *Fidiobia* **Platygastrinae** *Leptacis* *Synopeas* *Platygaster*

Two encyrtids, *Proleurocerus fulgoridis* Ferriere on eggs of fulgorid and *Proleuroceroides pyrillae* (Crawford) on the eggs of pyrilla on sugarcane were recorded. *Telenomus* sp. on the eggs of sugarcane top shoot borer (*Scirpophaga excerptalis*), *Jamides celeno; Ooencyrtus* spp. on eggs of *Papilio polytes*, *P. demoleus* (on *Citrus* spp.) and *Erionota thrax* on banana were collected.

New taxa described

Zaplatycerus notialis Hayat & Poorani (Encyrtidae) (Fig. 7) and *Poropoea bella* Hayat & Poorani (Tricho-grammatidae) (Fig. 8) were described from Karnataka. *Coccipolipus synonychae* (Acari: Podapolipidae) was described as a parasitoid of the giant bamboo ladybird, *Synonycha grandis*. *Asprothrips navsariensis* Tyagi and *Psephenothrips moundi* Tyagi (Thysanoptera) were described from Gujarat and Karnataka, respectively. *Lohiella longicornis* (Noyes & Hayat) (Encyrtidae)

Fig. 7. *Zaplatycerus notialis* Hayat and Poorani

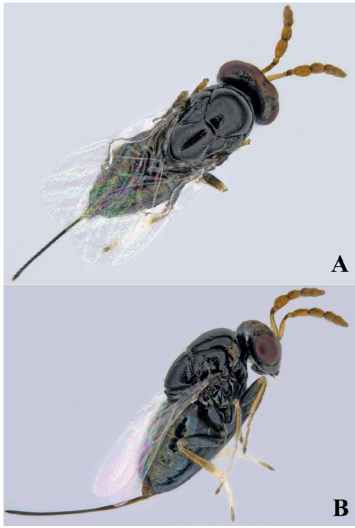


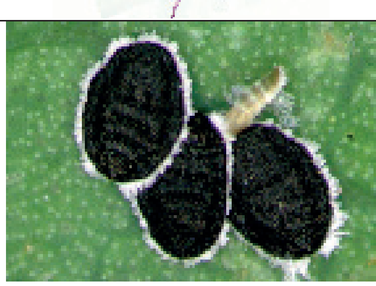
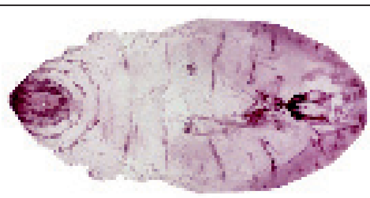
Fig. 8. ***Poropoea bella*** **Hayat and Poorani**

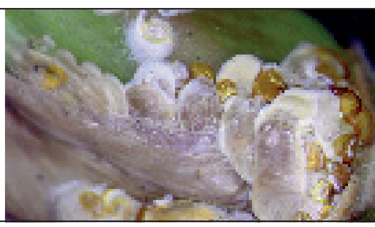
was recorded for the first time from India (Karnataka) and the hitherto unknown male was described. *Anagyrus qadrii* and a fortuitously introduced species of *Anagyrus* were recorded in association with the Madeira mealybug in and around Bangalore. The latter is being described as a new species.

Biosystematic studies on Aphidoidea and Coccoidea

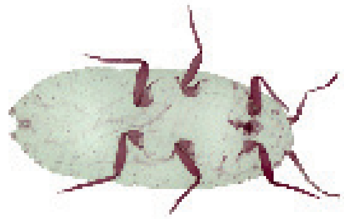
A total of 24 new distribution records made, 13 were first records for India, while remaining were new distribution records for South India (Table 2). Following are the aphids, mealybugs and scale recorded for the first time either from India or South India.

Table 2. New records of aphids, mealybugs and scales

Hemiptera: Aphididae	
	*Pleotrichophorus chrysanthemi* (Theobald) is a new record from Karnataka. This species was collected from *Chrysanthemum* sp. at Bangalore.
	*Astegopteryx nipae* (van der Goot) was collected from coconut plants from Mudigere (Karnataka). This is a new record from Karnataka.
	*Reticulaphis foveolatae* (Takahashi) was collected from *Ficus religiosa* during November - January, 2012 from Bangalore. This species is being recorded for the first time from India.
Hemiptera: Diaspidiidae	
	*Aulacaspis tegalensis* was collected from sugarcane during November - January, 2012 from Bangalore and is first recorded from Karnataka.

	*Odonaspis ruthae* (Kotinsky) is a new record from India and was collected from indetermined grass during August, 2012 from Bangalore.
	*Andaspis hawaiiensis* (Maskell) was collected from indetermined tree belonging to Leguminaceae during August, 2012 at Bangalore for the first time from India.
	*Fiorinia externa* Ferris is a diaspid bug feeding on *Thuja occidentalis* and collected during June, 2012 from Bangalore and is a new distribution record from South India.
	The diaspid, *Chionaspis heterophyllae* Cooley was collected from Bangalore from a grass during June, 2012 for the first time from South India.
	*Froggattiella penicillata* (Green) was collected from *Bambusa* sp. during January, 2013, from Hebbal, Bangalore and is a new record from India.
	*Lepidosaphes laterochitinosa* Green was observed to feed on *Sansevieria trifasciata* at Bangalore during July 2012. It was recorded for the first time from India.
Hemiptera: Asterolecaniidae	
	*Russelaspis pustulans* (Cockerell) belonging to Asterolecaniidae was collected from *Morus papyrifera* in and around Bangalore, Karnataka during February 2013 and is a new record from India.

Hemiptera: Pseudococcidae



Heliococcus summervillei Brookes was found feeding on unidentified frass from Bangalore during August, 2012. This is first record of the species from South India.

Taxonomic studies on fruit flies (Diptera: Tephritidae) of India

Fruit flies are economically important group of insects. Several of them are serious pests of various crops like mango, guava and cucurbitaceous plants. During 2012-13, eighty one species were collected/studied in 33 genera and five subfamilies namely Dacinae, Tephritinae, Trypetinae, Phytalmiinae and Tachiniscinae.

New taxa described and new synonyms proposed

Based on the morphological characters, four new species of genus *Euphranta* Loew were described from India namely *E. dysoxyli* David, *E. diffusa* David, *E. thandikudi* David and *E. hyalipennis* David & Freidberg and a new species from Sri Lanka, *E. neochrysopila* David, Freidberg, Hancock & Goodger (Fig. 9). An illustrated key to 12 species of *Euphranta* from India was published. Through systematic studies using morphological characters, *E. dissoluta* (Bezzi) and *E. burtoni* Hardy were synonymised with *E. crux* (Fabricius).

New records for India

Four species of tribe Adramini namely *Coelotrypes latilimbatus* (Enderlein), *Dimerino-*

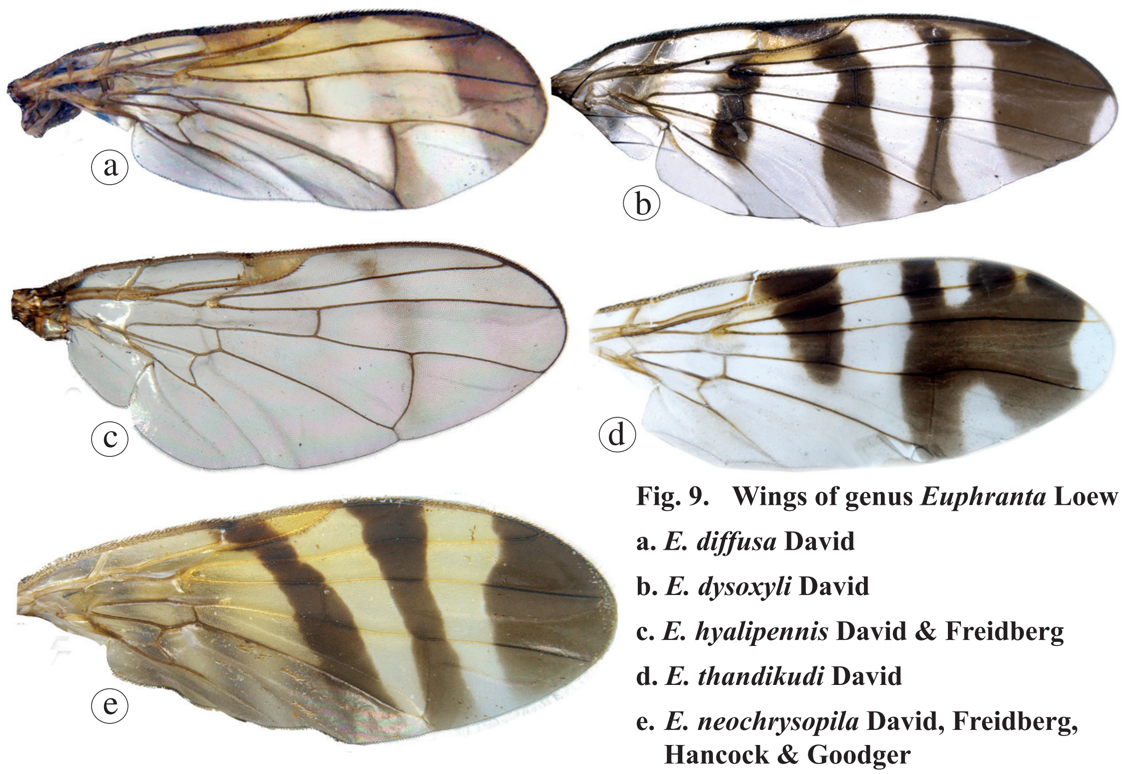


Fig. 9. Wings of genus *Euphranta* Loew

a. *E. diffusa* David

b. *E. dysoxyli* David

c. *E. hyalipennis* David & Freidberg

d. *E. thandikudi* David

e. *E. neochrysopila* David, Freidberg, Hancock & Goodger

gophrys parilis (Hardy), *Dimeringophrys pallidipennis* Hardy, *Hardyadrama excoecariae* Lee and an undescribed species of *Coelopacidia* are newly recorded from India (Fig. 10). *Ortalotrypeta isshikii* (Matsumura) and Subfamily Tachiniscinae was recorded for the first time from India (Fig. 11). *Acroceratitis histrionica* and *Platensina quadrula* were also recorded from India (Fig. 12 & 13).

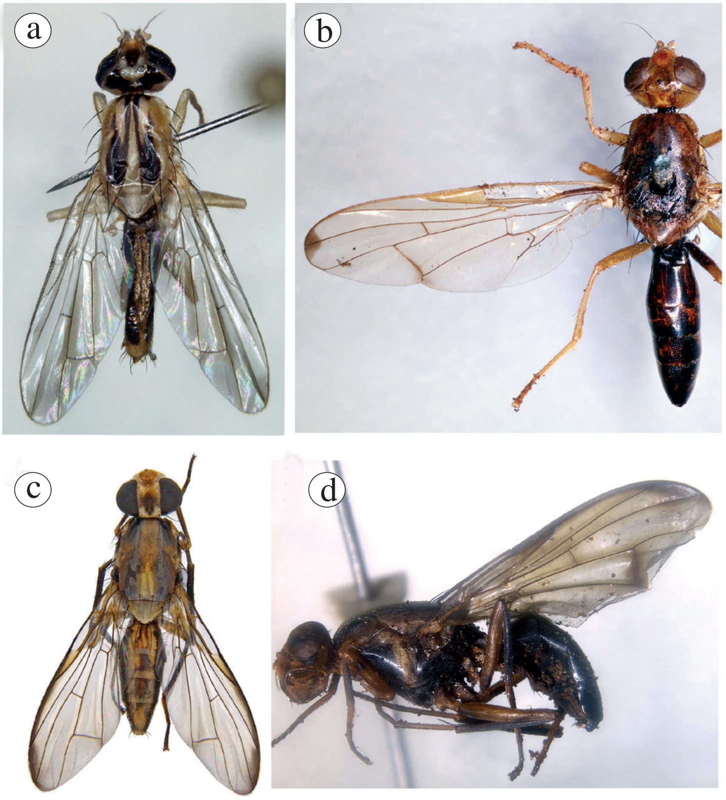


Fig. 10. New records of Tribe Adramini from India. a. *Coelotrypes latilimbatus* (Enderlein); b. *Coelopacidia* sp. © The Natural History museum, London; c. *Dimeringophrys pallidipennis* Hardy; d. *Dimeringophrys parilis* (Hardy)

Fig. 11. *Ortalotrypeta isshikii* (Matsumura) and Subfamily Tachiniscinae is recorded for the first time from India.

Fig. 12. ***Acroceratitis histrionica*** **belongs to sub family Dacinae and is known to infest bamboos. Known from Thailand, Sri Lanka and Laos, it is newly recorded from India**

Fig. 13. ***Platensina quadrula*** **belongs to subfamily Tephritinae. Members of Dithrycini are known to make stem galls in plants belonging to Asteraceae, Goodenaceae and Onagraceae. It has been collected for the first time from India**

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

Papaya mealybug, *Paracoccus marginatus*

Recurring incidence of papaya mealybug was observed in few locations of Chitradurga, Lingsagur, Bellary, Chamarajnagar, Maddur and Bangalore taluks in Karnataka, Penukonda, Kothanur from Andhra Pradesh, Andaman and Nicobar Islands, Salem and Erode districts of Tamil Nadu. Parasitoids were sent to the needed places where incidence was found. Three months after augmentation of the parasitoids control was obtained. A total of 43 shipments were made to different farmers and developmental officials.

During 2012-13, *Anagyrus loecki* and *Pseudleptomastix mexicana* were recovered from the samples of papaya mealybugs from Erode (Fig. 14), Salem, and in and around Bangalore showing that low populations of the parasitoids are still active in field. *A. loecki* was also found parasitizing *Phenacoccus madeirensis* in Bangalore.

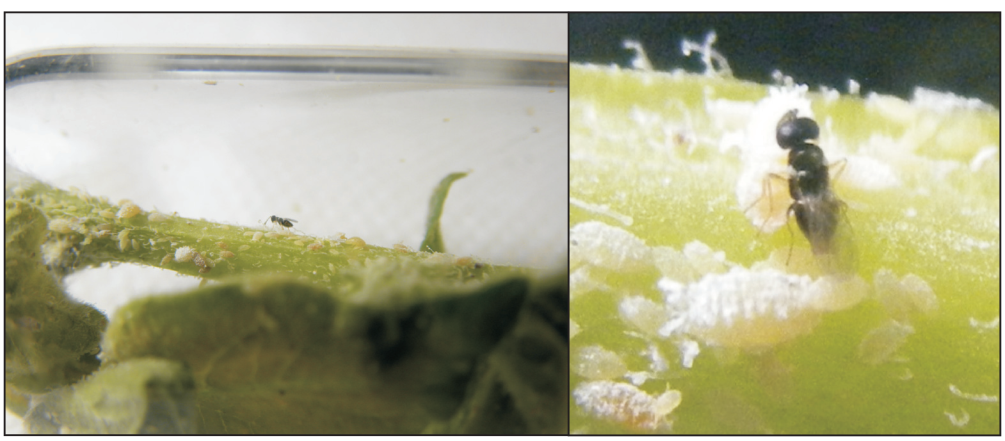


Fig. 14. ***Pseudleptomastix mexicana*** **active in field**

Hyperparasitoids of *Acerophagus papayae*

Acerophagus papayae was found to be parasitized by *Marietta lepardina* (Hymenoptera: Aphelinidae) and *Chartocerus* sp. (Hymenoptera: Signiphoridae) (Fig. 15). 2–5 per cent parasitization was found on the papaya mealybug from *Parthenium* and *Sida acuta* whereas on papaya *Chartocerus* sp. was dominant but, the per cent parasitization was between 2 and 5%.

Fig. 15. Hyperparasitoids *Chartocerus* sp. and *Marietta leopardina* on *Acerophagus papayae* pupae.

Occurrence of sac brood virus and other diseases in honey bees in Karnataka and Kerala

Bacteria were isolated from infected honey bee larval samples using NA, LB and blood agar. The bacteria were initially identified using Gram's staining and further 16Sr DNA analysis was done to identify the bacteria (Table 3).

Table 3: Identification of bacteria from larval samples.

Place	16SrDNA Identification
Sullia, Mangalore Dist.	*Proteus mirabilis*
Kasargod Dist.	*Proteus penneri*
Mekyamandapam, T.N. Kerala border	*Bacillus cereus*
Apiary, Trivanthapuram	*Pseudomonas aeruginosa*

The honey bee larvae were suspected to be infected with virus. RT-PCR studies were carried out to determine the viral infection. RNA was isolated from the larval samples suspected to be infected with Sac brood virus based on the symptoms observed from seven infected samples. The complete genome of this virus was obtained using primer walking. The sequences were submitted to NCBI using Sequin. This is the first sequence submission from India.

Study on the biology of *Anagyrus kamali* and mass production

Biology of *Anagyrus kamali*, an endoparasitoid of pink hibiscus mealybug, *Maconellicoccus hirsutus* obtained from Andaman islands was studied. *M. hirsutus* was maintained on potato sprouts and pumpkin. Although *A. kamali* parasitized 2nd instar nymphs, there was a marked preference towards the 3rd and adult female *M. hirsutus*.

The total developmental period of *A. kamali* on the 2nd stage nymph ranged from 25–29 days in case of males and 30-32 days in case of females. Development was faster in later stage nymphs (22 days) and in adult female (20–21 days). Longevity of male and female parasitoids varied between 30-32 days and 38–42 days, respectively. Adults fed with water and unfed adults could not survive for more than 36–48 hours. Temperature of 22–25°C was found to be optimum for survival of the parasitoid. At temperatures above 25°C, the longevity of adults decreased drastically. Three generations of the parasitoids were maintained successfully.

Fig. 16. ***Anagyrus kamali*** **ovipositing on** ***Maconellicoccus hirsutus***

Occurrence of invasive Madeira mealybug, *Phenacoccus madeirensis* Green (Hemiptera: Pseudococcidae) in India

Using different biosystematic characters, it was established that *Phenacoccus madeirensis* is present in India. The cotton crop in an area of about 7.5 ha located between Bandipur and Gundlupet on Mysore–Ooty highway was severely affected by *P. madeirensis.* The incidence was to the tune of 90-100 per cent of the cotton plants in the entire area. Leaf, stem, flower bases and bolls were heavily infested with *P. madeirensis* and boll opening was improper in many plants.

The following species of parasitoids were recorded in the field as well as from samples collected and kept for incubation in the laboratory *viz., Allotropa* sp., *Anagyrus* sp., *Anagyrus qadrii* (Hayat, Alam & Agarwal, 1975), *Anagyrus loecki* Noyes & Menezes and hyperparasitoids, *Prochiloneurus aegyptiacus* (Mercet) and *P. javanicus* Ferriere. Among them, the population of *A. qadrii* was in higher number compared to *Anagyrus* sp. and was found to parasitize efficiently.

Phenacoccus madeirensis was mainly observed on *Cestrum nocturnum, C. diurnum, Acalypha* sp., *Hibiscus rosa chinensis, Lantana camara, Clerodendron viscosum, Solanum melongena* and *Solanum tuberosum, Crossandra* sp., tapioca and mulberry plants from different parts of Karnataka and Tamil Nadu. *P. madeirensis* was also found associated with *Pseudococcus jackbeardsleyi* on tomato.

Several predators were observed feeding on *P. madeirensis,* mainly *Cacoxenus perspicax* (Drosophilidae: Diptera) and several species of cecidomyiids. *Cryptolaemus montrouzieri* and *Scymnus* sp. were predominantly feeding on *P. madeirensis. Anagyrus loecki* and *Anagyrus* near *sinope* were found predominantly parasitizing the mealybug.

Division of Molecular Entomology

Diversity and distribution of entomopathogenic nematodes in temperate, Gangetic plains of India and rootgrub endemic sugarcane growing areas

Eighteen soil samples were collected from three locations namely, Varanasi, Ghaziabad and Meerut districts of Uttar Pradesh. EPN were recovered from 2 of the 18 soil samples (11%). Among the 2 positive samples, one sample yielded heterorhabditids and one sample contained steinernematids when analysed by soil baiting technique using *Galleria mellonella* larvae.

Expeditions to rootgrub endemic sugarcane areas of north Karnataka, Maharashtra and western Uttar Pradesh were made to collect the grubs, eggs and infected cadavers. The endemicity of *Holotrichia serrata, H. consanguinea, Anomala* spp., *Leucopholis lepidophora, Lepidiota mansueta, Phyllophaga calciata* and *Phyllognathus dionycius* was recorded from different regions surveyed. Three new isolates of *Heterorhabditis* spp. and one isolate of *Steinernema abbasi* were recorded from diseased grubs collected from north Karnataka–Maharashtra border and added to NBAII collections. Eight new EPN strains were isolated and catalogued.

Barcodes for *Steinernema abbasi*, *Heterorhabditis indica*, *Heterorhabditis bacteriophora* were generated for the first time from India for NBAII isolates using COI gene.

Life cycle and biology of *Heterorhabditis indica* & *Steinernema abbasi* on different insect hosts

Development of *H. indica* (strain NBAII 101) was studied *in vivo* with larvae of *G. mellonella* as host. At 28°C, the duration of the life cycle from egg hatch to egg hatch was 96-104 hours. Juvenile development was 42–48 hours, with the duration of each juvenile stage ranging from 8 to 12 hours. Under crowded conditions the development proceeded to the infective juvenile (IJ) stage instead of the third juvenile stage (]3). Only hermaphrodites were obtained in the first generation of development of IJs and males were obtained only in the second generation. The ratio of males to hermaphrodites in the second generation was 1:9.4–6.8. The life cycle was shorter with less number of males, females and juveniles in *S. litura* and *H. armigera* compared to that in *G. mellonella*. Development of *H. indica* in *L. lepidophora* at 28°C ranged between 112 and 136 hours. First generation juvenile development was 60–72 hours followed by a shorter 2nd generation of 48–54 hours. The proportion of males was about 1:18.2. Development of *H. indica* and *S. abbasi* in grubs of *Myllocerus subfasciatus* lasted 1–2 generations in 2-36 hours, with very short juvenile stages. Further the infective juveniles emerged per grub were 140–200.

Performance conditions of the EPN against cryptic pests

Effect of EPN formulations in combination with entomopathogenic fungi on the incidence of *M. subfasciatus* grubs in brinjal was studied under field conditions. Two individual applications of nematode species were highly effective than the fungal species. Among the two fungal isolates treated *M. anisopliae* NBAII-Ma04 showed 54 and 33% of adult and grub population reduction, respectively. In combined applications, *H. indica* NBAII–Hi01+ *M. anisopliae* NBAII–Ma04 at half the dose of each showed about 75 and 67% of adult and grub population reduction followed by *S. abbasi* NBAII Sa01+ *M. anisopliae* NBAII–Ma04 combination.

In the studies on recovery of the entomopathogens from the treated plots in red laterite soil, both *H. indica* NBAII Hi01 and *S. abbasi* NBAII Sa01 showed highest recovery of 82 and 80%, respectively, in individual application compared to that of combined applications with two fungal pathogens after five months of application. Similarly, the recovery of the nematodes was on par in combinatorial treatment with *M. anisopliae* NBAII–Ma04 and *B. bassiana* NBAII–Bb5a. *Beauveria bassiana* (NBAII–Bb5a) did not show any pathogenecity on *M. subfasciatus* adults either immediately or four months after application.

Effect of EPN formulations on the incidence of sugarcane borers

Demonstration of efficacy of EPN formulations against whitegrubs in sugarcane in western Maharashtra was carried out in Varnanagar and Nagaon. Aqueous, cadaver and WP formulations were evaluated. Application of EPN and imidacloprid reduced the populations of whitegrub complex in sugarcane; tiller density and cane height was significantly higher in treated than the control (Fig.17). *H. indica* and *S. abbasi* performed better than *S. carpocapsae* and *S. glaseri*, WP formulation was the best, followed by cadaver and aqueous applications. The persistence of EPN was observed till 240 days after application.

Fig. 17. Damage caused by root grubs in untreated and EPN treated sugarcane field.

Virulence of entomopathogenic nematodes on sod webworm, *Herpetogramma phaeopteralis* Guenee (Lepidoptera: Pyralidae), a pest of turfgrass

Infectivity of entomopathogenic nematodes *Steinernema abbasi, Heterorhabditis bacteriophora* NBAII Hb101 and *Heterorhabditis indica* NBAII Hi01 against sod webworm, *Herpetogramma phaeopteralis* infesting turfgrass was studied in the laboratory. All the three species showed pathogenicity to the larvae of *H. phaeopteralis* in the initial bioassays. The nematode, *H. indica* (NBAII Hi01) was observed to be most virulent with significantly lowest LC_{50} and LC_{90} values (30 IJs and 131 IJs, respectively). Similarly, studies on time- mortality response indicated that *H. indica* NBAII Hi01 recorded significantly lowest LT_{50} and LT_{90} values (21h and 72h, respectively)

Virulence of entomopathogenic nematodes on coffee stem borer, *Xylotrechus quadripes* Chevrolat (Coleoptera: Cerambycidae), a persistent pest of arabica coffee

Infectivity of *Steinernema abbasi, Heterorhabditis bacteriophora* NBAII Hb101 *and Heterorhabditis indica* NBAII Hi01 against coffee stem borer, *Xylotrechus quadripes* were studied in laboratory. All the three nematodes species were pathogenic to the larvae in the Petri plate bioassays. The nematode, *H. indica* NBAIIHi01 was observed to be most virulent with significantly lowest LC_{50} and LC_{90} values (37.1 IJs and 88.9 IJs, respectively). Similarly, in the time mortality response, *H. indica* NBAIIHi01 recorded significantly lowest LT_{50} and LT_{90} values (22.8h and 52.0h, respectively).

Studies on *Bacillus thuringiensis*

Sequence analysis of *vip3A* gene (broad spectrum lepidopteran activity) was completed in 8 isolates and the same were submitted to GenBank. Further studies were carried out to purify the *vip*3A protein SDS–PAGE analysis revealed the 90 kDa protein in two of the isolates (Fig. 18).

Studies were conducted to characterize the native isolates for dipteran specificity. Indigenous isolates were probed for standardized *cry* genes and only 5 were positive for *cry*11 and *cry*10. Another dipteran specific gene (*cry*17) was identified with specific primers amplifying 1400 bp gene in AsBT 1, AsBt 3 and BTAs.

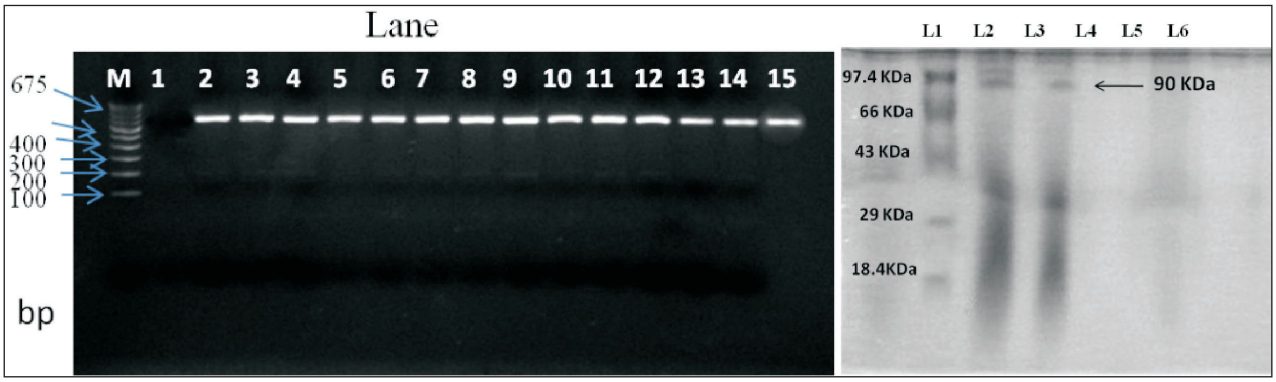


Fig. 18. Amplification of *vip*3A (675 bp) gene and SDS-PAGE of *vip*3A protein (90kDa).

The primer was primarily designed from *Bt* but was used for the detection of *cry*16A in *Clostridium bifermentan.* The *cry*16A gene was detected in 9 isolates (Fig. 19).

The dual toxic *cry*2a gene is usually expressed by both Lepidoptera and Diptera specific *Bt* and is supposed to be toxic to both dipterans and lepidopterans. The gene was detected in 14 of the isolates.

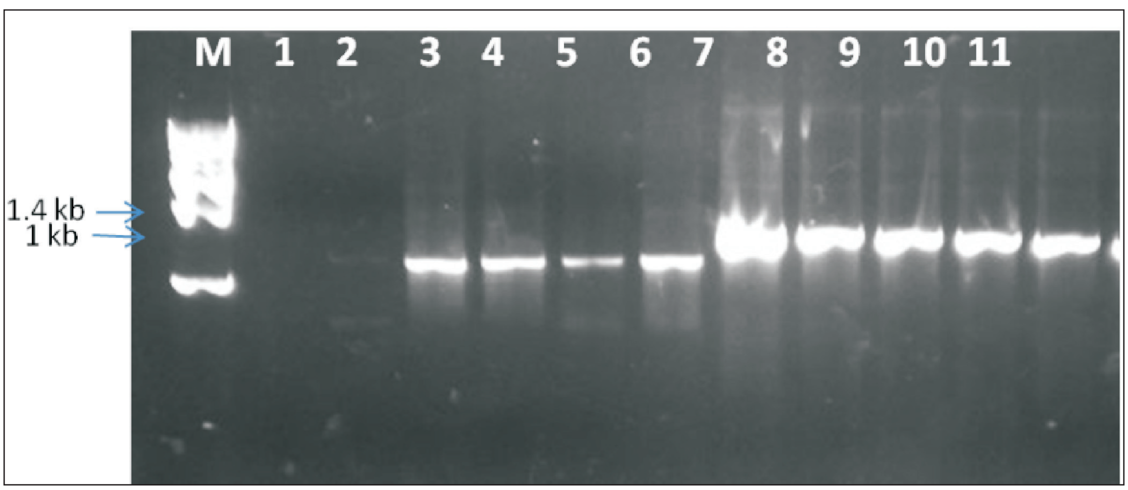


Fig. 19. Amplification of the rare dipteran toxic *cry*16A gene.

Crude preparations of *vip*3A protein was obtained from 20 isolates and their toxicity against second instar larvae of *S. litura* was analyzed. The protein from two of the isolates (EG1 and BtAN4) showed high toxicity with a LC_{50} value of 9.09 and 9.92 µg/ml, respectively

(Table 4). Liquid formulation of NBAII–EG1 against *H. armigera* under field conditions and pod damage parameters was studied. The results showed that the per cent pod damage was 11.20% with 2% spray of NBAII–EG1 and was on par with insecticide spray (11.11% pod damage).

Table. 4. Toxicity studies of crude *vip*3A protein against *Spodoptera litura*

Sl No.	Isolate	LC_{50} value (µg/ml)	95% confidence limits		Std. Error
			Lower	Upper	
1	Bt AN-1	15.85	1.0	27.12	0.71
2	Bt AN -3	29.00	8.35	42.88	0.63
3	Bt AN4	9.92	1.0	22.34	0.74
4	Bt AN-5	15.86	1.10	27.08	0.64
5	Bt D2	16.49	0.219	29.58	0.66
6	AgBt -7	17.70	5.31	26.14	0.83
7	Trbt -8	107.54	67.54	2341.97	0.49
8	Trbt -9	154.16	90.29	4747.04	0.53
9	AsBt 11	79.26	53.54	261.07	0.65
10	AgBt 14	28.29	9.29	41.16	0.64
11	AgBt -15	14.74	3.14	23.79	0. 55
12	TrBT -16	26.90	0.385	44.59	0.46
13	Trbt 17	13.79	1.16	23.08	0.94
14	Trbt -18	42.02	18.36	64.27	0.62
15	AgBt -21	16.72	4.49	25.90	0. 53
16	Asbt24	16.72	1.82	27.59	0.71
17	Asbt- 25	15.91	1.16	23.78	0.80
18	EG1	9.09	1.0	19.21	0.56
19	NE -60	36.21	10.92	54.80	0.46
20	N1	19.04	1.28	34.15	0.64

Endosymbionts on fitness attributes and insecticide resistance

Role of microbial flora of aphids in insecticide resistance

Live populations of *Aphis gossypii*, *A. craccivora* and *Myzus persicae* were collected from Bangalore, Malur and Dharwad districts, Karnataka from different crop plants. Eighty two culturable bacteria were isolated on nutrient agar medium, Yeast extract peptone dextrose medium and potato dextrose agar from surface sterilized beheaded aphids. Amongst them, 21 bacteria were subjected to molecular identification using 16S rDNA sequencing and identified based on 16S rDNA sequence homology search and phylogenetic affiliation as *Bacillus aryabhattai, B. cereus, B. firmus, B. horikoshii, B. jeotgali, B. massiliensis, B. subtilis, Exiguobacterium indicum, Moraxella osloensis, Paenibacillus lautus, Pseudomonas hibiscicola, Stenotrophomonas maltophilia* and *Zimmermannella faecalis.* From the studies it was concluded as *Bacillus* was the dominant genus found invariably in all aphid species.

Insecticide degradation studies with symbionts

The endosymbiont colonies isolated from *Trichogramma* were tested for the selected insecticides, *viz.*, imidacloprid and indoxacarb at concentration range of 100, 75, 50 and 25 ppm along with control. Initial studies were carried out on the microbial isolates for their growth on minimal salt medium (MSM) with and without insecticides. The observation was recorded using spectrophotometer at 650 nm.

The results presented in Table 5 indicated differential response of five different endosymbionts for their ability to degrade imidacloprid insecticide in a minimal media through spectrophotometer at 650 nm. After 96 h of observation, *Wickerhamomyces anomolus* was able to grow in insecticide media by 3.39 times compared to control followed by *Pichia ohmeri* 2.13 times, *Candida apicola* 1.80 times and *Metschnikowia reukaufii* 1.59 times, however, *Zygosaccharomyces rouxii* was not able to degrade imidacloprid, indicating that all symbionts do not have similar role. Similar studies with indoxacarb, indicated that after 96h of observation, *Wickerhamomyces anomolus* was able to grow in insecticide media by 1.97 times compared to control followed by *Zygosaccharomyces rouxii* 1.77 times, however, *Pichia ohmeri*, *Candida apicola* and *Metschnikowia reukaufii* were not able to degrade indoxacarb, indicating that all symbionts do not have similar role.

Determination of role of endosymbionts in fitness attributes of laboratory reared *Trichogramma* spp.

Endosymbionts are beneficial organisms in insects which help them to tolerate the biotic and abiotic stresses. In order to find out the role of yeasts in fitness attributes, yeasts such as *Metschnikowia reukaufii, Pichia ohmeri, Wickerhamomyces anomalus, Candida apicola* and *Zygosaccharomyces rouxii* were fed to the laboratory population of *Trichogramma japonicum* and *T. chilonis* for thirty generations.

The results in Table 6 indicated that per cent parasitism ranged from 46–84%, per cent females from 49.0–82.0% and fecundity from 32.0–57.0/female in F_5 generation in different yeast symbionts and after feeding these symbionts for 30 generations per cent parasitism ranged from 88.0–91.0%, per cent females from 63.0–85.0% and fecundity from 45.0–58.0/female compared to 58.0% parasitism, 55.0% females and fecundity of 36.0/female, respectively. Similar improvement in fitness attributes was observed in *T. chilonis*.

Table 5. Insecticide-imidacloprid degradation studies with endosymbionts isolated from *Trichogramma chilonis*

Insecticide concentrations (ppm)	Optical density (650 nm) for imidacloprid									
	Wickerhamomyces anomolus		*Pichia ohmeri*		*Candida apicola*		*Metschnikowia reukaufii*		*Zygosaccharomyces rouxii*	
	24h	96h	24h	96h	24h	96h	24h	96h	24h	96h
25	0.163	0.130	0.301	0.136	0.377	0.269	0.302	0.263	0.277	0.291
50	0.236	0.198	0.285	0.216	0.334	0.280	0.310	0.281	0.293	0.314
75	0.290	0.311	0.257	0.327	0.348	0.343	0.349	0.514	0.321	0.316
100	0.329	0.482	0.317	0.616	0.388	0.474	0.291	0.545	0.384	0.281
Control (Minimal media + inoculum)	0.337	0.142	0.274	0.289	0.292	0.263	0.300	0.342	0.298	0.272
SEM±	0.069	0.066	0.084	0.033	0.046	0.017	0.043	0.035	0.012	0.020
CD (P≤0.05)	0.218	0.207	0.264	0.104	0.146	0.055	0.136	0.109	0.036	0.064

Table 6. Horizontal transmission and determination of biological fitness of laboratory population of *Trichogramma japonicum* with various symbionts.

Yeasts fed / Generations	% Parasitism			% Females			Fecundity		
	F_5	F_{15}	F_{30}	F_5	F_{15}	F_{30}	F_5	F_{15}	F_{30}
Metschnikowia reukaufii	93	75	88	69	71	68	53	43	45
Zygosaccharomyces rouxii	88	89	81	76	85	65	43	60	58
Pichia ohmeri	97	80	87	82	75	70	44	49	57
Wickerhamomyces anomalus	85	75	79	76	63	66	57	51	56
Candida apicola	85	80	91	73	80	84	40	40	54
Control (50% sucrose)	33	40	58	49	46	55	32	38	36
SEM±	1.21	1.04	1.10	0.81	0.46	0.32	0.27	0.52	0.260
CD (P≤0.05)	3.74	3.20	3.38	2.49	1.42	0.98	0.82	1.60	0.80

Molecular characterization and identification of endosymbionts of chrysopid predators and their functional role on the biological attributes

Yeast DNA was successfully isolated from fat bodies, gut and diverticulum from different populations of *Chrysoperla zastrowi sillemi*. The PCR product was sequenced. The yeast isolates were found to be *Wickerhamomyces anomalus* (strain CZS–1 & 5), *Pichia anomala* (CZS–2, 8 &15), *Candida blankii* (CZS–3), *Candida apicola* (CZS–2), *Torulaspora delbrueckii* (CZS–4) *Zygosaccharomyces rouxii* (CZS–7), *Kodamea ohmeri* (CZS–9 &16), *Candida pimensis* (CZS-10). *W. anomalus* was found in most of the populations of the predator (CZS–1, CZS–2, CZS–5 and CZS–8). In general, yeast taxa obtained in gut, was also observed in fat bodies or diverticulum however, in CZS–2 (Dharward population), *W. anomalus* was isolated from gut and *C. apicola* was obtained in fat bodies.

Molecular characterization of bacteria isolated from the larvae of *Chrysoperla zastrowi sillemi*

Larval gut of *C. z. sillemi* was isolated and the tissues were mashed and the suspension thus obtained was spread on to YPDA media for the isolation of bacteria. The extracted genomic DNA of the pure culture was used as template DNA for amplification of the 16s rRNA gene. The primers 16S–F (5'–AGAGTTTGATCCTGGCTCAG–3') and 16S–R (5'–CGGTGTGTACAAGACCC-3') were subsequently used for the amplification of partial rRNA genes. Standard PCR protocols were followed for the amplification of 16 s RNA. The resulting PCR amplicons were sequenced. All sequence data were analyzed using BLAST. The determined bacterial communities were found to be *Enterobacter, Enterobacter hormaechei, Enterobacter cloacae*, *Enterobacter asburiae, Pantoea dispersa, Bacillus, Bacillus* *subtilis, Bacillus cereus Enterococcus faecalis*, *Bacillus pumilus, Enterococcus faecium, Empedobacter* sp, *Agrobacterium tumefaciens, Lactococcus garvieae* and *Enterococcus gallinarum*.

Role of yeast in increasing the fecundity of *Chrysoperla zastrowi sillemi*

Role of yeast on the fecundity of adults of *C. z. sillemi* was tested. Student's t–test was used for comparison of fecundity of *C. z. sillemi* reared on yeast plus castor pollen grains and honey (treatment 1) and castor pollen and honey (treatment 2). The study revealed that there was a significant increase in the fecundity levels in the adults provided with honey, pollen and yeast isolate (*T. delbrueckii)* for four generations when compared to control (honey +pollen). The same trend was observed for four generations. Mean fecundity of *C. z. sillemi* reared on honey, pollen and *T. delbrueckii* for four generations was significantly higher than that of honey and pollen reared females (116.14) (Student's t=17.33, $P < 0.05$, df = 110).

Role of endosymbiotic bacteria *Enterobacter* sp. isolated from *Chrysoperla zastrowi sillemi* in insecticide degradation

A study was undertaken to isolate the endosymbiotic bacteria from *Chrysoperla zastrowi sillemi* larvae and their role in insecticide resistance. Based on 16S rRNA gene sequence, *Enterobacter* sp. and *Paenibacillus* sp. were identified. All sequence data were analyzed using BLAST. The partial rRNA gene sequence including sequences for the 16S rRNA gene were deposited in GenBank. The YPDA broth culture of bacteria was added into minimal media supplemented with acephate, indoxacarb, imidacloprid (100mg/L). Insecticide detoxification by liquid chromatography–mass spectrometry (LCMS) revealed that *Enterobacter* sp. (PTS–8–ENT) was able to degrade acephate (6 times) (Fig. 20) and indoxocarb (11 times). The study indicated that *Enterobacter* sp. isolated from *C. z. sillemi* larvae may also play a role in imparting insecticide resistance.

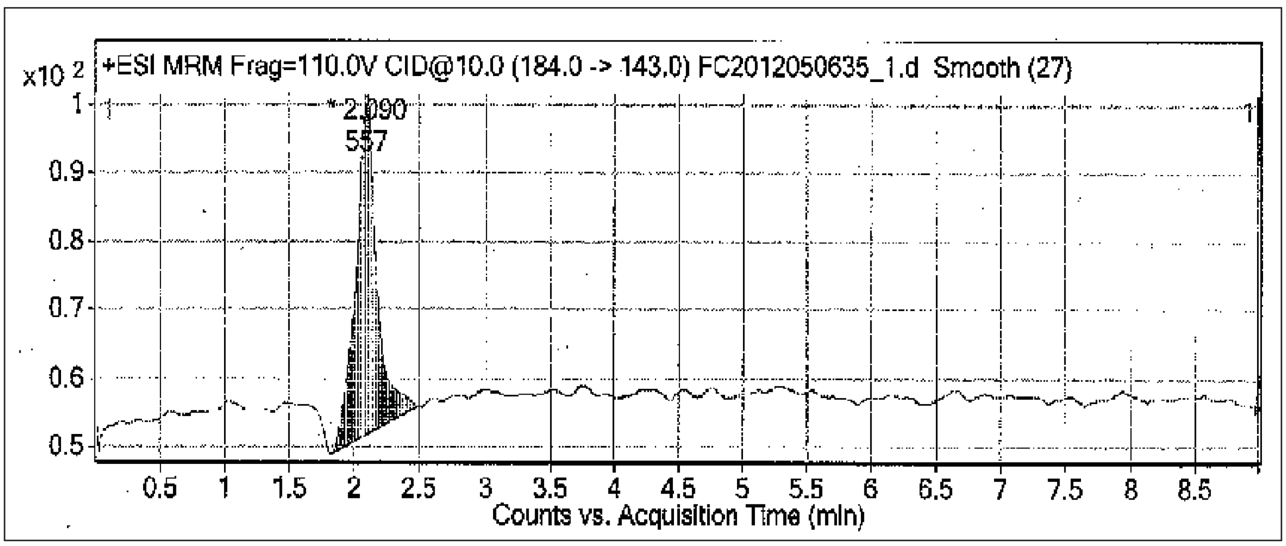


Fig. 20. Degradation of Acephate by *Enterobacter* sp. isolated from the larvae of *C. z. sillemi* by Liquid chromatography- Mass spectroscopy studies (LCMS): Minimal media plus *Enterobacter* sp. plus Acephate (2 ppm).

Studies on endosymbionts - Isolation and characterization of endosymbionts from field collected populations of *Cotesia plutellae* and *Trichogramma brassicae*

Cotesia plutellae, the endolarval parasitoid of the diamond back moth (DBM), *Plutella xylostella* was collected on cabbage/cauliflower crops, from different geographic locations of the country, *viz.,* Anand (Gujarat), Hoskote, Kolar, Malur (Karnataka), Hyderabad, Tirupathi, Rajahmundry (AP), Salem, Coimbatore, Oddanchatram and Palani (TN), Bhubaneshwar, Cuttack, Ganjam (Orissa), Pune (Maharshtra), Varanasi (UP), Solan Himachal Pradesh), Shillong (Meghalaya), Ganderbal (Jammu & Kashmir), Nawanshahar (Punjab) and Jorhat (Assam). The populations were maintained on DBM larvae reared on mustard seedlings. The egg parasitoid, *Trichogramma brassicae* was maintained on *Corcyra* eggs. Adults of *C. plutellae* collected from parasitized larvae of *P. xylostella* obtained from the different geographic populations were analyzed for the presence of endosymbionts. Species of microbials such as *Wolbachia, Enterobacter cancerogenous, Bacillus subtilis, Enterobacter* sp. *Bacillus cereus, Candida apicola, Pichia anomola, Candida rugosa, Pseudomonas putida, Bacillus clause* and *Candida diversa* were isolated from different populations.

Determination of the role of endosymbionts in the fitness costs of the parasitoid

Fitness benefits such as fecundity, a potential increase in longevity and tolerance to stressful environments and host reproductive manipulations (cytoplasmic incompatability, parthenogenesis, feminization, male killing and modulation of sex ratio) have been reported.

The populations fed with *Wolbachia* recorded significantly higher parasitism (74.8–91.2%) and adult emergence (64.1–82.2%) than the *Wolbachia* cured populations (68.2–82.3 and 60.4–72.2%, respectively). The population from Bangalore, Bhubaneshwar and Nawanshahar (Punjab) registered higher value in terms of these attributes. Though significant differences were observed among the populations in terms of adult longevity, the interaction between the *Wolbachia*-fed and cured populations was not significant.

Laboratory rearing of *Leucinodes orbonalis* and insecticide resistance monitoring studies

Various combinations of semi synthetic diets comprised of essential and micro nutrients, phagostimulants and antimicrobials were prepared and tested against the 2nd instar larvae of *L. orbonalis*. The nutritional and phagostimulancy improvements in diet combinations developed herein are useful for rearing of *L. orbonalis* larvae under laboratory conditions. Among the 13 diet preparations evaluated, the diet combination named "G" was found to support larval development better than others (Table 7).

Table. 7. Biology of *Leucinodes orbonalis larvae* on "G" diet

L. orbonalis	Duration (days)
Eggs	9.1 ± 0.23
1st Instar	4.0 ± 0.67
2nd Instar	2.8 ± 0.44
3rd Instar	3.1 ± 0.38
4th Instar	2.5 ± 0.57
5th Instar	8.0 ± 0.61
Larval duration	20.4 ± 1.4
Pupal duration	9.6 ± 0.73
Pupation %	56.3%
Adult Female	7.2 ± 0.76
Adult Male	5.3± 1.20

For insecticide resistance monitoring in *L. orbonalis*, the filter paper residue assay was found to be simple, precise and consistent in larval mortality. Four *L. orbonalis* populations collected from Bangalore, Guntur, Dharmapuri and Coimbatore were subjected to dose mortality bioassays against three insecticides to estimate resistance ratio. The study revealed up to six fold variation in insecticide susceptibility with respect to the insecticides *viz.,* fenvalerate, phosalone and emamectin benzoate in the populations of *L. orbonalis* tested. Quantification of midgut carboxylesterase from these four populations of *L. orbonalis* revealed significantly elevated activity in the larvae collected from Guntur region.

Division of Ecology

Documentation of thrips, mites and anthocorid fauna and host / host plant associations

Thrips subnudula from *Calotropis gigantea, Haplothrips* sp., *Macrocephalothrips abdominalis* and *Thrips palmi* from *Tagetes erecta, Haplothrips* sp. and *Thrips palmi* from chrysanthemum, *Frankiniella schultzei* from Freshno chilli, pomegranate, brinjal, watermelon and *Calotropis, Megalurothrips* sp. from *Butea monosperma* and *Pongamia, Haplothrips gowdeyi* from *Cassia javanica, Thrips hawaiiensis* from *Tecoma stans, Leeuwenia ramakrishnai* from Jamun tree (*Eugenia jambolana*) were recorded.

A predatory mite close to *Neoseiulus paspalivorus* was recorded on sugarcane eriophyid mite (*Aceria* sp.). From castor leaves infested with *Tetranychus urticae,* predatory mites, *Neoseiulus longispinosus, Amblyseius tetranychivorus* and two unidentified species were collected.

Anthocorids were collected from different crops during different seasons. *Carayonocoris indicus, Orius dravidiensis, O. niger, O. maxidentex, Cardiastethus exiguus, Cardiastethus pseudococci pseudococci, Cardiastethus affinis, Montandoniola indica, Xylocoris* (*Proxylocoris*) *afer and Buchananiella crassicornis,* were often encountered.

An undescribed species of *Montandoniola* on *Butea monosperma,* a new genus of Anthocorini from Ficus tree, *Orius maxidentex* for the first time from Andaman and Nicobar Islands, an undescribed species of *Blaptostethoides* from sugarcane, *Xylocoris afer* for the first time in India, *Cardiastethus pseudococci pseudococci* for the first time from mango inflorescence and *Cardiastethus affinis* for the first time as a predator of *Hemiberlesia lataniae* on Agave were new records.

Population fluctuations of *Gynaikothrips uzeli* on ficus in relation to its natural enemies

The population fluctuations of gall thrips *Gynaikothrips uzeli* infesting ficus in relation to its eulophid parasitoid, *Thripastichus gentilei* (Del Guercio) and predator, *Montandoniola indica* were monitored. During May–June months, there was a peak parasitism by *Thripastichus gentilei* (13.6 parasitoid stages/ leaf), which led to a reduction in thrips population. The anthocorid population increased during October – November, when 4.6 anthocorids per leaf could be recorded, following which there was a drastic reduction in the thrips population (Fig. 21) and further there was no curling due to *Gynaikothrips* till the end of March.

Rearing and predatory potential of *Montandoniola indica*

A method was standardized to rear *Montandoniola indica,* a predator of pepper gall thrips, *Liothrips karnyi* using UV irradiated *C. cephalonica* eggs as prey and bean pods as ovipositional substrates. In the laboratory studies, *M. indica* nymph fed on a total of 27.3 *C. cephalonica* eggs with a per day feeding rate of 1.56 eggs. *M. indica* adult male fed on a total of 38 eggs, with a per day feeding rate of 1.67 eggs, while the corresponding figures for the adult female was 56 and 1.79 eggs, respectively.

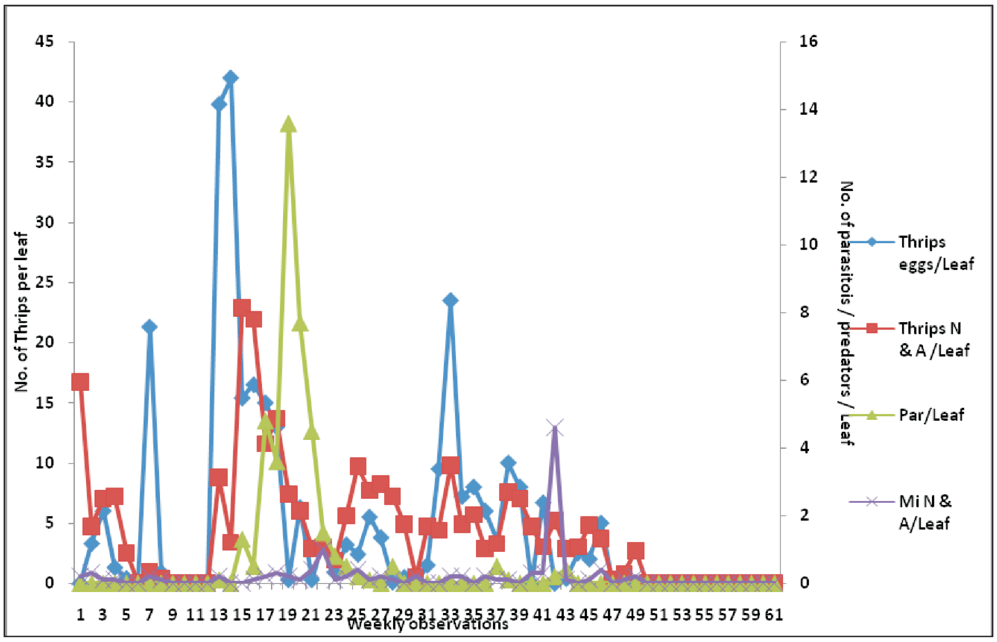


Fig. 21. Population fluctuations of *Gynaikothrips uzeli* in relation to that of the parasitoid *Thripastichus gentilei* (Par in Fig) and nymphs and adults of anthocorid predator *Montandoniola indica* (Mi N & A in Fig).

Studies on *Cardiastethus affinis* - Biology and feeding potential

Anthocorid predator, *Cardiastethus affinis* is amenable to production using *Corcyra cephalonica* eggs (Fig. 22). The incubation period was 6.3±0.21 days and nymphal period 20.3±0.5 and 21.0±0.5 days for male and female nymph, respectively. The mean male longevity was 81 days and female longevity was 88.7 days. Fecundity was 113.3 eggs per female. Percent hatching was recorded as 97.3 and per cent adult formation was 94.7%. The total feeding potential of male nymph was 63 eggs and female nymph 64.7 and daily feeding rate was 3.1 for both. The total feeding potential of adult male was 197 and per day feeding rate was 2.96 eggs, while the corresponding figures for the adult female were 374 and 3.58 eggs, respectively.

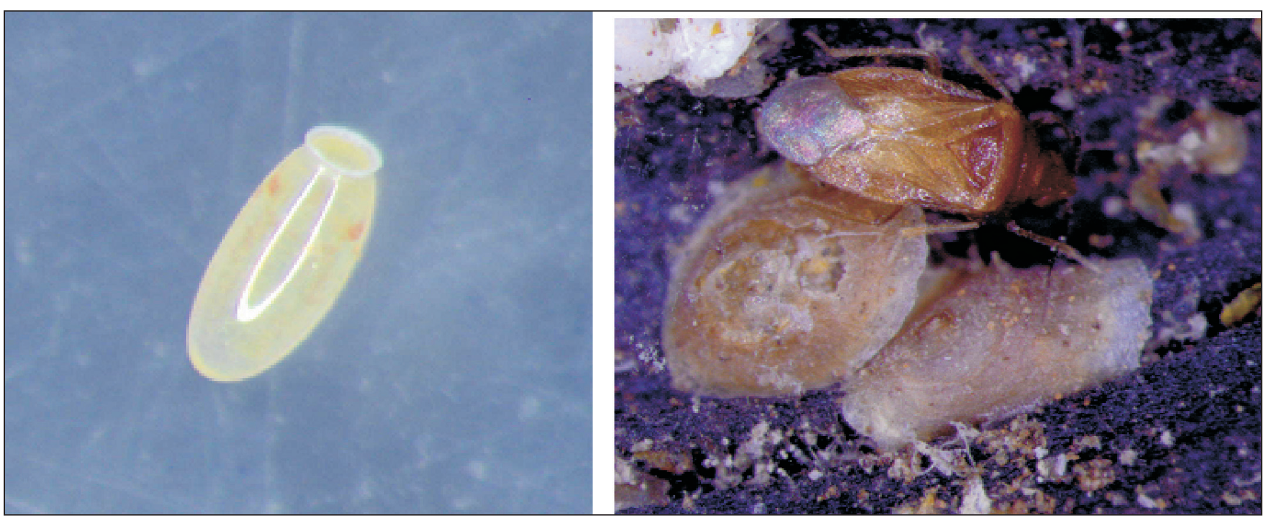


Fig. 22. Egg and adult of *Cardiastethus affinis*, a potential predator against *Hemiberlesia lataniae*

Studies on anthocorid predator, *Xylocoris afer* (Reuter)

Anthocorid predator, *Xylocoris* (*Proxylocoris*) *afer* (Reuter) was recorded for the first time in India and it is amenable to laboratory rearing on alternate laboratory host eggs. It has been reared for 6 generations in the laboratory. The predator could lay masses of eggs inside bean pods. The incubation period was 5.4 days and nymphal period was 16.9 days. Per cent hatching was recorded as 92.3 and per cent adult emergence as 90. The adult male and female *X. afer* lived for 34.5 and 20.0 days, respectively and the fecundity was 40.5 eggs per female.

Evaluation of *Blaptostethus pallescens* against pupal stages of *Frankliniella schultzei*

The anthocorid predator, *Blaptostethus pallescens* was evaluated against the pupal stage of thrips *Frankliniella schultzei* (Table 8). In the treatment where the *B. pallescens* nymph and adult were released against exposed pupae of *F. schultzei,* 80.7 and 94.0% mortality were recorded, respectively while 38.7% mortality was recorded in the control batch. In the treatment where the anthocorid nymphs and adults were released to target *F. schultzei* pupae under soil, 74.0% and 89.3% mortality were recorded, respectively, while in the control 41.3% mortality was recorded.

Table 8. Effect of releasing *B. pallescens* nymph and adult against *F. schultzei* pupae

Treatments	Per cent mortality of	
	Exposed pupae	Pupae under soil
B. pallescens nymph	80.7[a]	74.0[a]
B. pallescens adult *vs.* exposed pupae	94.0[a]	89.3[a]
Control	38.7[b]	41.3[b]
CD at 1%	21.45	18.04

Storage studies on *Corcyra cephalonica* eggs

Storage of *C. cephalonica* eggs for five days at 10, 12 and 14°C, resulted in a hatching rate of 48, 49 and 77%, respectively; while per cent adult emergence was recorded as 29.2, 67.4 and 90.9, respectively. This experiment indicated that eggs of *C. cephalonica* can be safely stored for 5 days at 14°C to obtain more than 70% hatching and 90% adult emergence. Eggs cannot be stored for more than three days at 4°C.

Rearing of *Trichogramma embryophagum* on eri silk worm (ESW) eggs

Trichogramma embryophagum, which was continuously reared on *C. cephalonica* when initially exposed to ESW eggs resulted in low per cent parasitism and adult emergence the values being 20 and 2%, respectively. Continuous rearing of *T. embryophagum* for 151 generations on ESW eggs resulted in 92.2% parasitism and 70.7% adult emergence.

Demonstration trial on evaluation of *Trichogramma chilonis* reared on Eri silkworm eggs against borers infesting paddy in Andhra Pradesh

Five releases of *T. chilonis* were made @ 10 cards per release at 10 days intervals. Comparisons were made between control plot, biological control plot and insecticidal control plot. The expenditure in the chemical control plot was Rs 2000 per acre, while in the biological control plot it was Rs 786 per acre.

Field evaluation of *Trichogramma chilonis* reared on ESW and *C. cephalonica* against sugarcane internode borer

In an experiment conducted in VC Farm, Mandya, eight releases of *T. chilonis* were made @ 20,000 adults per release per acre at weekly intervals. The per cent pest incidence in the control, *T. chilonis* (on ESW) released plot and *T. chilonis* (on *C. cephalonica*) released plot were 92, 76 and 68, respectively. The per cent pest intensity recorded were 10.6, 6.1 and 7.7, respectively and infestation index was 9.6, 5.1 and 6.1, respectively.

In yet another experiment conducted in a ratoon crop in a farmer's field at Madla, Mandya, fourteen releases of *T. chilonis* were made @ 40000 adults per release per acre at weekly intervals. The per cent pest incidence in the control, *T. chilonis* (on ESW) released plot and *T. chilonis* (on *C. cephalonica*) released plot were 76, 32 and 20, respectively. The per cent pest intensity recorded were 7.5, 2.1 and 1.1, respectively and infestation index was 6.1, 1.1 and 0.5, respectively.

Recording non Apis bee population from different agro ecosystems

Collections of Apis and non Apis pollinators were made from different crops and wild plants. Dipteran pollinators (Calliphoridae, Syrphidae, Sarcophagidae, Muscidae) and *Apis florea* were the major pollinators in mango. Studies were made on their visitation pattern, duration and time of visit. Non crop plants like *Calotropis* sp., and *Lagerstroemea flos reginae* supports the survival of *Xylocopa* spp. during off season of crops.


Sarcophagid on Mango flower


Calliphorid on Mango flower

Xylocopa on Sunflower


Megachilid on Sunhemp

Pollinators of Mango

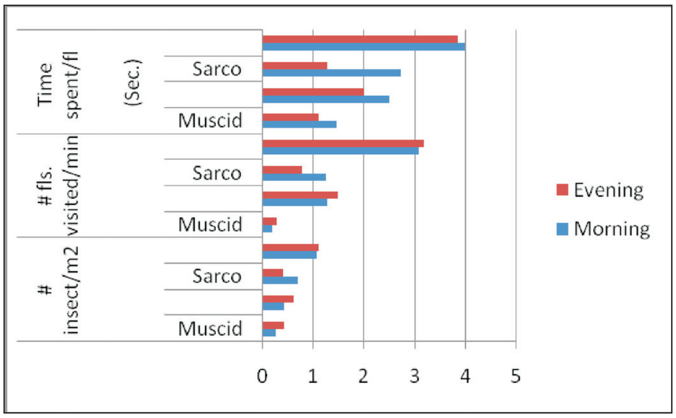


Fig. 23. Pollinator activity in cv. Banganapalli

As a group, dipterans (Muscidae, Sarcophagidae and Calliphoridae) comprised the major non Apis pollinators and *Apis florea* was a dominant pollinator in mango (Fig. 23) and the studies on five mango varieties indicated that Banganapalli and Totapuri Banganapalli) were found to be more attractive to both dipterans and *Apis florea* in terms of number flowers visited per minute and time spent in each flower (3flowers/min: 4sec/fl. by *A. florea* and 1-2 flowers/min: 2-3 sec/fl. There was no significant difference in the visiting pattern of these pollinators across the time of the day (Morning or Afternoon hrs) (Fig. 24).

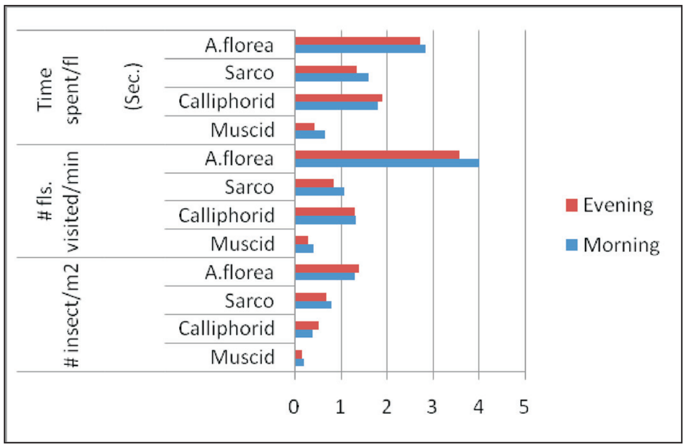


Fig. 24. Pollinator activity in cv. Totapuri

Pollinators of Jamun

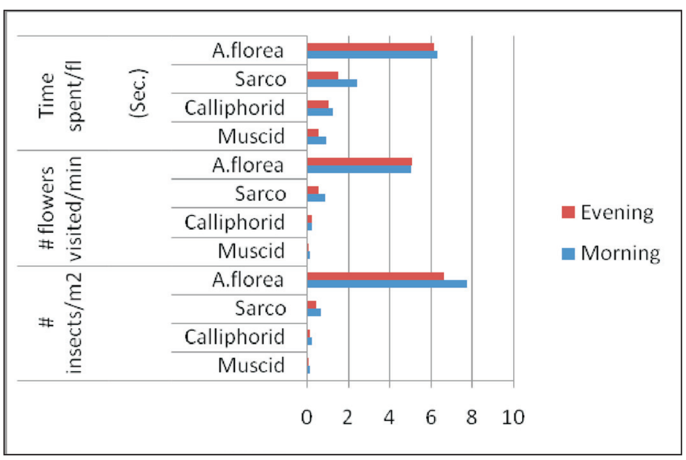


Fig. 25. Pollinator activity in jamun

The major pollinators were similar to mango wherein *Apis florea* is a dominant over dipterans. *A. florea* visited 4-5 flowers/min and spent 6 sec/ flower with a density of 68 bees/ m^2 while dipterans visited 1-2 flowers/min and spent 1-3 sec/fl (Fig. 25).

Pollinators of Sunhemp

Sunhemp is an important green manure crop when allowed for flowering, it attracts a huge population of megachilids and xyloccopids and serves as an excellent conservation strategy for this group of pollinators which are helpful in pollination of other leguminous crops like pigeon pea, field bean etc (Fig. 26).

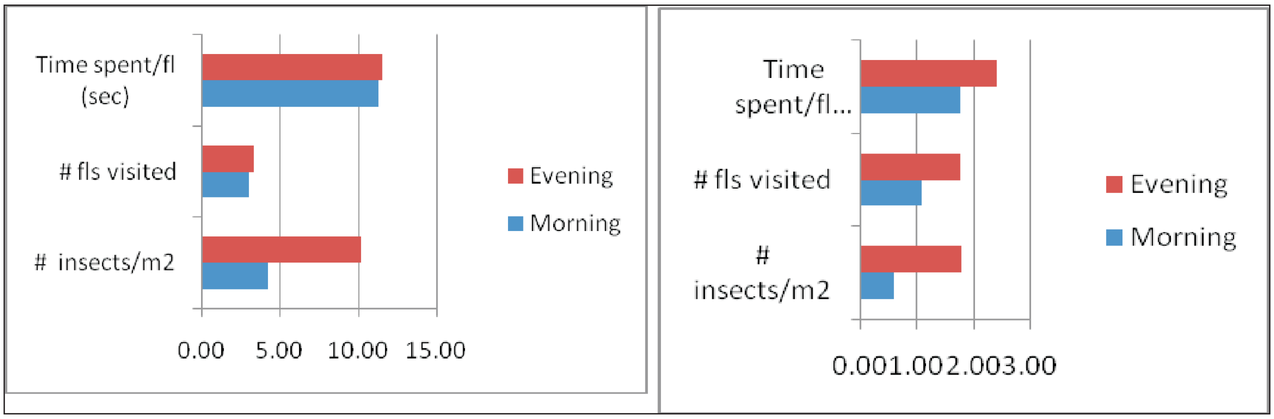


Fig. 26. Activitities of Megachilid and *Xylocopa* activity on sunnhemp

In situ conservation of pollinators

To understand the role of pollinators on enhancement of the yield in pigeon pea and sunflower, a replicated field trial was conducted in Kharif season of 2012 at NBAII Research Farm. Intercropping pigeon pea (cv. TTB–7) 10 rows with marigold (cv. Local) 2 rows and sunflower (cv.KBSH–53) 2 rows and a sole crop of pigeon pea was laid out. In each intercrop, 6 randomly selected pigeon pea plants were covered with nylon net just before flower initiation stage to exclude all the insects including pollinators. Another six control plants adjacent to the bagged plants were tagged for comparison of yield and other parameters. Similarly in sunflower, the capitulam was bagged at the matured bud stage for six plants with their controls adjacent to them for comparison of the yield attributes.

The results indicated that pigeon pea + marigold intercrop was found to be effective in enhancing the yield compared to pigeon pea + sunflower but both intercrops were better than the sole crop. The test weight of pigeon pea increased from 11.8g to 13.8 (pigeon pea + sunflower) and 15.7g(pigeon pea + marigold) indicating the role of pollnators in enhancing the yield.

In sunflower, increase in seed set by 3.7% and 1.04g increase in test weight of seeds in open pollinated condition compared to control (pollinator exclusion) indicated the role of pollinators in yield enhancement.

Climate change and insect diversity

The effect of climate change, with particular reference to the elevated levels of carbon di oxide and temperature on the diversity of insects on pigeon pea was studied under open top carbon dioxoide chambers with the simulated carbon dioxide and temperature levels. The incidence of pests like *Maruca vitrata, Aphis gossypii* and *Orygia leucostigma* was insignificant. However the incidence of *Coccidohystix insolita* was significantly greater in plants grown under elevated levels of CO_2 and temperature (Table. 9).

Semiochemicals for important pests

Two plant based compounds were formulated for the attraction of fruitflies and *Leptocybe invasa,* respectively. The formulation at different doses were used in delta traps as

Table. 9. Diversity of insects on pigeon pea plants under climate change conditions.

	Aphis gossypii	*Maruca vitrata*	*Orygia leucostigma*	*Coccidohystix insolita**
Ambient conditions	0.00	0.26	0.33	19.60
CO_2 500 ppm and ambient temperature	26.33	0.00	0.00	48.83
CO_2 -500 ppm and + 2°C ambient temperature	0.00	0.00	0.00	45.14
CD at 5%	NS	NS	NS	11.67

Number per plant
***percent leaves infested .**
Significant at 5%

attractants for *L. invasa*. The traps efficiently recorded more number of adult *L. invasa* than the control with solvent only. The number of *Bactrocera cariyae* trapped were more in the fruit fly traps baited with the plant compound and is better than the methyl eugenol**.**

Collection and identification of putative insect vectors of phytoplasmas from south India

Leafhoppers and other prospective insect vectors belonging to Hemiptera were collected from Karnataka, Kerala, Odisha and Tamil Nadu during 2012-13. In addition, insect species belonging to all the three sub–orders of Hemiptera, *viz.,* Auchenorrhyncha, Sterno-rrhyncha and Heteroptera, were also observed and recorded on plant species that have been reported to be infected with phytoplasma diseases.

The two commonly occurring leafhoppers, *Hishimonus phycitis* (Distant) and *Amrasca biguttula biguttula* (Ishida) on brinjal were collected from Karnataka, Kerala, Odisha and Tamil Nadu. In addition, four unidentified leafhoppers and a membracid (typical treehopper) were also collected. Also found in small numbers in Bangalore was *Batracomorphus angustatus* (Osborn), a leafhopper earlier suspected to be a vector of Australian lucerne yellows in Australia, but is not a confirmed vector of any disease in India. *Austroagallia sinuata* (Mulsant & Rey) was rarely captured from periwinkle [*Catharanthus roseus* (L.) G. Don] plants in Bangalore, India.

Studies on the natural incidence of little-leaf phytoplasma and its putative insect vectors in brinjal

Late in the growing season, in a non–experimental crop of brinjal (cv. MEBH–11) at the NBAII/Biocontrol Research Farm, Yelahanka, Bangalore, *H. phycitis* population was relatively more (Fig. 27). Unlike in the two preceeding field trials, it was observed in this crop that there was a spatio-temporal correlation between the population of the vector and the little-leaf disease. Collections made at about weekly intervals four times in January 2013 indicated that the population peaked (23 per trap) around the last week of the month. The disease incidence though was just below 2.1%, the infected plants were scattered around the entire crop. It was also evident, from molecular studies conducted later, that brinjal could act as an alternate host for sesame phyllody phytoplasma and that *H. phycitis* could be transmitting the phytoplasma in both brinjal and sesame.

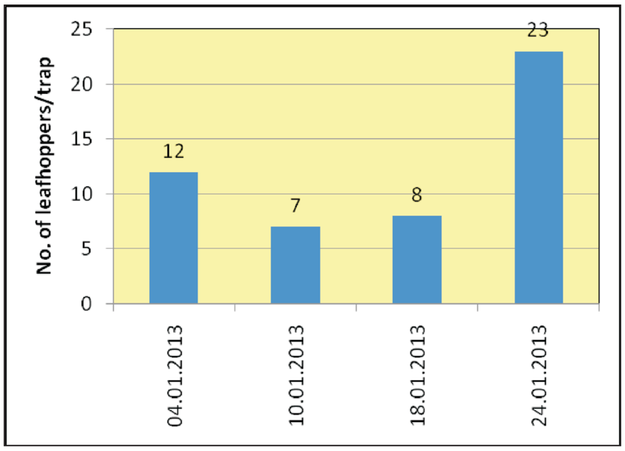


Fig. 27. Trap catches of *Hishimonus phycitis* in brinjal: Non–experimental crop.

Microflora associated with insecticide resistance in cotton leafhoppers (*Amrasca biguttula biguttula*)

Sixteen live populations of *Amrasca biguttula biguttula* were collected from the cotton growing areas of Ludhiana, Guntur (AP), Dharmapuri, Dharwad, Bangalore, Raichur and Srivilliputtur (TN) and one live population of *Nilaparvata lugens* of rice was collected from Hyderabad. Totally fifty two culturable bacteria were isolated from the seventeen live populations of insects and were morphologically and molecularly characterized. The common species identified were *Serratia marcescens, Pantoe anthophila, Lysinibacillus sphaericus, Proteus mirabilis, Staphylococcus pasteuri, Enterococcus silesiacus* and *Enterobacter asburiae.*

Evaluation of fungal pathogens on *Aphis craccivora* in cowpea and *Bemisia tabaci* in tomato and capsicum.

All the nine entomofungal pathogens tested showed lower aphid population (21.37–50.33 aphids/plant) compared to untreated plants (146.26 aphids/plant). Among the nine fungal pathogen isolates tested, Ma-6 & Ma–41 isolates of *Metarhizium anisopliae*, Vl-32 of *Lecancilium lecanii* and Bb–68 of *Beauveria bassiana* showed significantly low aphid population/plant (21.37, 22.85, 26.25 & 28.95 respectively) with a reduction of 65.60–76.61% over control. No significant differences in the natural population of coccinellids were observed in the fungal treated plots and untreated control indicating the safety of fungal pathogens to the natural enemy of cowpea aphid (coccinellids). With regard to yield, significantly higher yields were recorded in the plots treated with Ma-6 & Ma–41 isolates (29.59 & 27.87 grams/plant) compared to control (20.89 grams/plant) other isolates (21.12-26.49 grams/plant) (Table 10).

Table. 10. Effect of fungal pathogens on incidence of cowpea aphid (*A. craccivora*) in cowpea.

Isolate	No. of Aphids/ Plant	% Reduction over Control	No. Coccinellids/ Plant	Yield (g/Plant)
Bb-36	50.33[c]	43.99	1.86	23.16[b]
Bb-68	28.95[a]	65.60	2.10	25.92[b]
Bb-9	37.30[b]	51.96	1.98	22.16[b]
Ma-42	34.21[b]	61.26	2.41	25.68[b]
Ma-41	22.85[a]	71.63	1.71	27.87[a]
Ma-6	21.37[a]	76.61	1.78	29.59[a]
Vl-8	46.76[c]	44.43	1.96	21.12[b]
Vl-12	36.26[b]	50.28	2.51	24.42[b]
Vl-32	26.25[a]	68.22	1.67	26.48[b]
Control	146.26[d]	-	2.36	20.89[b]
CD@5%	8.54	-	NS	6.12

Effect of entomofungal pathogens on *Bemisia tabaci* infestation in tomato and capsicum under protected cultivation

Evaluation of entomofungal pathogens on *Bemisia tabaci* infestation in tomato (variety, NS501) and capsicum (var. Indria) was carried out in the polyhouse at NBAII Farm, Attur with nine isolates of entomopathogenic fungi (*B. bassiana* Bb–36, Bb-68 & Bb-9, *M. anisopliae* Ma–42, Ma–41& Ma–6 and *L. lecanii* Vl–8, Vl–12 & Vl–32) during June-October, 2012. The trial was laid out in RBD with three replications for each treatment with 24 plants for each treatment. Four rounds of foliar sprays with oil formulations of fungal pathogens at a spore dose of $1x10^8$ spores/ml were applied at 15 days intervals during July–September, 2012. Observations on the number of white flies per plant were recorded before and after each spray. Yield of tomato & capsicum/plant was recorded treatment-wise. Among the nine entomofungal pathogens tested, *B. bassiana* (Bb–9 isolate) and *L. lecanii* (Vl–8 isolate) treatments showed significantly lower white fly population in tomato (12.24 & 14.96 whiteflies/plant respectively) and capsicum (6.18 & 7.12 whiteflies/plant respectively) compared to the higher whitefly population in the untreated control (39.84 whiteflies/plant in tomato and 21.36 whiteflies/plant in capsicum) indicating reduction of 69.29 & 62.45% in tomato and 71.17 & 66.67% in capsicum. With regard to yield, statistically significant differences in the yield were not observed in entomofungal pathogen treated plants and untreated control plants.

Effect of chitosan-alginate (CS-ALG) nanoparticles blank and loaded with *Helicoverpa armigera* pheromone (HAP) on *Chrysoperla zastrowi sillemi*

The larvae of *Chrysoperla zastrowi sillemi*, especially the third instar, has a good predation potential on *H. armigera* eggs and larvae in various crops. Toxicology studies were carried out to find the effect of chitosan-alginate nanoparticles (CANPs) blank and loaded with 35 µl *H. armigera* pheromone blend (HAP) on *C. z. sillemi* at different stages of life cycle. The results indicated that survival percentage of larva was highest in control (eggs of *Corcyra cephalonica*) and CANPS alone) while the CANPs incorporated with pheromone and pheromone alone showed lesser survival.

Lateral Funded Projects at NBAII

Microbial Control of Insect Pests-II (Under ICAR-AMAAS Network)

Nine isolates of entomopathogenic fungi belonging to *Beauveria bassiana* (NBAII-Bb-78, 79, 80, 81& 82), *Metarhizium ansiopliae* (NBAII-Ma-56, 57, & 58) and *Paecilomyces* spp. (NBAII-Pfu-10) were isolated from different insect hosts and soils from Banswara (Rajasthan), Almora (Uttarakhand), Thrissur (Kerala), Solan (HP), Panchavati (Middle Andamans) and Davanagere & Mandya (Karnataka) were isolated. Data bases of these nine isolates with regard to cultural & morphological characters, chitinase, protease and lipase activities have been generated. Highly sporulating isolates like, Bb-82, Ma-57 and Pfu-10 were identified.

Promising entomofungal isolates like, NBAII-Bb-23, 45, 14 & 7 and NBAII-Ma-35, 36 & 40 isolates were identified against maize stem borer, *Chilo partellus* which caused 70.0-97.8% mycosis.

Isolates of NBAII Ma-4 and 42 and NBAII Vl-8, 7, 10 & 30 were found to produce toxic proteins effective against *Spodoptera litura*.

Effect of abiotic stresses on the natural enemies of crop pests: *Trichogramma*, *Chrysoperla*, *Trichoderma* and *Pseudomonas*, and mechanism of tolerance to these stresses (NAIP)

The field trials were initiated with multiple insecticide resistant *Trichogramma chilonis* on tomato at Ludhiana (Punjab) and Dhramapuri (Tamil Nadu), brinjal at Dharmapuri (Tamil Nadu) and temperature tolerant strains of *Trichogramma chilonis* on Sugarcane at Surat and Junagadh (Gujarat) at 5-10 acres area with promising results.

Field trials of insecticide tolerant strain of *Chrysoperla zastrowii* sillemi was done at Dharmapuri against the sucking pests on tomato with promising results.

2D electrophoresis and MALDi-TOF analysis revealed that the proteins involved in the stress tolerance in *Trichoderma* were thiol-specific monoxygenease, glucose starvation modulator protein1, phosphoglycerate kinase, lipase 3 precursor, xylulose reductase, glyceroldehyde 3 phosphatase dehyrogenase, HSP70, phosphoglycerate kinase, actin and alcohol dehydrogenase.

The Carbendazim tolerant isolate GJ16B was showing tolerance to 400 ppm Carboxin (Vitavax) and 500 ppm imidocloprid which are commonly used agrochemicals.

Field demonstrations of the selected two formulations (salinity tolerant and Carbendazim tolerant) have been carried out at 5 locations in Gujarat (Mitiyaj, Sindhaj, Kadvachan, Ghusiya of Junagarh), four locations in Karnataka (Udupi district) for the management of seed and soil borne disease of groundnut with the help of KVKs of Zonal Directorates VI and VIII respectively. Field demonstrations at Kolar, Tindivanam, Dharmapuri, Trichy (Zone VIII) and Surat (Zone VI) have been planned for the forthcoming Kharif season.

Multilocational field evaluation was initiated to test the efficacy of *Pseudomonas fluorescens* PFDWD in abiotic stressed soils of Udupi and Gujarat.

Liquid and solid formulations of the abiotic stress tolerant strains have been prepared and shelf-life studies showed that liquid formulations showed higher cfu even after two months of storage.

As promising salinity (P43) and drought tolerant (P17) were identified as *Pseudomonas aeruginosa,* further tested for pathogenic nature. AlgD, pilB, nan1, lasB, plcH, exoS and exoU were amplified by designing of primers in these stress tolerant isolates. P43 has *alg*D, *las*B and *plc*H genes and P17 lacked all the genes.

Identification of Nucleopolyhedrovirus (NPV) encoded proteins and small RNAs and the feasibility of their expression in plant to control *Helicoverpa armigera* (NFBSRA)

Collection of *Helicoverpa armigera* from all over India, *viz*, Punjab, Rajasthan, Gujarat , Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu was carried and 12 populations were deposited and maintained.

With the LC_{50} and LC_{90} values obtained after conducting the bioassay for the different *H. armigera* populations collected, the subsequent virus population obtained was collected, purified and each virus was used to set up bioassay against all the *H. armigera* populations available. This enabled to study the infectivity factor of each viral population in response to different *H. armigera* population (Ludhiana, Bangalore, Sriganganagar, Nanded, Nagpur,

In continuation to the characterization of the conserved gene regions in HaNPV genome, the Inhibitor of apoptosis gene and the ss DNA Binding protein encoding gene were amplified. All the amplicons were amplified based on the hot-start PCR method.

The least virulent and the most virulent NPV populations were identified based on the LC_{50}

values calculated from the bioassays set against all the population. Both viral populations have been subjected to the whole genome sequencing to analyze and study the variations (if any) visible at the gene level. The transcription level studies will also be conducted subsequently based on the results obtained from the whole genome sequencing.

Establishment of National Agricultural Bio-informatics Grid in ICAR

Data mining for about 8000 records pertaining to the Insect Genome related sequences like

whole genome, ITS, EST, Protein, Gene, Barcode, etc. was done.

Information on 400 insect pests infesting pulses, vegetables, fruits, tuber, plantation, spices and condiments, tobacco, ornamental, jatropha, mulberry, green manure, etc. were collected. The information on classification, field identification, nature of damage, key natural enemy, distribution map and gene sequences was documented.

iGenBank database was developed for insect genomic information. About 1000 records were updated in the database.

IBIn and Insect pest info base website's GUI were upgraded including the functionalities of efficient search engine and Pie charts of statistical data were created. Barcode generator tool, separate login for users, administrator and reviewers and conformational email system were created.

iGenomicTools developed were DNA to Protein translation with ORF finder, Customized Genetic Code, Alignment options, Customized number of frames, Minimum Size of Protein translation, masking option of Non-Coding region, etc.

Comparative studies were carried out on different HSPs and insecticide resistant genes across the insect orders.

Eco-friendly approaches for the management of Coffee white stem borer, *Xylotrechus quadripes* Chev. (Coleoptera: Cerambycidae) (Coffee Board)

Nano formulations of pheromone containing 25 mg and 50 mg of pheromone was tested at Balehannur, Chettahalli and Thandikudi in comparision with standard pheromone (75mg). The results indicated that the pheromone 75mg continued to trap more adults in all the three locations with less trap in other nanoformulations. A kairomone formulation based on the volatiles from Coffee Arabica was developed and tested as trap at Chettahalli. Though adults could be trapped, the number of adults trapped were less than the pheromone traps. The entompathogenic nematode strains, were tested agains the larvae of *Xylotrechus quadripes* and *Heterorhabditis indica* was very effective interms of least LC 50 values. *Parallorhogas pallidiceps* (Perkins) Hymenoptera: Braconidae) a larval parasitoid was attempted for rearing on Galleria with no success.

Influence of Eucalyptus species on the natural enemy incidence on the gall wasp *Leptocybe invasa* (IFGTB)

Based on the earlier studies, a kairomone dispenser was developed and field tested in eucalyptus gardens at Kolar and other areas. The number of adults of *L. invasa* trapped were more in the traps.

Nanoparticles for enhancing shelf life/storage and field application of semiochemicals (DBT)

The non target effect of nanoformuations on the larvae of aphid lion, *Chrysoperla zastrowi sillemi* was done using nanoformulations containing the pheromone through contamination method. The results based on the mortality of larvae and histopathological studies indicated that the larvae fed with nanogel alone showed no harmful effects, however the larvae fed with nanogel containing pheromone showed more mortality and histopathological changes.

All India Coordinated Research Project on Biological control

Evaluation of *Trichogramma* strains for searching efficiency, temperature tolerance and fecundity.

All the populations of *Trichogramma* could tolerate temperatures up to 30°C under laboratory conditions. The isofemale lines of *Trichogramma* had relatively lower fecundity, *viz.,* Sirsa, Haryana (61), Ballabhgarh, Haryana (85), Nawanshahr, Punjab (98), Morinda, Punjab (98) and Silao and Bihar (46).

Pest surveillance in Kerala

Random surveys were undertaken in various districts of Kerala *viz.,* Trivandrum, Kollam, Kottayam, Alappuzha, Ernakulam and Kasaragod to record incidence of pest and natural enemies. Red palm weevil (5–7%) was the major pest problem in southern districts causing death of the palm. Eriophyid mite incidence ranged from 8–20% in various locations. Outbreak of black headed caterpillar was reported from Kottayam and Trivandrum. In addition special surveillance at quarterly interval was conducted near airport and sea port areas to locate incidence of invasive pests on coconut. The invasive pest *Brontispa longissima* was not reported from any of the areas surveyed during the year.

The entomopathogens *viz*., *Oryctes rhinoceros* nudivirus and *Metarhizium anisopliae* were field collected from Alappuzha and Kollam districts. Natural enemies of coconut black headed caterpillar include *Apanteles taragamae, Goniozus nephantidis, Bracon brevicornis* and *Brachymeria* spp. from both the infested locations. No natural enemy could be collected from red palm weevil. Predatory mites *viz., Neoseiulus baraki, N. paspalivorus, Typhlodromus* sp., *Chelacaropsis moorei* and *Bdella* sp. were collected from all locations with predominance of *N. baraki* in 60–80% nuts. Spiders were collected from coconut ecosystem and sent for identification.

Pest surveillance in Andaman Islands

Survey was conducted in Havelock Island, CARI farm, Siphighat farm and Kurmadera coconut farm for recording the incidence of various pests infesting coconut. Among the key pests infesting coconut, rhinoceros beetle (*Oryctes rhinoceros*) was recorded in 1-2% of palms with negligible damage on leaves. Eriophyid mite incidence was very low (only recorded in one Andaman Yellow Dwarf palm). Rodent damage on nuts was found to be <10% in the surveyed gardens. No incidence of red palm weevil was recorded in the survey. Damage by leaf eating caterpillar, white grub as well as the invasive pest, *Brontispa longissima* was not intercepted during the survey. In the coconut nursery at CARI farm, lace bugs (*Stephanitis typica*), spiralling whitefly (*Aleurodicus dispersus*), coconut scale (*Aspidiotus destructor*), bagworms and slug caterpillar (*Thosea* sp.?) were recorded at low level of infestation. Damage by lace bugs leading to typical white speckles on the rabbit ear leaf of coconut seedlings as well as the adult lace bugs @ 1–3 adults/ leaf was observed. Presence of the natural enemies *viz*., lady beetles (*Chilocorus nigritus*) and *Cybocephalus* sp. and spiders were also recorded.

In the Siphighat farm, colonies of palm aphid (*Cerataphis brasiliensis*) were observed on the undersurface of coconut as well as arecanut seedlings. In addition, coconut moth, *Batrachedra arenosella* Walker (Lepidoptera: Cosmopterygidae) was found inside the unopened and opened coconut inflorescence especially on the anther and pollens. Niu Lekha variety was found to be more susceptible compared to other varieties. Damage by coconut moth was also observed at Wandoor area on Andaman Green Dwarf. Occurrence of the caterpillar was observed on the harvested nuts at Kurmadera farm thereby warranting strict quarantine measures when nuts are transported to mainland. During a general observation on the ornamental palm, *Washingtonia* sp. stellate scale, *Vinsonia stellifera* was recorded from one of the palms in Port Blair.

Pest surveillance in Minicoy (Lakshadweep)

Surveys conducted in Lakshadweep Islands did not reveal the presence of the invasive pest, *Brontispa longissima.* Minor occurrence of inflorescence moth, *Batrachedra arenosella* was reported from coconut varieties Laccadive ordinary and LCOD. Rat (*Rattus rattus*) is the major pest of coconut in the island causing damage of 33-44% in Minicoy. Gangabondam was highly preferred by *R. rattus* followed by Laccadive Orange Dwarf, Laccadive Green Dwarf and Laccadive Yellow Dwarf.

Survey indicated that the damage caused by *Oryctes rhinoceros* in the island less than 5%. (4.3% in Laccadive Green Dwarf, 2.6% in Laccadive Ordinary Tall and 3.7% in Laccadive Yellow Dwarf). Periodical and timely augmentation of *O. rhinoceros* nudivirus in Lakshadweep Island was found effective in the bio-suppression of *O. rhinoceros*.

Scale insects of coconut and their natural enemies

Four different types of scale insects *viz*., coconut scale, *Aspidiotus destructor* Signoret (Diaspididae: Hemiptera), pink wax scale, *Ceroplastes rubens* Maskell (Coccidae: Hemiptera), mussel scale, *Lepidosaphes* sp. (Diaspididae: Hemiptera) and a soft scale, *Lecanium* sp. (Coccidae: Hemiptera) were recorded feeding on coconut leaflets/nuts. Mealybug *Planococcus* sp. (Pseudococcidae: Hemiptera) was also found feeding on the under surface of the coconut leaflets. Two different species of lady beetles *Chilocorus subindicus* Booth and *Scymnomorphus* sp. (Coccinellidae: Coleoptera) were found predating on coconut scale. In addition one more effective predator *viz*., *Cybocephalus* sp. (Cybocephalidae/ Nitidulidae: Coleoptera) was also recorded.

Papaya mealy bug (*Paracoccus marginatus*)

Good establishment of the parasitoid of papaya mealy bug, *Acerophagous papayae* as well as the predatory caterpillar, *Spalgius epius* was observed in the CPCRI farm in most of the mealybug infested papaya plants. The population of *Acerophagous papayae* was so high that the parasitoids were collected and released in other areas.

Pest surveillance in Cumbum and Colachel (Tamil Nadu)

Coconut scale insect, *Aspidiotus destructor*, star scale, *Vinsonia stellifera*, soft scale, *Lecanium* sp., wax scale. *Ceroplastes* sp. and the mealybug, *Pseudococcus cryptus* were recorded at moderate levels of infestation. In addition the whitefly, *Aleurocanthus arecae* and spiralling whitefly, *Aleurodicus dispersus* were also observed at low levels. These sucking insect pests were naturally suppressed by *Chilocorus nigritus* as well as cybocephalid beetles in the coconut. Occurrence of plant hopper, *Proutista moesta* was recorded in certain pockets with coconut root (wilt) disease. Rat damage was found to be quite severe in the garden with sporadic incidence of leaf damage by black beetle.

At Colachel, mealybugs, *Pseudococcus cryptus,* coconut scale, *Aspidiotus destructor* and wax scales, *Ceroplastes* sp. were recorded at low levels. These sucking pests were naturally suppressed by biotic agents. *Proutista moesta* and *Stephanitis typica* could be located at random in the coconut gardens. Infestation by red palm weevil was also recorded in a few gardens (<0.5%).

Pest surveillance in NEH region (Assam and Meghalaya)

Surveys were conducted in Morigaon, Kamrup and Goalpara districts of Assam, Ri–Bhoi and East Garo Hills of Meghalaya with emphasis on invasive pests. The invasive pest *Brontispa longissima* was not reported from any of the areas surveyed. Pest problems identified are minor incidence (<1%) of red palm weevil and low to medium (20–30%) incidence of eriophyid mite. Minor incidence of mealybugs, white fly, *Aleurocanthus arecae* and scale, *Aspidiotus destructor* were also recorded from juvenile and young palms which were naturally bio-suppresed by lady bird beetles especially *Chilochorus* spp. Mealy bug (*Paracoccus marginatus*) infestation was recorded as very severe in papaya in all the areas surveyed in Assam and Meghalaya

Sugarcane

Monitoring the sugarcane woolly aphid (SWA) incidence and impact assessment of natural enemies on its bio suppression (MPKV, TNAU, UAS-Raichur)

The sugarcane woolly aphid incidence and occurrence of natural enemies (*Dipha aphidivora, Micromus igorotus, Encarsia flavoscutellum,* syrphid, spider) were recorded during June 2012 to March, 2013 at five agro-ecological zones of western Maharashtra covering Pune, Satara, Sangli, Kolhapur, Solapur, Ahmednagar, Nashik, Nandurbar, Dhule and Jalgaon districts. The SWA incidence, pest intensity rating (1-6 scale) and natural enemies population were recorded at five spots and five clumps per spot from each plot during crop growth period. The pest incidence was recorded in riverside and canal areas in 10 tehsils from Pune region during July to December, 2012. The SWA incidence was also noticed in Satara, Sangli and Kolhapur areas in Krishna and Panchaganga riverside fields; its intensity was low in Ahmednagar and Jalgaon districts and very low in the remaining parts of western Maharashtra. The average pest incidence and intensity were 0.44 per cent and 1.39, respectively. The natural enemies recorded in the SWA infested fields were mainly predators like *Dipha aphidivora* (0.5-2.3 larvae/leaf), *Micromus igorotus* (1.2-5.1 grubs/leaf), syrphid, *Eupoderes confractor* (0.03-1.1 larvae/leaf) and spider (0.02-0.5 per leaf) during August to November, 2012 on 7 to 10 month-old canes. The parasitoid, *Encarsia flavoscutellum* was observed in Pune and Satara districts. These natural enemies were found to be distributed and established well in sugarcane fields and regulated the SWA incidence in western Maharashtra.

The sugarcane woolly aphid incidence and occurrence of natural enemies (*Dipha aphidivora, Micromus igorotus, Encarsia flavoscutellum,* syrphid and spider) were recorded from different agro-ecological zones of Tamil Nadu and correlated with abiotic factors. The Sugarcane woolly aphid incidence and occurrence of natural enemies were recorded from July 2012 to February 2013 from seven major sugarcane growing districts covering different agro ecological zones of Tamil Nadu *viz.*, Coimbatore, Erode, Salem, Cuddalore, Karur, Vellore and Tirunelveli at monthly basis. The pest incidence and the natural enemies were not noticed during July-September 2012. The SWA was noticed in patches and the occurrence of *Encarsia flavoscutellum*, *Dipha aphidivora* and *Micromus igorotus* was observed along with the population of SWA thereafter. A maximum of 68.2 *Encarsia*/ leaf was observed in Coimbatore during December 2012. SWA incidence was noticed in all the locations from September-

October 2012 to January 2013. *Dipha* and *Micromus* populations were also observed during October 2012 to January 2013.

Field evaluation of *T. chilonis* produced using Eri-silk worm eggs host against early shoot borer of Sugarcane (ANGRAU, TNAU, NBAII)

Eri silk worm eggs can be used as a factitious host for mass production of the available strains of trichogrammatids under laboratory condition. The efficiency of *T. chilonis* produced using Eri silk worm eggs was compared with the parasitoids produced using *Corcyra* eggs in the field evaluation against sugarcane internode borer with release of *Trichogramma* reared on Eri Silk worm eggs or on *Corcyra* eggs @ 20,000/acre. The release was made at weekly intervals for 8 weeks after 4th month of planting. Preliminary laboratory studies showed that difference in parasitisation between *Trichogramma* reared on Eri silk worm eggs and that reared on *Corcyra* eggs was only five percent.

There was a significant reduction in the incidence and intensity of damage due to internode borer (INB) infestation by the release of *Trichogramma chilonis* reared on Eri Silk worm eggs @ 20,000 / acre and release of *Trichogramma chilonis* reared on *Corcyra* moth eggs @ 20,000/ acre than the unreleased fields. The level of damage due to INB was low in the both the parasitoid released plots whereas it was significantly high in the unreleased field. Similarly, the intensity of damage in the parasitoid released fields was significantly lower as compared to the unreleased plots. After eigth release, the release of *Trichogramma chilonis* reared on Eri Silk worm eggs @ 20,000/acre recorded significant reduction of INB (5.4%) as compared to release of *Trichogramma chilonis* reared on *Corcyra* eggs @ 20,000/ acre (7.2%). The untreated control recorded higher INB incidence (21.8%).

Cotton

Monitoring the diversity and outbreaks of sap sucking pests, mirids and their natural enemies in *Bt* cotton (MPKV, UAS–Raichur)

The incidence of aphids was recorded from 1st week of August 2012 (33rd MW), whereas jassids, thrips and white flies were observed during 3rd week of August 2012 (35th MW). Mites were noticed from 4th week of September 2012 (40th MW). Initially, the pests population was low but it increased gradually from 40th MW. The peak incidence of jassids and thrips was recorded during 1st week of November 2012 (46th MW) and white flies in subsequent fortnight (48th MW). The aphid population was maximum during 2nd week of January 2013 (2nd MW). The incidence of mealybug and mirids were not observed throughout the crop growth period. Coccinellids, *Menochilus sexmaculata* Fab., *Coccinella septempunctata* Linn. and spiders were recorded from 1st week of September 2012 and their population recorded maximum during 3rd week of November 2012 (48th MW). The chrysopid *Chrysoperla zastrowi sillemi* Esb. observed from the last week of September (40th MW). All these predators were recorded till harvest of the crop. Besides, the farmers' plots were also surveyed from September to November 2012 but the incidence of all these sucking pests was comparatively low in *Bt* cotton plots due to stress conditions during this year. (MPKV)

Among various sucking insect pests, leafhoppers was maximum during September to October. Thrips population reached peak during August and was low during December month. In general, whiteflies population was low during the season. Maximum mirid bug population was recorded in December. Similarly, the activity of mealybug was noticed on first week of

December and continued till January and the peak activity of parasitoid was noticed on January second week. **(UAS, Raichur).**

Rice

Seasonal abundance of predatory spiders in rice ecosystem (AAU-A, AAU–J, ANGRAU, KAU, TNAU)

Collection was made during morning hours during *kharif*. In Gujarat, a total of 36 species were collected. Highest species richness was observed for *Neoscona theisi* (133) and *Leucauge* sp. (133) followed by *Cyrtophora cicatrosa* (72), *Argiope* sp. (72), *Tetragnatha javana* (72), *Argiope anasuja* (65) and *Leucauge decorate* (65) as evident from the collections.

Oxyopes javanus, Tetragnattha sp., Lycosa psedoannulata, Argiope catanulata, Uluborous spp. *Tomisus* spp. *Neoscona* spp. were observed from Assam. The population of predatory spiders was maximum during September to mid of October (2012) Among the different spiders *Oxyopes* spp. was recorded maximum followed by *Argiope* spp, *Tetragnatha* spp and *Lycosa* spp. Data collected from different rice field was analysed to know the species richness, species diversity and species evenness for each predatory species. (AAU-J).

Nine genera of spiders were collected during the *kharif* from five locations in Rajendranagar. A total of nine genera were recorded. Species Diversity (Shannon Weiner Index) (H) was found to be 1.91. *Oxyopes* sp. was found to be the most abundant genus with a relative abundance of 0.27 followed by *Tetragnatha* sp. with a relative abundance of 0.25. *Neoscona* sp. was the least abundant with a relative abundance of 0.02. Species evenness was 0.87. and Spider density ranged between 1.36–6.00/sq.m. with an average of 3.68/sq.m. In *rabi*, Species Diversity (Shannon Weiner Index)(H) was found to be 1.29. A total of 5 genera were recorded. *Tetragnatha* was found to be most abundant genus with a relative abundance of 0.41 followed by *Oxyopes* with 0.3. *Thomisus* and *Atypena* were found to be least abundant with a relative abundance of 0.03. Spider density ranged from 12.28–17.76 spiders/sq.m.with an average of 15.02/sq.m. (ANGRAU)

Ten species of spiders were identified and *Pardosa pseudoannulata* was seen in large numbers. (KAU).

Evaluation of IPM for upland rice pests and diseases (CAU)

At Sille, no significant difference was observed between IPM practice and untreated control in stem borer infestation during the vegetative stage of the crop. However, at reproductive stage, the per cent white earhead (WEH) in the IPM field was significantly lower than the untreated control (6.08 per cent WEH). Lowest incidence of stem borer was recorded in the farmer's practice. At Pasighat, significantly lower infestation of stem borers in the IPM field than the untreated control was recorded from 65 DAT onward. Similar with the observation at Pasighat, significantly lower incidence of stem borers in the IPM field than the untreated control was recorded from 65 DAT onward at Mebo. At 85 DAT, the incidence of stem borers in the IPM field (2.37 per cent WEH) was even comparable with the farmer's practice (1.41 per cent WEH).

No significant difference was observed between the farmer's practice and IPM practice in the infestation of rice gundhi bug in all the three locations except at 105 DAT at Sille. However, the mean per cent grain infestation between the farmer's practice and IPM practice were comparable in all the locations. Significantly higher infestation of rice gundhi bug was recorded in the untreated control than the other two treatments. Highest grain yield of 46.55q/ha was recorded in farmer's practice followed by IPM practice (43.65q/ha) at Sille. Similarly, at Mebo also, the grain yield of Farmer's practice (42.51q/ha) was comparable with the IPM (40.66q/ha). However, at Pasighat, Farmers practice (43.84q/ha) gave significantly higher yield than the IPM practice (40.37q/ha).

Pulses

Evaluation of NBAII liquid formulations (PDBC-BT1 and NBAII-BTG4) and IARI *Bt* against pigeon pea pod borer (*Helicoverpa armigera*) and legume pod borer (*Maruca testulalis*) (AAU-A, ANGRAU, MPKV, PAU, TNAU, JNKVV, UAS-Raichur)

Larval population of *H. armigera* recorded at 7 and 14 days after treatment (DAT) in Anand indicated that minimum number of larvae was registered in plots treated with NBAII-BT G4 @ 1% followed by chemical insecticide, PDBC–BT–1 @ 2%, NBAII–BT G4 @ 2%, IARI *Bt* isolate @ 2%, and IARI *Bt* isolate @ 1%. All the *Bt* based formulations performed equally effective against *H. armigera*. The pooled results for 3 sprays indicated that all the treated plots registered significantly less number of *H. armigera* larvae than the untreated control. All the microbial insecticides were equally effective in suppressing the incidence of the pest, however, relatively lesser population of *H. armigera* larvae was found in PDBC–BT1, IARI *Bt* isolates, and NBAII–BT G4 sprayed at 2% concentration.

All the *Bt* based treatments performed equally effective and found comparable with the treatment of chemical insecticide at 14 DAT. The pod damage (7.92 to 58.92 %) recorded at harvest showed that the treatments of NBAII–BT G4 @ 1%, NBAII–BT G4 @ 2 %, PDBC–BT1 @ 2% and IARI *Bt* isolate @ 1 and 2% found equally effective,

Grain damage recorded at harvest revealed that the plots treated with chemical insecticide registered significantly low incidence of *H. armigera* in comparison to microbial insecticides. In all the *Bt* based microbial insecticides grain damage ranged from 7.62 to 10.77% and was at par. *B. bassiana* applied @ 1.5 and 2.0 kg/ha proved inferior in suppressing the pest incidence. Maximum grain yield (1832 kg/ha) was registered in plots treated with chemical insecticide followed by NBAII–BT G4 2% (1750 kg/ha) and 1% (1695 kg/ha). Both the doses of NBAII–BT G4 produced significantly higher yields than *Beauveria bassiana* and NSKE @ 5%.

At PAU Ludhiana, the population of *H. armigera* larvae was lowest (0.33) in NBAII–BtG4 2% treated plot and was at par with NBAII–BtG4 1%, Bt1 1%, Bt1 2%, Bb @ 2.0Kg/ha and chemical control and were significantly better than other treatments. Lowest pod damage (8.0%) due to *Maruca testulalis* was recorded in Bt1 2% which was at par with Bt1 1% (8.66%), NBAII– BtG4 1% (9.71%), NBAII–BtG4 2% (9.19%), Bb @ 2.0 Kg/ha (9.28%) and chlorpyriphos 0.04% (10.05%). Seed damage was lowest (17.30) in NBAII BtG4 1%. The grain yield in BtG4 2% treated plot was maximum (11.75 q/ha) and was at par with Bt1 (2%) (10.85q/ha).

At TNAU, BTG4 @ 2% spray, PDBC-BT1 @ 2% spray, and chlorpyriphos 0.04% were highly effective in reducing the larval population of *H. armigera* and *M. testulalis* in all stages *viz.*, pre–flowering, post flowering and pod emergence with lesser pod and seed damage and recording higher yield NSKE 5%, *B. bassiana* @ 2 kg/ha. and *B. bassiana* @ 1.5kg/ha were moderate in managing the pest population and were significantly better than control.

NBAII BTG 4 *Bt* @ 2g/lit was found effective in the experiments conducted at UAS, Raichur which recorded minimum pod damage of 14.38 per cent and it was statistically superior. The NBAII BTG 4 *Bt* @ 1g/lit recorded 16.49 per cent pod damage and was on par with all the dosages of PDBC *Bt* 1 @ 2g and 1g/lit which recorded 15.72. Untreated control recorded maximum pod damage of 27.35% while, NBAII BTG 4 *Bt* recorded minimum seed damage of 1.14%. NBAII BTG 4 *Bt recorded* higher grain yield of 10.49 q/ha which was on par with PDBC *Bt* 1 @ 2g/lit (10.18 q/ha).

Influence of crop habitat diversity on natural enemies in pigeonpea through FLD/OFD (ANGRAU, MPUAT)

Among the three modules tested, pigeonpea module with sorghum as the border crop and sunflower as the intercrop recorded least population of *H. armigera* larvae compared to the pigeonpea module with maize as the border crop and sunflower as the intercrop and the sole pigeonpea module. It also recorded maximum population of coccinellids compared to the pigeonpea module with maize as the border crop and sunflower as the intercrop and the sole pigeonpea module. The population of predatory stink bugs was more in the pigeonpea module with sorghum as the border crop and sunflower as the intercrop than pigeonpea module with maize as the border crop and sunflower as the intercrop and the sole crop. Yield was better in the pigeonpea module with sorghum as the border crop and sunflower as the intercrop than the other two modules respectively.

Oil seeds

Biological suppression of safflower aphid, *Uroleucon compositae* (ANGRAU, MPKV)

Verticillium lecanii was better than *Metarrhizium anisopliae* and *B. bassiana* in bringing down the population of *U. Compositae. V. lecanii* was on par with neem oil and together they were on par with the insecticidal check on its lower side in recording minimum aphid population (65–123 aphids/10 plants) and maximum yield (469–509 kg/ha). Control recorded maximum aphid number (413–435 aphids/10 plants) and minimum yield (245 kg/ha) (AGRAU).

An experiment comprising release of *C. zastrowi sillemi* @ 5,000 grubs/ha, spraying of *Verticillium lecanii, Beauveria bassiana, Metarhizium anisopliae* each @ 10^{13} conidia/ha, NSKE 5% suspension, insecticidal check dimethoate 30EC @ 1.45 ml/l and untreated control. Two releases of *Chrysoperla* and three sprays of remaining treatments were given at fortnightly intervals. Three sprays of dimethoate @ 1.45 ml/lit at fortnightly interval were significantly superior over other treatments in suppressing the aphid population (4.4 aphids/5 cm apical twig) on non–spiny variety of safflower and increased the yield (11.2 q/ha) (MPKV).

Biological control of groundnut pests (OUAT)

The pre treatment incidence of *S. litura,* leaf miner and hairy caterpillars varied from 4.2 to 5.2,3.9 to 4.9 and 0.4 to 1.2 larvae/10 plants. Insecticidal treatment recorded the lowest pest population in all cases with 0.7,0.4 and 0.1 larvae of *S. litura,* leafminer and hairy caterpillar, respectively. In case of *S.litura,* incidence in *Sl*NPV treatment (0.9) was at par with the insecticidal treatment (0.7). Treatment of *Bt* (1.4) and *B. bassiana* (3.0) *Trichogramma* (4.0) and NSKE (4.5) treatments were not significantly effective against this pest. Against leafminer, *Bt* treatment (0.9) was at par with the insecticidal treatment (0.4) followed by *Trichogramma* (2.7) and NSKE (2.9). In case of hairy caterpillars, insecticide treatment recorded the lowest pest incidence (0.1) followed by *Bt* (0.4) and NSKE (0.6).

*Sl*NPV against *S. litura* was next to insecticide (0.2) followed by *Bt* (0.4). Against leafminer and hairy caterpillar, Bt (0.3) treatment followed the insecticide treatment. The yield was highest in insecticidal treatment (21.17 q/ha) followed by Bt (18.97 q/ha). Releases of *Trichogramma* was also responsible for good yield with 17.28q/ha. Control plots had the yield of 7.98 q/ha.

Evaluation of entomopathogens and botanicals against soybean pest complex (MPKV)

Three sprays of *Sl*NPV @ 250 LE/ha (1.5 x 10^{12} POBs/ ha) was significantly superior in suppressing the larval population of *S. litura* (3.0 larvae/m row) with 78.5 per cent mortality and gave maximum of 21.6 q/ha yield of soybean. The PKV strain of *N. rileyi* showed av. 3.3 surviving larval population of *S. litura* per m row with 62.5 per cent mortality and 19.8 q/ha yield followed by NBAII strain.

Coconut

Surveillance and need-based control of coconut leaf caterpillar, *Opisina arenosella* in Kerala (CPCRI)

Incidence of *Opisina arenosella* was noticed in Puthiyavila (Trivandrum) with leaf infestation of 59.6% and population of 141/100 leaflet. Awareness campaign was conducted in the area with collaboration of Parasite Breeding Station, Trivandrum and Dept. of Agriculture, Kerala. Regular monitoring and release of stage specific parasitoids resulted in 55.7% reduction of leaf damage and 94% reduction in pest population over a period of 8 months. Outbreak of *O. arenosella* was also noticed in Kallara (Kottayam) region during August 2012 with leaf infestation of 83.4% and pest population 288/100 leaflets. Systematic monitoring and release of larval parasitoids *viz., Goniozus nephantidis* and *Bracon brevicornis* could reduce leaf damage (42%) and pest population (93%) in a period of 7 months.

Scaling up and utilization of *Metarhizium anisopliae* through technology transfer (CPCRI)

Area wide community adoption of management practices for rhinoceros beetle was evolved and implemented in 520 ha covering more than 5500 farmers and about 1 lakh palms. The social process was enumerated through effective linkages and networking with stakeholders, community based treatment of rhinoceros beetle breeding sites with *M. anisopliae* (farm level production by women farmers group) was done in the entire 17 clusters (wards) of Edava Grama panchayat.

The technology of treating breeding sites with *M. anisopliae* was integrated with other ecofriendly IPM practices *viz.,* incorporation of *Clerodendron infortunatum* in the breeding sites, phyto sanitation and prophylactic leaf axil filling of juvenile and young palms with botanicals admixed with sand. The impact analysis indicated reduction of pest incidence in all the clusters proving the effectiveness of community adoption against this ubiquitous pest. The leaf damage reduced by 55.2% which was statistically significant at 1% level. The knowledge and skill of farmers also improved by more than 60%. Farmer to farmer technology dissemination was achieved through trainings (18 trainings), sharing of experience, media publicity and providing 500 packets of *M. anisopliae* at low cost for farmer groups in four districts.

Tropical Fruits

Field evaluation of *Metarhizium anisopliae* against mango hoppers (ANGRAU, MPKV)

Results after three sprays indicated that weekly sprays of *M. anisopliae* @ 1 X 10^9 spores/ml could reduce population of hoppers on mango effectively. Population of hoppers in treatments where off-season spray of

M. anisopliae @1x$10^9$was given was on par with treatments where no offseason spray was given and the treatment where *M. anisopliae* was used at 1x10^7 spores/ml. All the three treatments recorded 2.6–2.7 hoppers/inBoresence. The chemical spray however, recorded least population (0.5 hoppers/inflorescence), while the control recorded maximum population (6.3 hoppers/inflorescence). No added advantage of the offseason spray was observed (ANGRAU).

In Maharashtra spraying of *M. anisopliae* @ 1x10^9 spores/ml during off-season in the month of December followed by four sprays of the pathogen mixed with adjuvant (sunflower oil 1 ml/lit + Triton-X 100 @ 0.1 ml/lit) at weekly interval during flowering found significantly superior over other treatments in suppressing the hopper population and increased fruit setting. The mean surviving population was recorded as 10.4 hoppers and 12.1 fruit sets per inflorescence in this treatment as against 52.1 hoppers and 6.0 fruits set of mango per inflorescence in untreated control block. (MPKV).

Biological suppression of mealybugs, *Maconellicoccus hirsutus* and *Ferrisia virgata* with *Scymnus coccivora* on custard apple (MPKV)

Two releases of *Scymnus coccivora* @ 10 grubs per infested tree at monthly interval during July-August 2012 found to be significantly superior in suppressing the population of mealybug species *viz.*, *M. hirsutus* (9.8 mealybugs/fruit) and *F. virgata* (3.3 mealy bugs/fruit) in custard apple orchards and increased yield of marketable fruits (34.1 kg/tree). It was, however, at par with similar releases of *Cryptolaemus montrouzieri* @ 5 grubs per infested tree. The pest intensity rating was recorded low (1.0–1.1) in orchards with these treatments. (MPKV).

Economic analysis of impact of release of *Acerophagus papayae* on papaya production, seed production, papain industry, mulberry and tapioca (TNAU)

The yield loss caused by *Paracoccus marginatus* and economic analysis was computed on papaya, mulberry and tapioca during this year.

1. Yield of papaya fruits/ha (First flush): av. 40 fruits/plant x 2,500 plants

   = 1, 00,000 fruits

   Yield on weight basis : av. 1.0 kg/fruit x 1, 00,000 fruits = 1, 00,000 kg/ha

   (Considering the weight fruits 1.0 kg/fruit in first flush)

2. Market value of papaya fruits (per ha) : av. Rs. 5/- per kg fruit x 1,00,000 kg = Rs. 5,00,000/- (The current market rate is Rs. 5 per kg of fruit)

3. Yield of papaya fruits from second flush/ha : av. 30 fruits/plant x 2,500 plants

   On number basis = 75,000 fruits/ha

   On weight basis = 1.0 kg/fruit x 75,000 fruits

   = 75,000 kg/ha

4. Market value of papaya fruits in the second flush (per ha): av. Rs. 5/- per kg fruit x75,000 kg = Rs. 3,75,000/-

Gross return for two flushes = 5,00,000 + 3,75,000 = Rs. 8,75,000 /-
Hence for one season = Rs. 4,37,500/-
Net profit = 4,37,500 – 1,05,000 = Rs. 3,32,500/ha.
Net profit for 2 flushes = Rs. 6,65,000

The incidence of papaya mealybug started in the month of October 2011 and about 45% of papaya fruits were infested with mealybug during January 2012. Such papaya plants had bearing of average of 22 fruits/plant.

Therefore, No. of infested plants/ha on farmer's field = 1125 plants/ha (45%).

No. of fruit loss due to PMB infestation = 18 fruits/plant x1125 infested plants

= 24,750 infested fruits/ha

5. Quantity fruit loss (wt. basis)/ha during first flush (May, June, July) = 1.0 kg/fruitx24,750

   = 24,750 kg infested fruits/ha

6. Loss in terms of cash receipt = Rs. 5/- per kg x 24,750 kg infested fruits = Rs. 1,23,750/-

To control PMB infestation, the parasitoid *Acerophagus papayae* was released @ 100 adults/acre in the first week of January 2012 and February 2012 in the mealybug colonies on infested papaya plants in the farmer's orchard. The parasitoid population built–up rapidly and a parasitoid population of 90–120 adults/leaf was observed on PMB infested fruits and leaves of papaya by first week of May 2012. Then the pest incidence was declined and during June–July 2012, it was less than 5 per cent. More than 95% control of PMB was observed in parasitoid released plots. During the second flush of the crop, the PMB infestation was very low due to release of parasitoid in the first flush.

7. Cost of inputs for 2 flushes = Rs. 2,10,000/-

   Loss inflicted due to 45% infestation of PMB = Rs. 1,23,750/-

   The expenditure incurred on inputs + Loss due to PMB = 2,10,000 + 1,23,750/-

   = Rs. 3, 33,750/-

8. If the parasitoid release was not undertaken, total losses voided due to PMB = Rs. 6,65,000/-
   i.e. loss of entire crop) (For 2 seasons)

9. Due to parasitoid release, the losses voided by PMB = Rs. 3,32,500/-

10. Benefit to farmer due to release of parasitoid = Rs. 3,32,500-1,05,000 – Rs. 2,27,500/ one season

Total : Rs. 105,000/-

As per the area under papaya cultivation in Tamil Nadu (1500 ha) and total income Rs. 6.65 lakh per ha for 2 flushes.

Based on these figures, the estimated annual gain and loss due to PMB in Tamil Nadu:

Total revenue receipts for the state = Rs. 123.08 crores per annum from fruits alone)

Total revenue receipts for the state = Rs. 28.75 crores per annum from latex alone)

Total loss due to PMB in the state = 46.8+13.15 = Rs. 59.95 crores per annum

Economic analysis of biological control of papaya mealybug with the release of parasitoid *Acerophagus papayae* in farmer's field in tapioca

Total revenue receipts for the state = Rs. 3500 x 5964500 = Rs. 2087 crores per annum)

Total loss due to PMB in the state 617.4 crores per annum. For mulberry it was estimated around Rs 135 crores.

Temperate Fruits

Survey for identification of suitable natural enemies of Codling moth (SKUAST)

Fewer numbers of endoparasitic ichneumonid and ectoparasitic braconid were found associated with overwintered larvae of codling moth in Kargil. The parasitoids were found both under the bark of principal host plant and other trees as well. The parasitoids overwintered in the host larvae and emerged during late June to early July.

Evaluation of entomopathogenic fungi and EPNs for the suppression of Apple root borer, *Dorysthenes hugelii* under field conditions (YSPUHF).

Entomopathogenic fungi, *B. bassiana* and *M. anisopliae* (10^6 conidia/cm² each), and EPNs, *Steinernema carpocapsae,* *Heterorhabditis indica* (80IJ/ cm² each), were evaluated against apple root borer, *Dorysthenes hugelii* and compared with chlorpyriphos (0.06%) and untreated control in the farmer's field at Chopal, District Shimla, Himachal Pradesh. The experiment was conducted on bearing trees of apple (cv. Royal Delicious) in randomized block design with each treatment replicated four times. During observation in January, 2013 the number of live and dead larvae of *D. hugelii* were counted and pooled to get total number of larvae present in the tree basin for calculation of per cent mortality. Data revealed that chlorpyriphos (0.06%) resulted in the highest grub mortality (86.4%) followed by (74.4%) by *M. anisopliae* (10^6 conidia/cm²). Other biopesticides like *B. bassiana* (10^6 conidia/cm²), *H. indica* and *S. carpocapsae* (80 IJ/cm² each) were moderately effective against apple root borer resulting in 34.0, 45.9 and 34.9 per cent mortality of the grubs, respectively, as against 8.5 per cent in untreated control.

Vegetables

Developing bio intensive IPM package for the pests of Cole crops (AAU-J, PAU, SKUAST, and YSPUHF)

In Assam, the population of *P. brassicae* and DBM significantly reduced from 2.45 to 1.34 and 4.85 to 1.94 in BIPM, whereas in farmers practice they were 2.6 to 1.4 and 4.65 to 1.97, respectively after 55 DAT (third spray). While considering the population of *B. brassicae*, no significant differences was observed between BIPM and farmers practice. Maximum yield (169.9 q/ha) was registered in IPM package which was significantly superior to farmer's practice (163.7 q/ha). The minimum yield (78.3 q/ha) was observed in control. The occurence of coccinellids was higher in IPM plot than in farmers' practice. It was concluded that the IPM package was as effective as chemical control in reducing the incidence of sucking and lepidopteran pests and thereby increasing the marketable yield of cabbage.

Evaluation of different BIPM modules against shoot and fruit borer, *Leucinodes orbonalis* in brinjal (MPKV).

Three sprays of profenophos (0.05%) at fortnightly interval was found significantly superior in reducing the shoot (9.0%) and fruit (9.6%) infestation and gave maximum marketable yield (228.7 q/ha). However, the BIPM module consisting release of *T. chilonis* followed by spraying of NSKE 5% and *Bt* @ 1 L/ha twice at weekly interval was the next best treatment showing 9.9% shoot and 15.3% fruit infestation with 42.5% parasitism of *T. chilonis* and gave 218.4 q/ha yield. It was on par with modules consisting *T. chilonis* + *Bt* and NSKE +*Bt*.

Biological suppression of onion thrips, *Thrips tabaci* with predatory anthocorid and microbial agents (MPKV).

Three sprays of profenophos at fortnightly interval was found significantly superior over other treatments in suppressing thrips (av. 3.1 thrips/plant) with 1 rating of intensity of white patches. However, 3 sprays of *M. anisopliae* @ 10^8 cfu/ml which showed 7.5 thrips/plant and 1.5 rating of white patches on leaves was the next best treatment.

Evaluation of anthocorid predator *Blaptostethus pallescens* against mite, *Tetranychus urticae* on brinjal and okra (OUAT, PAU)

Mite population before implementation of treatments varied from 439.88 to 680.80/10 plants. Seven days after imposition of treatments Propargite (@ 2ml/lit) registered the lowest mite population of 98.8/10 plants followed by *B. pallescens* (@ 30/plant) (138.30/10 plants) and @ 20/plant (146.70/10 plants). Release of *B. pallescens* @ 10/plant recorded 240.0 mites/10 plants which was also far superior in controlling the mite. The control plots had 721.50 mites/10 plants. The same trend continued 15 days after release of the predator. Propargite was the most effective treatment with 33.75 mites/10 plants followed by release of 30 and 20 anthocorids which recorded 84.80 and 91.30 mites/10 plants, respectively. These two treatments were at par in respect to their effectiveness in controlling the mite. Release of *B. pallescens* @ 10 per plant recorded 110.40 mites/10 plants which was far superior in respect of mite control as the untreated plots recorded 765.80 mites/10 plants. Maximum webbings/10 plants was observed in control plots (29.75) followed by the predator released plots at 30, 20 and 10 *B. pallescens*/10 plants, respectively. (OUAT)

The mite population before implementation of treatments varied from 276.5 to 320.6/10 plants. Seven days after treatment, Propargite registered the lowest mite population (65.2/10 plants) followed by *B. pallescens* @ 30/plant (97.4/10 plants) and @ 20/plant (108.7/10 plants). Release of *B. pallescens* @ 10/plant recorded 197.2 mites/10 plants which was also far superior in suppressing the mite. The control plots had 312.5 mites/10 plants.

The same trend continued 15 days after release of predator. Propargite was the most effective treatment with 51.4 mites/10 plants followed by release of 30 and 20 anthocorids which recorded 77.9 and 81.6 mites/10 plants, respectively. These two treatments were at par in respect of their effectiveness in controlling the mite. Release of *B. pallescens* @ 10/plant recorded 151.30 mites/10 plants which was far superior compared to untreated plots (326.8 mites/10 plants).

Maximum webbings/10 plants was observed in control plots (21.4) followed by *B. pallescens* released plots at 30, 20 and 10 /10 plants, respectively.

Study on effectiveness of bioagents and botanicals against aphid, *Lipaphis erysimi* infesting mustard (MPUAT)

Among the different bioagents and botanicals, the mean per cent reduction in aphid population was more with 2 sprays of NSKE 5% (54.82), which was statistically at par with 2 sprays of *Veticilium* sp. (52.58). However, 2 sprays of imidacloprid was most effective in mean per cent reduction (79.74) of *L. erysimi* population at 7 days after 2nd spray and yielded 9.52, 9.44, 10.85 q/ha, respectively over control 6.20 q/ha.

6. TECHNOLOGIES ASSESSED, TRANSFERRED AND MATERIALS DEVELOPED

NBAII

Technologies related to *in vivo* production, down–stream processing and development of formulations of *Heterorhabditis indica* strain NBAIIHi1, and their field use for the management of whitegrubs, was sold to three entrepreneurs including Camson Biotech Ltd., Bangalore, and FARMER, Ghaziabad and generated a revenue of Rs. 3.5 lakhs.

AAU–Jorhat

The technology of growing mustard as trap crop and three releases of *T. brassicae* and *T. pieridis* @ 1,00,000/ha/week for management of *P. brassicae* and *P. xyllostella* has been assessed and validated in farmers field during 2011-2013.

Eleven releases of *T. chilonis* could reduce the infestation of *Chilo tumudicostalis* and gave better yield when compared to chemical control. Parasitoid released plots showed high parasitization than chemical control plots. The Technology has been assessed and validated in farmers' field during 2010-2013.

ANGRAU–Hyderabad

Combination of *T. pretiosum* @ 50,000/ ha-5 times and NPV @250 LE/ha–3 times effectively managed *H. armigera* in tomato.

Pigeonpea bordered with two rows of sorghum and intercropped with sunflower (9:1) gave better yield and recorded lesser population of pests due to high natural enemy population compared to the sole crop.

KAU-Thrissur

Trichogramma japonicum @ 1 lakh/ ha has been recommended for the management of rice leaf folder and stem borer.

MPKV-Pune

Mass production of MPKV isolate of *Nomuraea rileyi* was undertaken on solid media (jawar + soybean) and its efficacy was demonstrated over 62 ha in soybean and potato fields against *S. litura* at the College Research Farm, Pune; Agricultural School Farm, Manjari; Agricultural Research Station, Digraj and farmers' fields in Rajgurunagar area. The infection of larvae was 62% and 70% respectively in soybean and potato.

Mass production of *Metarhizium anisopliae* was carried out on solid media (rice + soybean) and the product was demonstrated over 47 ha against mango hoppers in Pune region and 60 acres on safflower aphids at Solapur. It was found infectious to safflower aphids, wheat aphids and onion thrips on the College Research farm at Pune with >65% decline in pest population. Moreover, *M. anisopliae* was also supplied for the control of white grubs in sugarcane to farmers from Pune, Solapur, Sangli and Kolhapur region.

7. GENBANK ACCESSIONS SUBMITTED BY NBAII

Organism	Gen Bank Accession Number
Pantoea sp strain CV-Pt.a1	KC582827
Candida rugosa	JX524461, JX524462
Candida diversa	JX 524463
Wolbachia	JX458515
Enterobacter cancerogenous	KC 139361
Pseudomonas sp.	KC441059
Pantoea agglomerans	KC 512244
Endosymbiotic bacteria of cotton leaf hopper	JX893010 to JX893015, KC428703 - KC428706, KC425474, KC427093, KC443040 to KC443042, KC465360 to KC465365, KC603547. KC603548 to KC603572.
Endosymbiotic organisms from aphids	KC465366, KC603539 to KC603546, KC707524 to KC707552
Enterobacter cloacae	KC 333898, KC 333907

Enterobacter sp.	KC 333890, JX873958, JX 873959, KC407909, KC 333908, KC 333891
Pantoea dispersa	JX873957
Bacillus sp.	JX 873960, KC 333897
Agrobacterium tumefaciens	KC 333915
Enterobacter hormaechei	KC 333906
Enterobacter asburiae	KC 333899
Enterobacter hormaechei sp.	KC 333901
Bacillus cereus	KC 333903
Enterococcus faecium	KC 333895
Enterobacter hormaechei	KC 333894
Empedobacter sp.	KC 333902
Lactococcus garvieae	KC 333889
Enterococcus gallinarum	KC 333905
Bacillus subtilis	KC 333910
Enterococcus faecalis	KC 333911
Bacillus pumilus	KC 333997
Stenotrophomonas sp.	KC603552
Serratia marcescens	KC603548, KC603553, KC603547
Staphylococcus sciuri	KC603550
Acinetobacter gyllenbergii	KC603549
Acinetobacter bereziniae	KC603551
Apanteles galleriae Wilkinson	JN790942
Fornicia ceylonica Wilkinson	JN613568
Apanteles hyposidrae Wilkinson	JQ308797
Apanteles machaeralis Wilkinson	JQ844449
Apanteles mohandasi Sumodan & Narendran	JX083405
Apanteles taragamae Viereck	JX083404

*Bacillus thuringiensis cry*11 gene (Dipteran), partial cds from strains - AgBt-4, AgBt-6, AsBt-12, TrBt-10 and BT-3.	KC596015, KC596016, KC596017, KC596018 KC596019
*Bacillus thuringiensis cry*3a gene (Coleopteran), partial cds from strains - BTAN-5, TRBT-17, BTAN-4, TRBT-10, TRBT-17, ASBT-21, ASBT-20 and ASBT-24.	KC416617, KC416618, KC416619, KC416620, KC416621, KC416622, KC416623
*Bacillus thuringiensis vip*3a gene, partial cds from strains - TRBT-19, ASBT-15, BTD-2, NE-60, ASBT-25, BTEG-1, C3 and TrBt 10.	KC596007, KC596008, KC596009, KC596010, KC596011, KC596012, KC596013, KC596014
Apis cerana sac brood virus complete CDS from strains - II-2, II-9, K1A, K5B, K3A and S2, first submission from India.	JX270795, JX270796, JX270797, X270798, JX270799, JX270800
Blaptostethus pallescens	JQ 609281
Cardiastethus exiguus	KC886281)

8. INSECT IDENTIFICATION SERVICES

Authentic identification of insect specimens is an important assignment of NBAII. The expertise available for a selected taxa of insects is appropriately used for the identification of insects received from various parts of India and abroad

Ichneumonoidea & Chalcidoidea (Dr. Ankita Gupta)

Crop Protection Division, Coconut Research Institute, Sri Lanka; Central Sericultural Research & Training Institute, Cental Silk Board, Govt. of India; Pampore, Srinagar, J&K; KVK, Poonch, Jammu & Kashmir; Dept. of Agril. Entomology, College of Agriculture, UAS, Dharwad; DOR, Hyderabad; Deptt. of Entomology, PAU, Ludhiana; Bombay Natural History Society, Mumbai, Maharashtra; Entomological Research Institute, Loyola College, Chennai; Directorate of Medicinal and Aromatic Plants Research, Anand, Gujarat; National Research Centre for Citrus, Nagpur, Maharashtra; Indian Institute of Pulses Research, Kanpur, Uttar Pradesh; Navsari Agricultural University, Navsari; Butterfly Park, Belvai, Mangalore; Dept. of Agricultural Entomology, TNAU, Coimbatore; Forest Protection Division, Institute of Forest Productivity, Ranchi Jharkhand; UAS, GKVK, Bangalore and Directorate of Oil Palm Research, Pedavegi, W. Godavari (Dt), A. P.

Tephritidae, Cecidomyiidae, Drosophilidae Agromyzidae, Syrphidae & Tachinidae (Mr. K.J. David)

Indian Institute of Horticulture Research, Bangalore; Vivekanda Parvidya Krishi Anusandan , Almora; ICAR Research Complex for NEH region, Barapani; National Research Centre for Citrus, Nagpur; National Research Centre for Grapes, Pune; SVP University of AG.&T, Meerut and University of Agricultural Sciences, Dharwad.

Diaspididae, Aphididae, Coccidae, Pseudo-coccidae (Dr. Sunil Joshi)

Central Sugarcane Research Station, Padegaon; YSRHU, Hyderabad; KAU, Kerala; Anand Agricultural University, Anand; Central Sericultural Research & Training Institute; MPKV, Rahuri; NRC for Grapes, Pune; Sugarcane Breeding Institute, Coimbatore; Maharashtra Hybrid Seeds Co. Ltd., Bangalore; NPIB Akola, Department of Entomology; Bangalore University; CRS, Pampadumpara; Groundnut Research Station, Junagadh; IIHR, Bangalore; Assam Agril. University, Jorhat, Assam; MPKV, College of Agriculture, Pune; National Research centre for Citrus, Nagpur; AICRP on Tropical Fruits (Citrus) PAU, Ludhiana; Institute of Wood Science & Technology, Bangalore; Central Plantation Crops Research Institute, Kayangulam; Anand Agricultural University, Anand; University of Agricultural Sciences, Dharwad and Directorate of Oilseeds Research, Hyderabad.

Coleoptera (Coccinellidae, Curculionidae, Dermestidae), Chalcidoidea (Encyrtidae, Aphelinidae, Chalcididae, Pteromalidae, Eulo-phidae), Ichneumonoidea (Ichneumonidae, Braconidae), Hemiptera (Pentatomidae, Aphid-idae, Coccoidea) and Diptera (Tachinidae, Syrphidae) (Dr. J. Poorani)

CSIR Institute of Himalayan Bioresource Technology, Palampur; Navasari Agricultural University, Navsari, Haryana; Central Silk

Board, AAU, Jorhat, Assam; Kumaun University, Nainital, Uttarakhand; BNPG college, Rath, Hamirpur, Uttar pradesh; Tamil Nadu Agricultural University, Coimbatore; University of Agricultural Sciences, Dharwad; Zoological Survey of India, Calicut; Regional Rearach Station, TNAU, Vamban; University of Agricultural Sciences, Bangalore; Indian Institute of Horticultural Research, Bangalore; Vivekananda Institute of Hill Agriculture, Almora; University for Horticulture & Forestry, Solan; Government Champhai College, Champhai, Mizoram; Punjab Agricultural University, Ludhiana IWST, Bangalore; Anand Agricultural University, Anand; AICRP on Palms, HRS, Ambajipeta; Sugarcane Breeding Institute, Coimbatore; National Research Centre for Grapes, Pune; Central Tuber Crops Research Institute, Bhubaneshwar; Institute of Organic Farming, UAS, Dharwad; Directorate of Rice Research, Hyderabad PAJANCOA & RI, Karaikal; Indian Institute of Horticultural Research, Chettalli; Plant Protection Centre, Laos PDR; Raffles Museum of Biodiversity, Singapore and Matthieu Cuenot, France.

9. EXTENSION ACTIVITIES

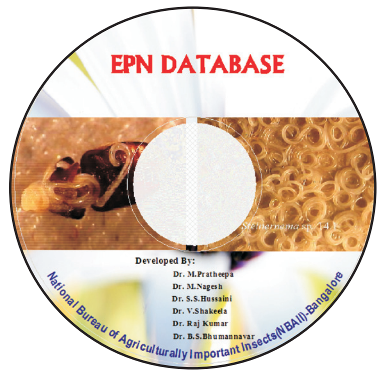
Development of NBAII databases

(i) Web content on Indian insects

An image gallery for agriculturally important insects of India, with particular emphasis on pests of crops, was hosted on NBAII's website and 510 species have been featured so far with over 3000 photographs and details of the current taxonomic position, hosts / associated habitat, and pest status. This site and "Featured Insects", the site on insect bioagents, have been included in ID Source, a worldwide compendium of web-based identification aids for pest organisms, hosted by USDA and Colorado State University. An interactive LucID Phoenix key to the genera of Mymaridae of India was prepared with fact sheets, diagnostics and illustrations for the 28 genera known so far.

(ii) Database on Entomopathogenic Nematodes

Database on Entomopathogenic Nematodes (EPN) was developed in HTML form. The topics covered in the database are introduction, taxonomy, barcodes of EPN isolates of NBAII, systematics, diagnostic characters of Steinermatidae and Heterorhabditidae, occurrence, then description of new species, distribution records, diversity maps, dispersal, virulence/host range/infectivity, temperature, survival and persistence, tritrophic effects, compatibility, genetic improvement, bioefficiency (lab/green house/field), mass production, formulation and storage, application, abiotic and biotic factors, integration in IPM, biosafety, nontarget effects, commercial products, quality, techniques, chromosomes and associated bacteria. This data-base helps the researchers and farmers to get the information about EPN in one CD. This database is user friendly and can get the information about EPN on a single click in the computer. This EPN database is available in the CD form, at NBAII Library and the cover page of the CD is given below:



(iii). Websites hosted / maintained

Factsheets on agriculturally important insects. URL: http://www.nbaii.res.in/Featured%20 insects/featured-insects.html (for 175+ species of common bioagents, invasives, and pests)

Biocontrol introductions. URL: http://www.nbaii.res.in/Introductions/Insects/index.htm (for 185 species of introduced bioagents in India)

Aphids of Karnataka - Web photo album on Picasaweb (the largest of its kind with ~1300 digital photographs of aphids of Karnataka). URL: http://picasaweb.google.com/home (30 new photographs uploaded).

Coccinellidae of the Indian Subcontinent (maintained) (URL: www.angelfire.com/bug2/j_poorani/index.html).

Education and Training

Trainings organized by farmers

Two training programs were organized on the biocontrol of crop pests and diseases for tribal farmers, one at Athanvoor village, Yelagiri hills, Vellore district in collaboration with Department of Agriculture, Tamil Nadu and the other at Asanoor in Arapalya near Sathyamangalam from 15/02/2013 to 16/02/2013. Lectures were given to the farmers on the importance of biological control, mass production and delivery systems of biocontrol agents and their field efficacy. Practical sessions were conducted on various application techniques of biological controlagents. More than 150 farmers participated in both the training programs.

Training on Plant protection technologies for tribal farmers at Arapalaya, Tamil Nadu

Training and field demonstration on biocontrol technologies of crop pests and diseases for tribal farmers at Yelagiri hills, Tamil Nadu

MPKV

Extension development activities/training imparted

The bioagents were exhibited in the State level farmers exhibition,"**KISAN-2012**" at Moshi, Pune during December 12-16, 2012.

The bioagents were exhibited in the National level farmers' exhibition '**AGROWON AGRI. EXPO-2012'** at College of Agriculture, Pune on December 1–5, 2012.

Demonstration on *M. anisopliae* and *N. rileyi* against *S. litura* on lucerne was conducted on farmers' fields at Digras and Pimpri Avghad, Dist Ahmednagar.

Demonstration on the effectiveness of *Nomuraea rileyi* against *S. litura* on potato was conducted in over 50 acres on farmers' field at Peth, Dist. Pune on 17/9/2012.

Demonstration on the effectiveness of *M. anisopliae* against safflower aphids was conducted in over 60 acres on farmers' fields in Solapur district on 27/11/2012.

Demonstration on the effectiveness of *M. anisopliae* against mango hoppers was conducted in over 25 acres on farmers' fields in Mulshi, Dist. Pune on 22/2/2013.

Radio Talk

Dr. D. S. Pokharkar delivered radio talk on 'Biological control of potato tuber moth' on AIR, Pune on 26/6/2012 and broadcasted on 4/7/2012 at 7:15 pm in *Amchi Mati Amchi Manase* programme.

Shri. N. D. Tamboli gave radio talk on 'Integrated pest management of soybean' on AIR, Pune and broadcasted on 25/06/2012 at 7:15 pm in *Amchi Mati Amchi Manase* programme.

Shri. A. S. Dhane delivered radio talk on 'Integrated pest management of *Kharif* crops' on AIR, Pune and broadcasted on 30/6/2012 at 7:15 pm in *Amchi Mati Amchi Manase* programme.

Shri. A. S. Dhane delivered radio talk on '*Chrysoperla*: an important bioagent in pest management' on AIR, Pune and broadcasted on 14/8/2012 at 7:15 pm in *Amchi Mati Amchi Manase* programme.

Dr. D. S. Pokharkar gave radio talk on 'Use of entomopathogenic virus in biological control of insect pests' on AIR, Pune on 13/8/2012 and broadcasted on 20/8/2012 at 7:15 pm in *Amchi Mati Amchi Manase* programme.

Maintenance and supply of live insect cultures at NBAII

One of the major contributions of NBAII to the biological control farmers and other beneficiaries is the timely supply of nucleus cultures of insects which includes host insects and the beneficial insects for the demonstrations to the AICRP centres. Infact, NBAII is the only institution in India maintaining and supplying the various insect species.

During the period under report, 113 live insect cultures were maintained including host insects, predators and parasitoids. Live insect cultures were supplied to different organisations (private and Government), students, researchers and farmers. 887 consignments of live cultures were sent and a revenue of Rs. 2,45,135 was generated (Fig. 28). Microbial biocontrol agents worth Rs. 2,72,000 were sent in about 127 consignment to different entrepreneurs. Total revenue generated was Rs. 5,17,135 (Table 11).

Human Resource Development

As a part of the mandate of NBAII, several training programs were conducted on the Biosystematics, biological control and molecular taxonomy. Besides NBAII, most of the AICRP centres have shown keen interest in conducting short term and long term training programs to benefit scientists, research students, developmental officials and farmers.

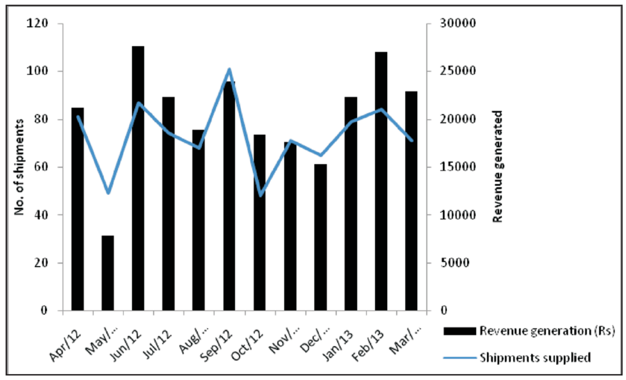


Fig. 28. Supply of live insect cultures from NBAII and revenue generated during 2012-13

Exhibitions Conducted/Participated

NBAII participated in the COP XI meeting of held at Hydrabad during 1/10/12 to 19/10/12. Dignitaries, including Honourable Shri. Kiran Kumar Reddy, Chief Minsiter of Andhra Pradesh, Honorable DDG (CS), ICAR, Dr. Dr. Swapan Kumar Datta, Dr. T. P. Rajendran, ADG (PP), ICAR, and several policy makers from various countries visited the stall and appreciated the efforts of NBAII in the biodiversity documentation and conservation.

The NBAII was represented at National Agricultural Science Congress conducted at Odisha, during 7th to 9th Februaruy 2013 through a stall explaining the actitivities of NBAII. The list of dignitories who appreciated the stall include Honorable Shri. Debi Prasad Mishra, Minister of Agriculture, Government of Odisha, Dr. S. Ayyappan, DG, ICAR & Secretary DARE, farmers and students.

The activities of NBAII especially, the mass production technologies and delivery systems of biological control agents were explained to the hundreds of farmers during the Krishi Mela held at New Delhi during 6-3-2013 to 8-3-2013.

NBAII was represented by a stall for the Indian Biodiversity Expo 9-11th Dec, 2012, Bangalore organized by the Indian Biodiversity Congress (IBC 2012).

Table 11. Live insect cultures supplied during 2012-13.

Sl. No.	Name of Species	No of shipments
Host cultures		
1	*Corcyra cephalonica*	170
2	*Samia cynthia ricini*	1
3	*Plutella xylostella*	7
4	*Chilo partellus*	9
5	*Maconellicoccus hirsutus*	7
6	*Ferrisia virgata*	01
7	*Sitotroga cerealella*	02
8	*Paracoccus solenopsis*	01
9	*Helicoverpa armigera*	116
10	*Spodoptera litura*	91
11	*Callosobruchus* sp.	1
Parasitoids		
12	Trichogrammatids	180
13	*Chelonus blackburnii*	21
14	*Goniozus nephantidis*	20
15	*Telenomus remus*	7
Predators		
16	*Chrysoperla zastrowi sillemi*	67
17	*Chilocorus nigrita*	4
18	*Cryptolaemus montrouzieri*	78
19	*Scymnus coccivora*	8
20	Anthocorid predators	22
21	*Cheilomenes sexmaculata*	15
22	*Brumoides suturalis*	03
Weed insects		
23	*Zygogramma bicolorata*	5
24	Other nucleus cultures	51
Microbials		
25	*Pseudomonas fluorescens*	18
26	*Bacillus subtilis*	5
27	*Bacillus megaterium*	2
28	*Trichoderma harzianum*	4
29	*Trichoderma viride*	13
30	*Paecilomyces fumosoroseus*	3
31	*Paecilomyces lilacinus*	13
32	*Metarhizium anisopliae*	19
33	*Beauveria bassiana*	25
34	*Beauveria brongniartii*	1
35	*Verticillium lecanii*	19
36	*Nomuraea rileyi*	4
37	*Hirsutella thompsonii*	1
Total		**127**
Total Revenue (Rs.)		**5,14,135**

Honorable Shri. Debi Prasad Mishra, Minister of Agriculture, Government of Odisha and students showing keen interest in exhibits of NBAII at Agricultural Science Congress, OUAT, Bhubaneswar from 7/2/13 to 9/2/13

Honourable Shri. Kiran Kumar Reddy, Chief Minister of Andhra Pradesh and foreign delegates from many countries showing keen interest in exhibits of NBAII At COP XI exhibition at Hyderabad from 1/10/12 to 19/10/12

Farmers learning about biological control agents at the NBAII stall At *Pusa Krishi Vigyan Mela* New Delhi from 6/3/13 to 8/3/13

10. AWARDS AND RECOGNITIONS

The National Biodiversity Authority of India has recognised NBAII and conferred the status of "National Repository" for housing and curating type specimens of insects.

Dr. R. J. Rabindra, Former Director, NBAII, Dr. B. S. Bhumannavar, Director (Acting) Dr. A. N. Shylesha, and Dr. Sunil Joshi, Principal Scientists, NBAII were honored on 20th October, 2012 for their contribution to the biological control of papaya mealybug during the meeting conducted to commemorate the success of biological control of papaya mealybug.

Dr. N. Bakthavatsalam Principal Scientist was conferred Fellow of Society for Applied Biotechnology

Dr. T. Venkatesan, Dr. Chandish R. Ballal (NBAII), Dr. Ganga Visalakshi and Dr. A. Krishnamoorthy (IIHR) and Dr. Chandrika Mohan (CPCRI) were conferred the Fellow of Association of Advancement in Pest Management in Horticultural Ecosystems, Bangalore

Dr. Chandish R. Ballal (NBAII) and Dr. Ganga Visalakshi (IIHR) were conferred with the Sithanantham award

Chandrika Mohan, (CPCRI), was presented Dr. C S Venkata Ram Memorial Award for the second best original research paper entitled "Field validation of biological suppression of coconut blackheaded caterpillar, *Opisina arenosella* Walker using larval parasitoids *Goniozus nephantidis* and *Bracon brevicornis*" presented at PLACROSYM XX, 2012 held at Coimbatore during December 12-15, 2012

Deepa Bhagat, Bakthavatsalam N. Ballal, C R., Krishnamoorthy, P. and Srinivasa R and Ramu, G. 2012, received best paper award for their paper entitled "Non–target effect of chitosan alginate nanoparticles on the biology of aphid lion, *Chrysoperla zastrowi sillemi* (Esben Petersen) (Nueroptera: Chrysopidae)", at 5th Bangalore Nano, 6–7th December 2012.

Dr. Chandrika Mohan (CPCRI) received best paper presentation for her paper "Coconut water as a promising culture media for *Hirsutella thompsonii* Fisher, a pathogen of coconut mite" presented at the 4th International conference on Insect science held during 14-17 February 2013 at Bangalore.

11. LINKAGES AND COLLABORATION IN INDIA AND ABROAD INCLUDING EXTERNAL PROJECTS

Research projects funded by lateral sources operating at NBAII

NAIP

- Effect of abiotic stresses on the natural enemies of crop pests: *Trichogramma, Chrysoperla, Trichoderma* and *Pseudomonas* and mechanism of tolerance to these stresses (Collaborating centres – DOR, CRIDA, Vittal Mallya Science Research Foundation, Bangalore and Mysore University).
- Establishment of National Agricultural Bioinformatics Grid (NABG) in ICAR.

DBT

- DNA-based early detection of post-harvest diseases in mango, banana and management using consortia of bioagents (NBAII work-isolation of pathogens and microflora from fruit surfaces of mango for post harvest management) (in collaboration with TNAU, Coimbatore).
- Development of fungal bionematicides: Scale-up, post-harvest processing, storage stability, toxicology and field evaluation.
- Genetic and functional analysis of novel genes from *Photorhabdus luminescens* and *Xenorhabdus nematophilus,* symbiotic bacteria associated with entomopathogenic nematodes for insect pest management.
- Nanoparticles for enhacing shelf-life/storage and field application of semiochemicals.

ICAR Cess–Fund

- Network Project on Insect Biosystematics.
- TMC MMI 3.3: Development, validation, utilization and/or commercialization of bio-pesticides and bio-inoculants.
- ICAR Network Project: Outreach programme on diagnosis and management of leaf spot diseases of field and horticultural crops (Sub-project: Biological Control of *Colletotrichum* diseases of chillies).
- PhytoFuRa – An outreach programme of IISR on *Phytophthora, Fusarium* and *Ralstonia* diseases of horticultural and agricultural crops.

AMAAS (ICAR)

- Microbial control of insect pests – II.

IPR

- Intellectual Property Management and Transfer/Commercialization of Agricultural Technology Scheme (upscaling of existing component, i.e. Intellectual Property Rights (IPR) under ICAR Headquarters Scheme on Management on Information Services).

ICAR–National Fund for Basic, Strategic and Frontier Application Research in Agriculture-Funded

- Identification of nucleopolyhedrovirus (NPV) encoded proteins and small RNAs and the feasibility of their expression in plant to control *Helicoverpa* (Lead Centre: ICGEB, New Delhi).

Institute of Forest Genetics and Tree Breeding

- Influence of euclayptus species on the natural enemy incidence on the gall wasp *Leptocybe invasa*.

12. AICRP/COORDINATION UNIT/NATIONAL CENTRES

With a view to fulfil the mandate of the AICRP on Biological Control effectively and efficiently, the NBAII is functioning with the following ICAR Institute – based and State Agricultural University – based centres.

Headquarters

National Bureau of Agriculturally Important Insects, Bangalore	Basic Research

ICAR Institute-based Centres

Central Tobacco Research Institute, Rajahmundry	Tobacco and Soybean
Central Plantation Crops Research Institute, Regional Centre, Kayalgulam	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, coconut 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 & Forestry, Solan	Fruits, vegetables and weeds
Govind Ballabh Pant University of Agriculture & 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 Science & Technology, Srinagar	Temperate fruits and vegetables
Tamil Nadu Agricultural University, Coimbatore	Sugarcane, cotton, pulses and tomato

Voluntary Centres (partially funded)

Jawaharlal Nehru Krishi Viswavidyalaya, Krishi Nagar, Adhartal, Jabalpur	Pulses
Maharana Pratap University of Agriculture & Technology, Udaipur	Vegetables, white grubs and termite
Orissa University of Agriculture & Technology, Siripur, Bhubaneswar, Khurda	Rice and vegetables
Central Agricultural University, College of Horticulture & Forestry, Pasighat	Rice and vegetables

Voluntary Centres

Chaudhary Charan Singh Haryana Agricultural University, Hisar	Sugarcane
College of Agriculture, Kolhapur	White grubs and weeds
National Research Centre for Soybean, Indore	Soybean
National Research Centre for Weed Science, Jabalpur	Weeds
Navsari Agricultural University, Navsari	Sugarcane and coconut
Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar	Vegetables
University of Agricultural Sciences, Bangalore	Cotton and pigeonpea
University of Agricultural Sciences, Dharwad	Cotton and chickpea
Vasantdada Sugar Institute, Pune	Sugarcane

13. LIST OF PUBLICATIONS

The strength of NBAII & AICRP centres is in the publications of national and international standards. This year the number of publications in both NBAII & AICRP centres is overwhelming.

Peer reviewed articles

NBAII

Ballal CR, Gupta T, Joshi S, 2012. Predatory potential of two indigenous anthocorid predators on *Phenacoccus solenopsis* Tinsley and *Paracoccus marginatus* Williams and Granara de Willink. *Journal of Biological Control* **26**(1): 18–22.

Ballal CR, Gupta T, Joshi S, 2012. Effect of different laboratory hosts on the fertility table parameters and continuous rearing of an anthocorid predator, *Orius tantillus* (Motsch.) *Pest Management in Horticultural Ecosystems* **18**(1): 24–28.

Ballal CR, Gupta T, Joshi S, 2012. Morphometry and biology of a new anthocorid *Montandoniola indica*, a potential predator of *Gynaikothrips uzeli. IOBC-WPRS Bulletin* **80**: 79–84.

Ballal CR, Gupta T, Joshi S, 2012. Production protocols for and storage efficacy of an anthocorid predator *Cardiastethus exiguus* Poppius. *Journal of Environmental Entomology* **34**(1): 50–56.

Bhagat D, Bakthavatsalam N 2012. Influence of rice cultivars on the parasitization efficiency of *Trichogramma chilonis* Ishii & *Trichogramma japonicum* Ashmead. *Journal of Biological Control* **26**: 329–333.

Bhagat D, Samanta SK, Bhattacharya S, 2013. Efficient management of fruit pests by pheromone nanogels. *Scientific Reports* **3**: 1294–1302.

Bhagat D, Samanta SK, Bhattacharya S, 2013. Protocol Exchange. *Nature Protocol* **20**: March.

David K J, Hancock DL, Freidberg A, Goodger KFM, 2013. New species and records of *Euphranta* Loew and other Adamini (Diptera: Tephritidae: Trypetinae) from south and southeast Asia. *Zootaxa* **3635**(4): 439–458.

Goudru HG, Kumar S, Jayalakshmi SK, Ballal CR, Sharma HC, Sreeramulu K, 2013. Purification and characterization of prophenoloxidase from cotton bollworm, *Helicoverpa armigera. Entomological Research* **43**: 55–62.

Gupta A, 2013. Diversity of economically important Indian Microgastrinae (Hymenoptera: Braconidae) with new records from India. In: *New horizons in Insect Science. 4th International Conference on Insect Science. 14–17 February, 2013*, Bangalore, India. 74–75 pp.

Gupta A, Ghosh A, Baby NL Jalali SK, 2012. Morphological and molecular characterization of *Apanteles mohandasi* Sumodan & Narendran (Hymenoptera: Braconidae), a solitary endoparasitoid of *Pammene critica* Meyrick (Lepidoptera: Tortricidae), with notes on biology from India. *Entomological News* **122**(4): 354–365.

Gupta A, Ghosh A, Baby NL, Jalali SK, 2011. Morphological and molecular characterization of *Apanteles mohandasi* Sumodan & Narendran (Hymenoptera:

Braconidae), a solitary endoparasitoid of *Pammene critica* Meyrick (Lepidoptera: Tortricidae), with notes on biology from India. *Entomological News* **122**: 354–365.

Gupta A, Kalesh S, 2012. Reared parasitic wasps attacking hesperiids from western ghats (Kerala, India) with description of a new species of *Dolichogenidea* (Hymenoptera: Braconidae) as a larval parasitoid of *Thoressa evershedi* (Evans) (Lepidoptera: Hesperiidae). *Zootaxa* **3413**: 29–43.

Gupta A, Swapnil A, Lokhande, 2013. A new host record and a new combination in *Cotesia* Cameron (Hymenoptera: Braconidae) from India. *Journal of Threatened Taxa* **5**(2): 3678–3681.

Guruprasad NM, Jalali SK, Puttaraju HP, 2013. *Wolbachia* and its prospectives in biological control of insect pests and diseases vectors. *Applied Entomology and Zoology* DOI: 10.1007/s13355–013–0178–2.

Hayat M, Poorani J, 2012. A new encyrtid *Zaplatycerus notialis* (Hymenoptera: Chalcidoidea) from India, parasitic on mealybugs (Hemiptera: Pseudococcidae). *Oriental Insects* **46**: 275–280.

Hayat M, Poorani J, 2012. A new species of *Poropoea* Foerster (Hymenoptera: Trichogrammatidae) from India. *Oriental Insects* **46**: 255–259.

Jose J, Jalali SK, Shivalingaswamy TM, Kumar NKK, Bhatnagar R, Bandyopadhyay A, 2013. Molecular characterization of nucleopolyhedrovirus of three lepidopteran pests using late expression factor-8 gene. *Indian Journal of Virology* (DOI) 10.1007/s13337–013–0126–3.

Lalitha Y, Nagesh M, Jalali SK, 2012. Intraguild predation and biosafety of entomopathogenic nematode, *Heterorhabditis bacteriophora* Poinar *et al*., and its bacterial symbiont, *Photorhabdus luminescens*, to parasitoid, *Trichogramma chilonis* Ishii and predator, *Chrysoperla zastrowi sillemi* (Esben-Petersen). *Journal of Biological Control* **26**(4): 334–340.

Murthy KS, Venkatesan T, Jalali SK, Jose J, 2012. Feminisation due to *Wolbachia* in *Cotesia vestalis* (Haliday), a parasitoid of the diamond back moth *Plutella xylostella* (Linn.). *Global Journal of Biology, Agriculture & Health Sciences* Vol. **1**(2): (In press).

Rajashekar Y, Ravindra KV, Bakthavatsalam N, 2012. Leaves of *Lantana camara* Linn. (Verbenaceae) as a potential insecticide for the management of three species of stored grain insect pests. *Journal of Food science* **49**(5): (Online publication)

Ramanujam B, Basha H, Hemannavar V, Chowdappa P, Rangeswaran R, 2012. Induction of defense related enzymes and phenols in chilli plants by *Bacillus subtilis* against anthracnose pathogen *Colletotrichum capsici*. *Indian Phytopathology* **65**(4): 382–385.

Ramanujam B, Hemannavar V, Basha H, Chowdappa P, Rangeswaran R, 2012. Standardization of suitable culture medium and formulation of bacterial antagonists to chilli anthracnose pathogen, *Colletotrichum capsici. Journal of Mycology and Plant Pathology* **42**(1): 141–145.

Ramanujam B, Hemannavar V, Basha H, Rangeshwaran R, 2012. Post harvest fruit bioassay of phylloplane, pomoplane and endophytic microbes against chilli anthracnose pathogen, *Colletotrichum capsici* (Syd.) E. J. Butler & Bisby. *Journal of Biological control* **26**(1): 62–69.

Ramaraju K, Poorani J, 2012. A new species of *Coccipolipus* (Acari: Podapolipidae) parasitic on the giant coccinellid beetle from India. *International Journal of Acarology* **38**: 260–296.

Rijesh K, Ravikumar P, Hegde R, Joseph A, Jalali SK, Kush, A, 2012. Genetic diversity estimates in *Trichogramma* populations from sugarcane cropping systems in India. *Karnataka Journal of Agricultural Sciences* **25**: 68–71.

Rousse P, Gupta A, 2013. Microgastrinae (Hymenoptera: Braconidae) of Reunion Island: a catalogue of the local species, including 18 new taxa and a key to species. *Zootaxa* **3616**(6): 501–547.

Veenakumari K, Peter N, Buhl, Rajmohana K, Mohanraj P, 2012. Three new species of Sceliotrachelinae (Hymenoptera: Platygastroidea: Platygastridae) from South India. *Entomofauna* **33**: 469–480.

Veenakumari K, Rajmohana K, Manickavasagam S, Mohanraj P, 2012. On a new genus of Teleasinae (Hymenoptera: Platygastridae) from India. *Biosystematica* **5**: 39–46.

AAU-Anand

Godhani PH, Patel BH, Korat DM, 2012. Evaluation of bio-intensive pest management (BIPM) module for the suppression of insect pests infesting *Bt* cotton. *GAU Research Journal*, **37**(1): 42–45.

Patel BH, Godhani PH, Patel RM, Patel HM, Patel BK, Korat DM, 2012. Impact of habitat manipulation on insect pests infecting *Bt*. cotton and their natural enemies. *Karnataka Journal of Agricultural Sciences,* **25**(3): 336–339.

CPCRI-Kayangulam

Rajan P, Mohan C, Rao CNBV, Thomas GV, 2012. Scenario of coconut eriophyid mite infestation in Andhra Pradesh. *Indian Coconut Journal* **55**(2): 25–31.

Josephrajkumar A, Rajan P, Mohan C, Thomas RJ, 2012. New distributional record of buff coconut mealybug (*Nipaecoccus nipae*) in Kerala, India. *Phytoparasitica* **40**: 533–535.

Rajan P, Nair CPR, Rajkumar AJ, Mohan C, 2012. Another invasive pest, coconut leaf beetle, *Brontispa longissima* (Gestro), an imminent biosecurity threat at the doorsteps of India. *Journal of Plantation Crops* **40**(2): 140–143.

GBPUAT-Panthnagar

Negi, DS, Kumar J, Gupta RK, Shah B, 2013. Integrated organic management of powdery mildew disease in vegetable pea caused by *Erisiphe poligoni*. *Journal of Ecofriendly Agriculture* **8**: 89–91.

Rawat A, Rawat L, Negi Y, Kumar J, 2012. Effect of population density of *Rhizoctonia solani* on biocontrol ability of *Trichoderma harzianum* in Frenchbean. *Vegetos,* **25**(1): 117–124.

Rawat L, Singh Y, Kumar J, 2012. Improvement in nutritional status of *Trichoderma* colonized FYM. *International Journal of Plant Protection* **5**(1): 154–156.

Rawat L, Singh Y, Kumar J, 2012. Management of sclerotium root rot in lentil and Fusarium wilt in chickpea using *Trichoderma* isolates. *International Journal of Agricultural Sciences* **8**(2): 416–422.

Rawat L, Singh Y, Shukla N, Kumar J, 2012. Seed biopriming with salinity tolerant isolates of *Trichoderma harzianum* alleviates salt stress in rice (*Oryza sativa* L.): growth, physiological and biochemical characteristics. *Journal of Plant Pathology* **94**(2): 353–365.

Saxena D, Tewari AK, Awasthi RP, 2012. Cultural, morphological and molecular characterization of *T. harzianum* PBT 23. *Pantnagar Journal of Research*, **10**(1): 35–39.

Shukla N, Awasthi RP, Rawat L, Kumar J, 2012. Biochemical and physiological response of rice (*Oryza sativa* L.) as influenced by *Trichoderma harzianum* under drought stress. *Plant Physiology and Biochemistry* **54** : 78–88.

IIHR-Bangalore

Krishnamoorthy A, 2012. Exploitation of egg parasitoids for control of potential pests in vegetable ecosystems in India. *Comunicata Scientiae* **3**: 1–15

Krishnamoorthy A, Visalakshi PNG, 2012. Thrips on mango. *Journal of Horticultural Sciences* **7**(1), 110–111.

Mani M, Joshi S, Kalyanasundram M, Shivaraju C, Krishnamoorthy A, Asokan R, Rebijith KB, 2012. A new invasive Jackbeardsley mealybug *Pseudococcus jackbeardsleyi* Gimpel and Miller on papaya in India. *Florida Entomologist* **96**(1): 242–245.

Mani M, Krishnamoorthy A, 2012. Determination of release time of the Australian ladybird beetle, *Cryptolaemus montrouzieri* Mulsant for the suppression of the pink Hibiscus mealybug, *Macconellicoccus hirsutus* (Green) on grapes. *Pest management in Horticultural Ecosystems* **18**(1): 98–99.

KAU-Thrissur

Lyla KR, Sinish MS, Vidya CV, Manichellappan, 2012. Classical biocontrol of papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink in Kerala using the parasitoid, *Acerophagus papayae* Noyes and Schauff (Hymenoptera: Encyrtidae). *Journal of Biological Control* **26**(4): 386–388.

MPKV-Pune

Pokharkar DS, Nakat RV, Dhane AS, Tamboli ND, 2013. Enhancement of natural enemies' population by habitat manipulation in rainfed cotton. *Journal of Agricultural Research Technology.* **38**(2): 271–276.

OUAT-Bhubhaneshwar

Ipsita M, Mandal SMA, Mishra BK, 2012. Biology and predatory potentiality of *Ischiodon scutellaris*(Fab.) on *Aphis craccivora* Koch. *Journal of Plant Protection and Environment* **9**(2): 42–45.

Ipsita M, Mishra BK, Mandal SMA, 2012. Ovicidal and larvicidal effect of some new insecticides and bio pesticides on *Chrysoperla carnea* (Stephens). *Journal of Plant Protection and Environment* **9**(2): 46–48.

Mishra BK, Ipsita M, Mandal SMA, 2012. Predatory potentiality of *Cryptolaemus montrouzieri* Mulsant on pink hibiscus mealybug *Maconellicoccus hirsutus* (Green) and papaya mealybug *Paracoccus marginatus* Williams and Granara De Willink. *Journal of Plant Protection and Environment* **9**(2): 39–41.

PAU-Ludhiana

Aggarwal N, Jindal J, 2012. Biological control of *Chilo partellus* (Swinhoe) using egg parasitoid *Trichogramma chilonis* Ishii in summer sown maize. *Crop Improvement* Special Issue: 991–992.

Jindal V, Aggarwal N, Singh V, 2012. Evaluation of Bt cotton as an integral component of integrated pest management. *Indian Journal of Ecology* **39**(1): 118–122.

Joshi N, Virk JS, Sharma S, 2012. Efficacy of HaNPV on larval population of lepidopteran pod borer complex infesting pigeon pea, *Cajanus cajan*. *Journal of Insects Sciences* **25**(2): 197–198.

Kaur R, Virk JS, 2012. Evaluation of different plants for rearing of Eri silkworm, *Samia Cynthia ricini* under Punjab conditions. *Journal of Insect Science* **25**(3): 270–271.

Neetan, Aggarwal N, 2013. Relative toxicity of some insecticides against *Chrysoperla zastrowi sillemi* (Esben–Petersen) under laboratory conditions. *Journal of Cotton Research Development* **27**(1): 119–23.

Sharma A, Joshi N, 2012. Media composition influences growth parameters of fungi and their LC_{50} against *Plutella xylostella* Linn. *Crop Improvment*, PAU (special issue): 881–882.

TNAU-Coimbatore

Divya S, Kalayanasundaram M, Karuppuchamy P, 2012. Efficacy of adult nutrition on longevity and parasitisation efficiency of *Acerophagus papaya*e. *Journal of Biological control* **25**(4): 316–319.

Jeyarani S, Sathiah N, Karuppuchamy P, 2013. An *in vitro* method of increasing UV tolerance in a strain of *Helicoverpa agrmigera* (Noctuidae:Lepidoptera) nucleopolyhedrovirus. *Biocontrol Science and Technology* **23**(3): 305–316.

Jeyarani S, Sathiah N, Karuppuchamy P, 2012. An *in vitro* enhancement of nucleopolyhedrovirus infection in *Helicoverpa armigera* (Hubner) by the granulovirus of *Spodoptera litura* Fabricius. *Journal of Biological Control* **26**(3): 234–239.

Kalyanasundaram M, Thiyagarajan P, Jawaharlal M, Muthulakshmi P, Ganga M, 2012. Effect of pesticides on management of blossom midge, *Contarinia maculipennis* Felt. (Cecidomyiidae: Diptera) in jasmine, *Jasminum sambac* (L.). *South Indian Horticulture* **60**: 169-172.

Muthulakshmi P, Jawaharlal M, Thiyagarajan P, Kalyanasundaram M, Senthilmurugan S. 2012. Ecofriendly methods to manage alternaria leaf blight (*Alternaria jasmini*) in jasmine, *Jasminum sambac* (L.). *South Indian Hort*. **60**: 190–192.

Sakthivel P, Karuppuchamy P, Kalyanasundaram M, Srinivasan T, 2012. Toxicity of insecticides to papaya mealybug parasitoid, *Acerophagus papayae* (Noyes and Schauff) (Hymenoptera: Encyrtidae). *Journal of Biological Control* **26**(3): 274–278.

Sakthivel P, Karuppuchamy P, Kalyanasundaram M, Srinivasan T, 2012. Host plants of invasive papaya mealybug *Paracoccus marginatus* (Williams and Granara de Willink) in Tamil Nadu. *Madras Agriculture Journal* **99**(7–9): 615–619.

Sakthivel P, Karuppuchamy P, Kalyanasundaram M, Srinivasan T, 2012. Potential native predators, *Chrysoperla zastrowi sillemi* (Esben-Peterson) and *Cryptolaemus montrouzieri* (Mulsant) on *Paracoccus marginatus* (Williams and Granara de Willink). *Madras Agriculture Journal* **99**(7–9): 620–622.

14. LIST OF ONGOING PROJECTS AT NBAII.

Sl. No.	Title	Name of Scientist
Division of Systematics		
1	Biosystematics of *Trichogramma* and *Trichogrammatoidea* (Hymenoptera : Trichogrammatidae)	Prashanth Mohanraj
2	Biodiversity of oophagous parasitoids with special reference to Scelionidae	K. Veenakumari
3	Effect of abiotic stresses on the natural enemies of crop pests *Trichogramma, Chrysoperla*, *Trichoderma* and *Pseudomonas* and mechanism of tolerance to these stresses	S.K. Jalali
4	National Agricultural Bioinformatics Grid - Insect Domain	S.K. Jalali
5	Network Project on Insect Biosystematics	J. Poorani
6	Introduction and studies on natural enemies of some new exotic insect pests and weeds	A. N. Shylesha
7	Biodiversity of aphids, coccids and their natural enemies	Sunil Joshi
8	Diversity of economically important Indian Microgastrinae (Braconidae) supported by molecular phylogenetic studies	Ankita Gupta
9	Taxonomic studies on fruit fly (Dipetra: Tephritidae) of India	K. J. David
Division of Molecular Entomology		
10	Development of fungal bionematicides, scale up, post-harvest processing, storage stability, toxicoloty and field evaluation	M. Nagesh
11	Genetic and functional analysis of novel genes from *Photorhabdus luminescens* and *Xenorhabdus nematophilus*, symtiotic bacteria associated with entomopathogenic nematodes for insect pest management	M. Nagesh

12	Genetic diversity, biology and utilization of entomopathogenic nematodes (EPN) against cryptic pests	M. Nagesh
13	Studies on molecular characterisation and identification of endosymbionts of chrysopid predators and the role on the biological attributes	T. Venkatesan
14	Studies on *Trichogramma brassicae* and *Cotesia plutellae* interaction with their host in cabbage ecosystem	K. S. Murthy
15	Mapping of the *cry* gene diversity in hot and humid regions of India	R. Rangeshwaran
16	Development of computational tool for prediction of insecticide resistance gene in agriculturally important insects	M. Pratheepa
17	Mechanism of insecticide resistance in *Leucinodes orbonalis* and *Leucopholis coneophora*	M. Mohan
18	Role of microbial flora of aphids in insecticide resistance	Mahesh Yandigeri
19	Diversity and distribution of entomopathogenic nematodes in temperate and gangetic plains of India	J. Patil
Division of Insect Ecology		
20	Influence of elevated levels of carbon di oxide on the tritrophic interactions in some crops	N. Bakthavatsalam
21	Semiochemicals for the management of coleopteran pests	N. Bakthavatsalam
22	Biological control of *Colletotrichum* diseses of chillies (ORP on Leaf Spot Diseases)	B. Ramanujam
23	Evaluation of fungal pathogens on *Aphis craccivora* in cowpea and *Bemisia tabaci* in tomato and capsicum	B. Ramanujam
24	Microbial control of insect Pests-II	B. Ramanujam
25	Diversity and predator-prey interactions with special reference to predatory anthocorids and mites	Chandish R. Ballal
26	*In situ* conservation of pollinators and natural enemies in pigeonpea and sunflower ecosystem	T. M. Shivalingaswamy

27	Pollinator diversity in different agro-climatic regions with special emphasis on non-*Apis* species	T. M. Shivalingaswamy
28	Insect vector components influencing phytoplasma diseases	P. Sreeramakumar
29	Interactions of microbial control agents in diverse soil types	P. Sreeramakumar
30	Microflora associated with insecticide resistance in cotton leafhoppers	G. Siva Kumar
31	Nanoparticles for enhancing shelf life/storage and field application of semiochemicals	Deepa Bhagat

15. CONSULTATION, PATENTS AND COMMERCIALIZATION OF TECHNOLOGY

Patents filed on the technologies developed

4227/CHE/2012	A process for preparation of biofumigants from leaves of *Lantana camara* against stored grain insect pests	Provisional filing as done on 15/10/2012 & Complete Specification was filed on 07/01/2013	Application pending
2272/CHE/2011	Bioformulations of carbendazim tolerant isolates of *Trichoderma* with biocontrol potential	Complete specification was filed on 02/07/2012	Application published on 10/08/2012
2273/CHE/2011	Bioformulations of salinity tolerant isolates of *Trichoderma* with biocontrol potential and also cable of inducing salinity tolerance in crop plants.	Complete specification was filed on 02/07/2012	Application published on 10/08/2012

Technologies commercialized

i. Development of novel insecticidal wettable powder formulations of *Heterorhabditis indica* (NBAII Hi1) & *H. bacteriophora* (NBAII Hb5) for the biological control of white grubs & other insect pests, & the methods thereof for their preparation & use.

Technology Ownership: Non-Exclusive
Sector: Crop Protection/Bio-control
Type of IPR: Patent Application No:3490/CHE/2010
Mode of transfer: Licensing

Client

a. Camson Bio Technologies Limited, Bangalore.

b. FARMER (NGO), New Delhi.

The technology was sold for Rs 2 lakhs (non-exclusive).

ii. Development of high temperature tolerant strain of egg parasitoid *Trichogramma chilonis*

Technology Ownership: Non-Exclusive

Sector: Crop Protection/Bio-control

Mode of transfer: Licensing

Client: Sun Agrobiotech Research Centre, Chennai

The technology was sold for Rs 0.50 lakhs

Technology developed

iii. Powder based formulation (WP) of *Bacillus megaterium* (NBAII 63) as growth promoter (phosphate solubilizer) and management of bacterial wilt disease.

Combined application of talc formulation as seed treatment, soil application, seedling root dip & foliar spray significantly reduced bacterial wilt respectively in tomato and brinjal.

Technology ownership: Non-Exclusive

Sector: Crop Protection/Bio-control

Mode of transfer : Licensing

16. CONFERENCES PAPERS

NBAII, Bangalore

Bakthavatsalam N, Ravindra KV, Bhagat D, 2012. Gas chromatography – coupled electroantennogram (GC-EAD) response of *Rhynchophorus ferrugineus* (Olivier) to volatiles of coconut In: *National Symposium on Plant Protection in Horticultural Crops,* 25–28 April 2012.

Bakthavatsalam N,Vinutha J, Ramakrishna P, Ravindra KV, Bhagat D, 2013. Biology of *Helicoverpa armigera* (Hubner) reared on pigeon pea grown under elevated level of carbon dioxide In: *International conference on Insect Science,* Bangalore 14th - 17th Febraury 2013, pp 81.

Ballal CR, 2012. Bioefficacy and Biosafety assessment of natural enemies. In: *Environmental Safety of Biotech and Conventional IPM Technologies* (Eds H. C. Sharma, M. K. Dhillon & K. L. Sahrawat), Satdium Press, LLC, pp. 105–126.

Ballal CR, Bhumannavar BS, Ramanujam B, Nagesh M, Sriram S, 2013. Biological control of pests and diseases for plant health management. Lead paper presented during the *National Workshop on Strategies and Action Plan for Plant Health Management in Twelfth Five year Plan,* organised by Kerala State Planning Board, 7th to 8th February, 2013, Trivandrum, Kerala, pp 6.

Ballal CR, Gupta T, Joshi S, 2012. Biological and fertility table parameters of an anthocorid predator *Orius tantillus* (Motsch.). Presented during the *Fourth National Symposium on Plant Protection in Horticultural Crops: Emerging challenges and Sustainable Pest management,* 25th to 28th April, 2012 at IIHR, Bangalore.

Ballal CR, Gupta T, Joshi S, 2013. Production and evaluation of the warehouse pirate bug *Xylocoris flavipes* (Reuter) (Hemiptera: Anthocoridae). In: *International Congress on Insect Science 2013*, 14th to 17th February, 2013 at GKVK, Bangalore.

Basha H, Ramanujam B, 2012. Plant growth promotion and induction of defense related compounds in chilli plants by *Trichoderma.* In: *National symposium on Heading towards molecular horizons in Plant Pathology: Host resistance, Pathogen dynamics, Diagnostics and Management* held during 16–17, November, 2012 at Sugarcane Breeding Institute, Coimbatore. Abstract, pp.120.

Basha H, Ramanujam B, 2012. Potential of yeast antagonists as plant growth promoters and inducers of defense related compounds against chilli anthracnose pathogen, *Colletotrichum capsici*. In: National symposium on *Blending conventional and modern plant pathology for sustainable agriculture* held during 04–06, December, 2012 at Indian Institute of Horticultural Research, Bangalore. Abstract, pp. 141.

Basha H, Ramanujam B, Hemannavar V, Chowdappa P, 2012. Mass production and formulations of *Hanseniaspora uvarum*, a promising yeast antagonist of chilli anthracnose pathogen, *Colletotrichum capsici*. In: *National symposium on Blending Conventional and Modern Plant*

Pathology for Sustainable Agriculture held during 04-06, December, 2012 at Indian Institute of Horticultural Research, Bangalore. Abstract, pp.131.

Bhagat D, 2013. Nanotechnology in Agriculture Research. In: *Foresight and Future pathways of agricultural research through involvement of youth in India*, 1–2 March, 2013, NASC Complex, New Delhi.

Bhagat D, Bakthavatsalam N, Chandish RB, Krishnamoorthy P, Srinivasa R, Ramu G, 2012. Non–target effect of chitosan alginate nano particles on the biology of aphid lion – *Chrysoperla zastrowi sillemi* Esben Pterson. In: *The 5th Bangalore Nano Conference* – December 5th to 7th, 2012, Bangalore.

Bhagat D, Bakthavatsalam N, Ramu G, Srinivasa R, Singh M, 2012. Effects of pH and temperature on chitosan–alginate nanoparticles incorporated with a pheromone of coffee stem borer, *Xylotrechus quadripes* Chevrolet (Coleoptera: Cerambycidae) In: *The International conference – 5th Bangalore Nano,* 6–7, December, 2012.

Bhagat D, Bakthavatsalam N, Vinutha J, 2013. Effect of volatiles of leaves of rice varieties on foraging behaviour of *Trichogramma* (Hymenoptera: Trichogrammatidae). In: *International conference on Insect Science,* 14th – 17th Febraury, 2013, GKVK, Bangalore, pp. 95.

Bhumannavar BS, Ballal CR, Ramanujam B, Nagesh M, Sriram S, 2012. Farmer friendly bio-control technologies. In: *Farmer Friendly Technologies in Horticulture*-Souvenir released during the 5th Indian Horticulture Congress 2012 on 6th November 2012.

Hemalatha BN, Reetha B, Venkatesan T, Jalali SK, Sriram S, 2012. Degradation of insecticides by *Enterobacter* sp. and *Peanibacillus* sp. isolated from midgut of *Chrysoperla zastrowi sillemi* larvae. In: *International Conference on Plant Health Management for Food Security,* Hyderabad 28–30th November 2012, pp. 104.

Hemalatha BN, Reetha B, Venkatesan T, Jalali SK, Sriram S, 2013. Transmission Electron Microscopy and molecular characterization of microflora of the *Chrysoperla zastrowi sillemi* (Esben-Petersen). In: *International Conference on Insect Science*, (ICIS), Bangalore 14–17th Feb. 2013, pp. 54.

Hemalatha BN, Venkatesan T, Jalali SK, Sriram S, Krishnakumar NK, 2012. Isolation and molecular characterization of microorganisms associated with *Chrysoperla zastrowi sillemi*, an important predator of sucking pests. In: *IVth National Symposium in Plant Protection in Horticultural Crops; Emerging Challenges and Sustainable Pest Management,* IIHR, Bangalore 25–28th April 2012, pp. 25-28.

Holajjer P, Patil J, Harish G, Nataraja MV, Jarsrotia P, Savaliya SD, 2013. Evaluation of entomopathogenic nematodes, *Steinerma carpocapsae* and *Heterorhabditis* sp. for their virulence against *Spodoptera litura*. In: *10th National symposium on Biotechnological approaches in Plant Protection: Constraints and Opportunities*, ICAR Research complex for Goa. Ela Old Goa. 27–29th January, 2013, pp. 127–128.

Mahesh S. Y, Sivakumar G, Mohan M, Sunil Joshi R, Rangeshwaran R, Sanjay Yalashetti, 2013. Molecular characterization of bacteria associated with aphids (*Aphis gossypii*, *A. craccivora* and *Myzus persicae*), In: International Conference on Insect Science, Bangalore, February 14–17, 2013, pg-56

Mohan M, Kumar SM, Shanker C, Sivakumar G, Karthikeyan K, Sudheer S, 2013. Toxicity of *Bacillus thuringiensis* strains and Cry toxins to rice stem borers, *Sesamia inferens* (Noctuidae: Lepidoptera) and *Scirpophaga fusciflua* (Pyralidae: Lepidoptera), In: *International Conference on Insect Science*, Bangalore, February 14–17, 2013, pp–44.

Mohan M, Sampath Kumar M, Chitra Shanker, Karthikeyan K, Sudheer S, 2012. Rice white stem borer, *Scirpophaga fusciflua*: Biology, alternate hosts and susceptibility to *Bacillus thuringiensis*, In: *International Conference on Plant Health Management for Food Security*, November 28–30th, 2012, Hyderabad. pp–81

Nagesh M, Mohite P, Suresh K, Javeed S, Thippeswamy R, 2012. Entomopathogenic nematodes as biotic factor in restoration of soil health in sugarcane against white-grubs (Scarabaeidae:Coleoptera): a field study. In: *International Conference* on *Plant Health Management for Food Security*, DRR, Hyderabad, November 28–30th, 2012.

Nagesh M, Shivalingaswamy TM, Balachander M, Javeed S, Pai N, Ramanujam B, 2013. Combination potential of entomopathogenic nematodes and entomopathogenic fungi for biological control of *Myllocerus subfasciatus* Guerin on *Solanum melongena* L. In: *4th International Congress on Insect Science IISC 2013*, February, 14–17th at UAS, GKVK, Bangalore.

Patil J, Rajkumar, Subaharan K, 2012. Impact of entomopathogenic nematodes on rhinoceros beetle larvae, *Oryctes rhinoceros* (Coleoptera: Scarbaeidae), In: *22nd Swadeshi Science Congress*, Central Plantation Crops Research Institute, Kasaragod 6–8th November 2012, pp. 82–83.

Patil J, Rajkumar, Subaharan K, 2013. Synergism of entomopathogenic nematodes and imidacloprid: A curative tool to white grub, *Leucopholis coniphora* (Coleoptera: Melolonthinae) control in plantation crops. In: *4th International Conference on Insect Science,* UAS, GKVK, Bangalore. 14–17th February, pp. 46.

Rakshit O, Jalali SK, Venkatesan T, Krishnakumar NK, 2012. Development of DNA barcode for Indian ant species. In: *IVth National Symposium in Plant Protection in Horticultural Crops: Emerging Challenges and Sustainable Pest Management*. IIHR, Bangalore, 25–28th April 2012, pp. 84.

Ramanujam B, Karmakar P, Roopa G, Basha H, 2013. Diversity and utilization of entomofungal pathogens in crop pest management. In: *International Conference on Insect Science,* Bangalore, February 14–17th, 2013, pp. 3.

Ramanujam B, Roopa G, Karmakar P, Basha H, 2012. Toxicity of extracellular crude proteins from *Beauveria bassiana* and *Metarhizium anisopliae* on *Spodoptera litura*. In: *International Conference on Plant Health Management for Food Security,* DRR, Hyderabad, November 28–30th, 2012, pp. 185.

Rangeshwaran R, 2013. *Bacillus thuringiensis* – current aspects in biological control. Lecture delivered during the Winter school on *Biodiversity, Biosystematics and Biocontrol* held from 21st January –10th February 2013.

Rangeshwaran R, Ashwitha K, Sivakumar G, Jalali S K, 2012. Characterization of *Pseudomonas* spp. for its abiotic stress tolerance mechanisms and plant growth promoting traits, In: National Symposium on *Blending Conventional and Modern Plant Pathology for Sustainable*

Agriculture, IIHR, Bangalore, 04–06th December, 2012, pp.123.

Sivakumar G, Rangeshwaran R, Mahesh S. Yandigeri, Mohan M, Yalashetti S, 2012. Molecular characterization of gut bacteria associated with cotton leafhoppers, In: *National Symposium on Innovative Approaches and Modern Technologies for Crop Productivity, Food Safety and Environmental Sustainability,* Thrissur, November 19–20th, pp.13.

Sivakumar G, Rangeswaran R, Sriram S, Yandigeri MS, 2012. *Bacillus megaterium* strain NBAII 63 a potential biocontrol agent for the management of bacterial wilt of tomato caused by *Ralstonia solanacearum*. In: National Symposium on *Blending Conventional and Modern Plant Pathology for Sustainable Agriculture*, December 4–6, 2012, Session IV, Sustainable Agriculture and Lively hood, at Indian Institute of Horticultural Research, Hesaraghatta Lake Post, Bangalore, pp. 102.

Sivakumar G, Rangeswaran R, Yandigeri MS, 2012. Shelf life of *Bacillus megaterium* strain NBAII 63 in various formulations. In: *International Conference on Plant Health Management for Food Security*, Hyderabad, 28–30 November, 2012, National Bureau of Plant Genetic Resources, Rajendranagar, Hyderabad, India, p. 226.

Sivakumar G, Yandigeri MS, Rangeshwaran R, Mohan M, Yalashetti S, 2013. Characterization of Microflora associated with cotton leafhoppers (*Amrasca biguttula biguttula*), In: International Conference on Insect Science, Bangalore, February 14–17th, 2013, pp.56.

Snehaa CP, Hemalatha BN, Reetha B, Venkatesan T, Jalali SK, 2013. Molecular characterization of microbes associated with cotton mealybug, *Phenacoccus solenopsis* Tinsley. In: *International Conference on Insect Science*, Bangalore, 14–17th February, 2013, pp. 55.

Sridhar V, Venkatesan T, Joshi S, Krishnakumar NK, Reddy U, 2012. Establishment of Genetic relationship among Aphidinae through microsatellite (SSR) markers. In: National Symposium on *Plant Protection in Horticultural Crops: Emerging Challenges and Sustainable Pest Management* held at IIHR, Bangalore during 25–28th April, 2012, pp.16.

Thippeswamy R, Nagesh M, Savithri HS, 2012. Cloning, over-expression and characterization of putative insecticidal protein from *Photorhabdus luminescens*- a bacterial symbiont of entomopathogenic nematode *Heterorhabditis indica*. In: International Conference on *Plant Health Management for Food Security*, DRR, Hyderabad, November, 28–30th, 2012.

Venkatesan T Jalali SK, 2012. DNA barcoding: An emerging global standard for species identification. Delivered in XV National Training Programme conducted at Centre of Advanced Faculty Training in Veterinary Parasitology, Karnataka Veterinary, Animal and Fisheries Sciences University, Hebbal, Bangalore, pp. 66–77

Venkatesan T, 2012. Allele mining in insects with special reference to development of microsatellite markers. Lecture delivered during the "subject training program on "Bioinformatics: Methods and Approaches for Insect Research" under NAIP–NABG project from 19th November to 1st December, 2012 at NBAII, Bangalore.

Venkatesan T, 2012. Concept note on DNA barcoding of Indian Insects. Lecture delivered at Brainstorming session on DNA Barcoding for Biodiversity Management, held at Central Institute for Fisheries Education (CIFE), Mumbai during December, 2012.

Venkatesan T, 2012. DNA barcoding of insects. Lecture delivered during the "Subject training program on "Bioinformatics: Methods and Approaches for Insect Research" under NAIP–NABG project from 19th November to 1st December, 2012 at NBAII, Bangalore.

Venkatesan T, 2012. Presented work done under Institute Technology and Monitoring Unit (ITMU) at Annual Workshop–cum–Meeting (2012–13) of Zonal Technology Management–Business Planning and Development (ZTM-BPD) Unit, South Zone at NAARM and DOR, Hyderabad on 06/03/12.

Venkatesan T, 2013. DNA barcoding of insects. Lecture delivered during the Winter school on *Biodiversity, Biosystematics and Biocontrol* held from 21.1.2013–10.2.2013.

Venkatesan T, 2013. Presented work done report at NAIP Workshop under component 4 project "Effect of Abiotic stresses on the Natural Enemies of Crop Pests: *Trichogramma*, *Chrysoperla, Trichoderma & Pseudomonas* & mechanism of tolerance to these stresses" at Virology Auditorium, IARI, New Delhi during 25 and 26th March 2013.

CTRI–Rajahmundry

S.Gunneswara Rao, H. Ravi Shanker and U Sreedhar. Expert system for identification of natural enemies of tobacco pests. International conference on Plant Health Management for food security during November 28th to 30th 2012 at Hyderabad under poster session.

Gunneswara Rao, S and U. Sreedhar. Determination of economic injury level of tobacco capsule borer *Helicoverpa armigera* (Hubner). International Conference on Insect Science during February 14th to 17th 2013 at UAS Bangalore under poster session.

GBPUAT–Panthnagar

Roopali Sharma, Rashmi Tewari, B.C. Kabadwal, J.Kumar and R.K. Sharma. 2012. Role of biocontrol agents in management of compost pit in 7th Uttrakhand State Science and Technology Congress during 21–23 Nov. pp–17.

Bhadauria, B. P., Roopali Sharma, P.K.Singh and J.Kumar. 2012. Study of pathogenicity of a local isolate of *Beauveria bassiana* against *Spodoptera litura* (Fab.). 65th IPS National Symposium Indian Phytopathological Society National Symposium on Blending Conventional and Modern Plant Pathology for Sustainable Agriculture held on 4–6 December, p 124–125.

Bhupesh Chandra Kabadwal, Rashmi Tewari, Roopali Sharma and J.Kumar. 2012. A common minimum programme of pest/ disease management for small farms in hills of Uttarakhand. 65th IPS National Symposium Indian Phytopathological Society National Symposium on Blending Conventional and Modern Plant Pathology for Sustainable Agriculture held on 4–6 December, pp. 47.

Kumar, J. and Puri, S. 2012. Biological control of soilborne pathogens under green house conditions. *In: Proceedings of the 26th Training on "Diseases and management of crops under protected cultivation",* held at the Centre of Advanced Faculty Training in Plant Pathology, GBPUAT, Pantnagar, pp. 134–140.

Kumar, J. and Puri, S. 2012. Evaluation risks related to the release of biocontrol agenmts active against plant pathogens. *In: Proceedings of the 26th Training on "Diseases and management of crops under protected cultivation*", held at the Centre of Advanced Faculty Training in Plant Pathology, GBPUAT, Pantnagar, pp. 199-204.

Tewari, A.K. 2012. Biological control of foliar diseases under protected cultivation In: "Diseases and management of crops under protected cultivation". *In: Proceedings of the 26th Training on "Diseases and management of crops under protected cultivation"*, held at the Centre of Advanced Faculty Training in Plant Pathology, GBPUAT, Pantnagar, pp. 166-167.

Tewari, A.K. 2012. Commercial aspect of biological pest control in green houses *In: Proceedings of the 26th Training on "Diseases and management of crops under protected cultivation*", held at the Centre of Advanced Faculty Training in Plant Pathology, GBPUAT, Pantnagar, pp. 231–233.

Tewari, A.K. 2013. Influence of Environmental Parameters on *Trichoderma* Strains with Biocontrol Potential. *In: managing plant microbe interactions for the management of soil borne plant pathogens*. Jan.22–Feb.11 , p.129–130.

Evaluation and Selection of promising *Trichoderma* isolates for the management.

of soil borne plant pathogens. *In: managing plant microbe interactions for the management of soil borne plant pathogens*. Jan.22–Feb.11, p.102–105.

Sharma, R, Puri, S and Erraya, 2013. Isolation, Identification and Quantification of Trichoderma. *In:Proceedings of the 27th Training Managing Plant Microbe Interactions for the Management of Soil–borne Plant Pathogen.* held at the Centre of Advanced Faculty Training in Plant Pathology, GBPUAT, Pantnagar, pp. 177–179.

Sharma, R., Puri, S and Tewari, R. 2013. Mechanism of Mycoparasitism and Antibiosis. *In: Managing Plant Microbe Interactions for the Management of Soil–borne Plant Pathogens* held at the Centre of Advanced Faculty Training in Plant Pathology, GBPUAT, Pantnagar, pp. 180–183.

Sharma, R and Bhadauria, B.P. 2013. Mass production and formulation technology of *Trichoderma*. *In: Managing Plant Microbe Interactions for the Management of Soil–borne Plant Pathogens* held at the Centre of Advanced Faculty Training in Plant Pathology, GBPUAT, Pantnagar, 184 p.

Kumar, J., Sharma, R., Puri, S and Arzoo, K. 2013. Identification of *Pseudomonas and Bacillus* Isolates using Biolog System. *In: Managing Plant Microbe Interactions for the Management of Soil-borne Plant Pathogen* held at the Centre of Advanced Faculty Training in Plant Pathology, GBPUAT, Pantnagar, pp. 185–187.

IIHR-Bangalore

Ganga Visalakshy. PN and Krishnamoorthy. A. 2013 Comparative field efficacy of various entomopathogenic fungi against *thrips tabaci*: prospects for organic production of onion in India. ISHS Acta Horticulture 933: XXVIII In: International Horticultural Congress on Science and Horticulture for People (IHC2010): International Symposium on Organic Horticulture: Productivity and Sustainability.

Ganga Vislakshy, PN, Jayanth, KP. Ghosh.SK and Choudhary. M. 2013. Development of anatomical age grading technique for *Zygogramma. bicolorata* and its implications in biological control of invasive weed *Parthenium hystereophorus* in India–ICIS, 2013, Bangalore.

Ganga Visalakshy. PN .2013 Factors influencing the abundance of *Dolichogenidae stantoni (*Asheamd), a potential natural enemy of *Diaphania indica* (Saunders) ICIS–2013, Bangalore.

Ganga Visalakshy. PN and Krishnamoorthy. A. 2013 Management of *Thrips tabaci* on onion – possible alternatives. In: IV National symposium on Plant protection in horticultural crops Emerging challenges and sustainable pest management, 25–28 April, 2012, Bangalore.

KAU-Thrissur

Joy, PJ and Lyla, KR, 2012. Successful biosuppression of *Salvinia molesta* using *Cyrtobagous salviniae* in Kerala. Biennial conference of Indian Society of Weed Science on "Weed Threat to Agriculture, Biodiversity and Environment", April 19–20, 2012, Kerala Agricultural University. p.5.

PAU-Ludhiana

Aggarwal N, Neetan and Kour G 2013. Integration between entomopathogenic nematodes and *Bacillus thuringiensis* as a novel approach for the biological control of Diamondback moth, *Plutella xylostella* (L.) In International Conference on Insect Science, Bangalore, February 14–17, 2013, p 42.

Arora R, Suri KS, Kumar V, Chandi RS, Aggarwal N and Bhullar HS 2013. Bioefficacy of novel insecticides against the tobacco caterpillar, *Spodoptera litura* infesting cole crops in Punjab. In: International Conference on Insect Science, Bangalore, February 14–17, 2013, p 120.

Joshi N, Sharma N and Bhullar BM, 2013. Bioassay of fungal isolates against two spotted spider mite, *Tetranychus urticae* Koch. In: proceedings of the International Conference on Insect Science, Bangalore, February 14–17th 2013, pp. 116.

Malhan G S, Arora R Suri K S, Aggarwal N and Arora PK, 2013. Farmer's knowledge, perceptions and management of insect pests of cole crops in Punjab. In: International Conference on Insect Science, Bangalore, February 14–17, 2013, p 23.

Saini M K, Aggarwal N and Kumar V, 2012. Impact of an integrated pest management programme in transgenic cotton in Punjab. In: Proceedings of the "National Seminar on Biotechnological Approaches in Pest management", PAU, Ludhiana from 4 – 5th May, 2012, pp. 117.

Singh K, Singh G, Kaur R and Chandi AK, 2013. Influence of spinosad on the ovaries of diamondback moth, *Plutella xylostella* (Linnaeus). In: International Conference on Insect Science, Bangalore, February 14–17, 2013, p112.

Singh S, Pandher S, Shera PS, Aggarwal N and Jindal V, 2013. Changing insect pest scenario in *Bt* cotton era in Punjab). In: International Conference on Insect Science, Bangalore, February 14–17, 2013, p 11.

TNAU-Coimbatore

Jonathan EI, Karuppuchamy P, Kalyanasundaram M, Suresh S and Mahalingam CA, 2010. Status of Papaya Mealybug in Tamil Nadu and its Management. Classical Biological Control of Papaya Mealybug (*Paracoccus marginatus*) in India. In: Proceedings of the National Consultation Meeting on Strategies for Deployment and Impact of the imported Parasitoids of Papaya Mealybug, 30th October, 2010, pp. 24–33.

Kalyanasundaram M, Karuppuchamy P, Divya S, Sakthivel P, Rabindra RJ and Shylesha AN, 2010. Impact of release of the imported parasitoid *Acerophagus papayae* on the management of Papaya Mealybug *Paracoccus marginataus* in Tamil Nadu. In: Proceedings of the National Consultation Meeting on Strategies for Deployment and Impact of the imported Parasitoids of Papaya Mealybug, 30th October, 2010, pp. 68–72.

Samiayyan K, Sudha V, Radha Krishnan V, Karuppuchamy P and Jonathan EI, 2012. Spider Diversity in different Short Duration food Legumes Ecosystems of Tamil Nadu, India. In: Second International Symposium of Biopesticide and Eco–Toxicological Network (ISBiOPEN) – Abstracts 130–131.

YSPUHF–Solan

Sharma PL and Ajay Sharma, 2012. Efficacy of *Beauveria bassiana* (Balsamo) alone and in combination with endosulfan and deltamethrin against *Spodoptera litura* (Fabricius)", In: National symposium on Emerging Issues in Plant Health Management organized by Indian Phytopathlogical Society at UHF, Solan w.e.f. September, 28–29, 2012.

Nisha Devi, Sharma K. C, Sharma P. L, Chandel R. S and Thakur Y. 2012. "Laboratory Bioassy studies on some entomopathogenic fungi against greenhouse whitefly, *Trialeurodes vaporariorum* Westwood", In: National symposium on Emerging Issues in Plant Health Management organized by Indian Phytopathlogical Society at UHF, Solan September, 28–29, 2012.

Nisha Devi, Sharma KC, Sharma PL, Chandel RS and Thakur Y, 2012. "Bioefficacy of two pyrethroid insecticides and two entomopathogenic fungal formulations against greenhouse whitefly, *Trialeurodes vaporariorum* westwood", In: National symposium on "Indian Agriculture: Present situation, challenges, remedies and road map" organized by CSK HPKV, Palampur August, 4–5, 2012.

CPCRI-Kayangulam

Chandrika Mohan, Josephrajkumar A and Rajan P, 2012. Field Validation of Biological Suppression of Coconut Black Headed Caterpillar, *Opisina arenosella* Walker using larval parasitoids *Goniozus nephantidis* and *Bracon brevicornis*. In: *XX PLACROSYM–2012*, Coimbatore, December, 12–15, 2012, 107p.

Chandrika Mohan, Radhika, MK., Josephrajkumar A and Rajan P, 2013. Coconut water as a promising culture media for *Hirsutella thompsonii* Fisher, a pathogen of coconut mite. In: *Souvenir and Abstracts: New Horizons in Insect Science* (Eds.) Chakravarthy AK, Ashok Kumar CT, Abraham Verghes NE, Thiagaraj, International Congress on Insect Science, Bangalore, February, 14-17, 2013, 48p.

Josephrajkumar A and Chandrika Mohan, 2012. Issues, challenges and future thrust of coconut entomology. In: *Brainstorming session on Plant Protection of Spices and Plantation Crops*, June, 20, 2012, CDB, Kochi.

Josephrajkumar A, Chandrika Mohan and Rajan P, 2013. Evaluation of entomopathogenic nematodes against red palm weevil, *Rhynchophorus ferrugineus* (Olivier) and synergistic interaction with the neonicotinoid, imidacloprid. *In Souvenir and Abstracts: New Horizons in Insect Science* (Eds.) Chakravarthy AK, Ashok Kumar CT, Abraham Verghese NE, Thiagaraj. In: International Congress on

Insect Science, Bangalore, February, 14–17, 2013, 48–49p.

Training Manuals

- Nagesh M, Bhumannavar BS, Saleem Javed, Nikhita Pai, Jagadeesh Patil and Jalali SK, 2012. Production, Commercialization and Utilization of Beneficial Organisms for the Management of Plant Parasitic Nematodes 27–31 August 2012.

(ii) Technical/popular articles

1. Mahesh SY and Sivakumar G, 2013. Phylogenetic affiliation of microbial flora of insects and their resources. In: Biodiversity, Biosystematics & Biocontrol, 21 days training programme from January 21 to February 10, 2013 at National Bureau of Agriculturally Important Insects, Bangalore, India.
2. Sivakumar G, Rangeshwaran R, Mohan M and Mahesh SY, 2013. Insects and Microbes. In: Biodiversity, Biosystematics & Biocontrol, 21 days training programme from January 21 to February 10, 2013 at National Bureau of Agriculturally Important Insects, Bangalore, India.

(iii) Technical bulletins/books

Book Chapters

Mahesh SY and Dhananjaya PS, 2013. Beneficial plant-microbe interactions in the soil for sustainable agriculture. In: Behera KK. (Ed.), Newer Approaches to Biotechnology, Narendra Publishing House, pp. 187–213

Radha TK, Mahesh SY and Roopa TK, 2013. Microbial plant growth promotion and biological control of plant pathogens. In: Behera KK. (Ed.), Newer Approaches to Biotechnology, Narendra Publishing House, pp. 239–255

Ramanujam B, Chowdappa P and Honnur Basha, 2012. Biological control of foliar diseases. p 274–287 In: *Leaf spot diseases of annual and perennial crops* (Eds.) Chowdappa P and Singh HP. Westville Publishing House, New Delhi. 327pp.

Rangeshwaran R, Rabindra RJ, Sriram S, and Ramanujam B, 2012. Evaluation of Bioefficacy and environmental safety of microbial pesticides. p 87–104 In: *Environmental safety of Biotech and conventional IPM Technologies* (Eds.) Sharma HC, Dhillon MK and Sharawat KL, Stedium Press LLC, Texas, USA. 416pp.

Vimala Devi PS, Ranga Rao GV, Gopalakrishnan S and Sivakumar G, 2012. Environmental Impact of Microbial Pesticides. (Eds.) Sharma, HC, Dhillon MK and Shrawat, KL, In: Environmental safety of Biotech and Conventional IPM Technologies. Stedium Press LLC, USA (ISBN: 1-933699-68-X)

Nagesh M, Nikhita Pai, Saleem Javed and Balachander M, 2012. Biodiversity, genomics, computational biology and markers – application to veterinary arthropod and nematodes. In *Biotechnological Applications in Veterinary Parasitology* (Eds.) Placid E. D'souza. CAFTVP, KVAFSU, Bangalore, pp. 109-137.

Nagesh M, Seema Wahab, Saleem Javed and Thippeswamy R, 2012. Bacterial toxins and their application in insect pest management. In: *Biopesticides in environment and food security Issues and strategies*. Scientific Publishers, India. pp. 77-88.

AAU-Anand

Janardan JJ and Godhani PH, 2013. "Fundamentals of microbial biocontrol and plant growth promotion practices". Publisher: Biological Control Research Laboratory, AAU, Anand

AAU-Jorhat

Anjumoni Devee and Kotoky U, 2013. Commercial nursery management of Horticultural crops (Assamese), Vol. I and Vol. II.

PAU-Ludhiana

Virk JS, Sharma S and Joshi N, 2012. Management approaches for sugarcane insect pests. In: Dhawan AK, Singh B Arora R and Bhullar M (Eds.) "Advances in Agricultural Entomology" (Accepted).

CTRI-Rajhamundry

Gunneswara Rao S and Sreedhar U, 2013. Egg parasitoids in tobacco ecosystem. In: (Eds.) Sitanantham S, *et al.,* Biological control of insect pests using egg parasitoids. Springer International.

Popular article / Technical / Extension Bulletins

NBAII, Bangalore

Sequence submissions and DNA Barcoding made from NBAII under DBT projects, 2013. (Eds.) Nagesh M, Savithri HS, Bhumannavar BS, Sinha RR, pp. 38. NBAII Technical Bulletin No. 65.

AAU-Anand

Patel CC, Radadiya BV and Godhani PH, 2012. Suryamukhi ane Kasumbini Jivato. Krushi Pakoma Sankalit Jivat Yvasthapan (Book), Department of Entomology, BACA, Anand Agricultural University, Anand-388 110, Gujarat.

AAU-Jorhat

Anjumoni Devee U, Kotoky: Sustha sabal puli utpadanar sathik padakkhep, (Assamese), 12th Nov. Asamia Khabar, 2012.

Anjumoni Devee U, Kotoky: Tamol- Narikalar puli utpadan, (Assamese), 29th October. Asamia Khabar, 2012.

Anjumoni Devee, Gautam Handique: keetnasak drabya proyogar samayat loba loga sabadhanata, (Assamese), 10th May. Doinik Janambhumi, 2012.

Saikia DK, Joibik krishit Trichogrammar bhumika .

Saikia DK, Sak – pachalirjoibik krishit keet–patanga niyantranar byabastha.

MPKV-Pune

Tamboli ND, Nakat RV and Dhane AS, 2012. Integrated pest management. *Krishi Bhushan*, April, 2012, pp. 61–62.

Tamboli ND, Pokharkar DS and Dhane AS, 2012. Production technique of *Cryptolaemus montrouzieri* for the control of mealybug. *Bhusawanardhan*, October 2012, pp. 13–14.

Tamboli ND, 2012. Biological control of sugarcane pyrilla. *Bhusawanardhan*, October 2012, pp. 31–32.

Pokharkar DS, Kharbade SB, Jadhav SS and Dhane AS, 2013. Occurrence of mealybug on tomato. *Sakal AGROWON*, January 29, 2013. pp.11.

PAU-Ludhiana

Aggarwal N**,** Jindal J and Singh G, 2013. Manage insect pests of spring maize for higher yield *Prog Fmg*. 49(1): 23–24**.**

Aggarwal N**,** Jindal J and Singh G, 2013. Bahar rut di makki nu kide makudiyan ton bachao *Changi Kheti* 48(1): 8–10

Aggarwal N, Jindal J and Brar D S, 2012. Bahar rut di makki da jiyada jhar lain layi kide makudiyan di roktham de ahem nukte. *Modern Kheti* 28(4): 32-33

Brar D S, Jindal J and Aggarwal N, 2012. Sauni di makki di fasl te hanikarak kidian di suchaji roktham *Modern Kheti* 28(2): 32–34

Aggarwal N, Kaur R and Sharma S, (2013). Experiential learning on mass production of biocontrol agents. pp 40

YSPUHF-Solan

Usha Chauhan, Harinder Gautam and Gupta YC, 2013. Carnation cultivation and its management under polyhouse conditions 60 pages (In press).

Usha Chauhan, 2013. Two spotted spider mite and its management 160 pages (In press).

Usha Chauhan, 2013. Indentification of various insect, mite pests and their natural enemies under polyhouse conditions. 60 pages (In press).

CPCRI-Kayangulam

Rajan P, Nair CPR, Josephrajkumar A and Chandrika Mohan, 2012. *Nariyal Patha Fring* (*Brontispa longissima*) Hindi translation by Sreelatha K and Alka Gupta, *Technical folder*, CPCRI publication.

Josephrajkumar A, Chandrika Mohan, Rajan P, Thomas RJ, Chandra-mohanan R and Jacob PM, 2012. *Pest Management in Coconut Nursery*, CPCRI, Kasaragod, *Technical Bulletin No: 73*, p 16.

17. MEETINGS HELD AND SIGNIFICANT DECISIONS MADE

Quinquennial review team (QRT) recommendations

The quinquennial review team with Dr. G. K. Veeresh as the Chairman and Dr. V. Ragunathan, Dr. L. K. Hazarika, Dr. Suresh Pal, and Dr. B. S. Bhumannavar as members reviewed the progress of work made by NBAII and AICRP on Biological Control and made the following recommendations.

1. Exploratory surveys should be made for the collection of insects (pests and natural enemies) representing all states in India and special attention should be given to Andaman & Nicobar Islands, Northeastern region and Western Ghats.
2. There is a need to induct more insect taxonomists.
3. Prioritization of family for taxonomic study especially natural enemies in Hymenoptera, Coleoptera, Diptera and Neuroptera should be given priority. Similarly there is a need to work on Cerambycidae and Scolytidae as borers are becoming important. Work on Isoptera (termites), gall midges, etc. need to be taken on priority.
4. NBAII should comprehensively look into developing expertise in pests, parasites affecting veterinary animals (Tabanids, mites, ticks, etc.).
5. Systmatics and diversity of entomopathogenic nematodes can be taken up by NBAII while plant parasitic nematodes can be addressed by IARI.
6. Standardize and develop protocols for a number of other natural enemies and host insects and maintain cultures for national research use.
7. Mass production of EPN without use of wax moth, extending shelf life and reducing cost of production should be the future priority.
8. Focus insect pollinators work on cross pollinated crops.
9. Need to generate supporting data for the slow release of nanoformulations for *H. armigera*, *S. incertulas, B. dorsalis* and *L. orbonalis* in the field.
10. Development of molecular markers for *Leucinodes orbonalis*, DBM and mealybugs.
11. Work to be initiated on ecological understanding of pest-parasitoid relationship (density dependence, k vs r (environmental resistance vs reproduction potential) strategies, type I – to - type IV relationship, numerical response, non-linear responses.
12. Study and document the impact of high temperature, CO_2 concentration, etc. on parasitoids complex impacting major pests, such as mealybugs, scales etc.
13. Work on pollination ecology has to be strengthened, especially on role of non-bee pollinators on crops and seed productivity and impact of high temperature on pollination efficiency
14. Ecological impact of invasive species, strategy for management on lines of anticipatory research.
15. Work on ecology of spiders need to be initiated.

16. Development of molecular markers for studying genetic variation in various biotypes in *Leucinodes orbonalis*, DBM and mealybugs, molecular mechanism involved in insect resistance to certain abiotic factors and identification of endosymbionts of natural enemies and their role in providing pesticide and temperature tolerance to insects.
17. Work to be initiated in emerging fields of RNAi in IPM and transcriptome analysis.
18. IPR with respect to molecular data, genes need to be kept in mind.
19. Study on vector dynamics influencing vector-transmitted plant viruses is needed.
20. Study role of insect endosymbionts diversity, their impact on fitness, IRM, virus transmission, etc. is needed.
21. Initiate work on diversity of Bt genes to effectively manage the other orders of insects.
22. Mapping of *Bt cry* gene diversity in hot and humid regions of India anddevelopment of computational tools for prediction of insecticide resistance gene in agriculturally important insects is needed.
23. The QRT looks forward to the generation of useful information under elevated CO_2 levels for host insects and natural enemies in future. There is a need to start a network project on entomopathogenic nematodes.
24. There is a need for more entomologists at NBAII. Now with 3 pathologists, 3 microbiologists and 1 organic chemist, nearly 7 posts are occupied by other displines. In the XII plan one microbiologist and one pathologist are enough and other 5 positions can be converted to entomology.
25. The organic chemist may be better adjusted in places such as IARI where the work on nano-technology may be more meaningful.
26. Policy decisions need to be evolved for the creation of earthquake and fire-proof Insect/ Arthropod National Reference Collection at NBAII and there is a need to establish two insect museums with a specialized curator, one at NBAII and another one at IARI.
27. NBAII should have a Scanning Electron Microscope (SEM) to address the futuristic need of arthropod systematics which could be a national facility for ICAR/SAU in the country.
28. The QRT recommends allocation of building space (at least one floor) at NCIPM new facility at Mehrauli for NBAII research activities along with additional manpower. The QRT also recommends for coordination with NCIPM in various research activities.
29. Further QRT recommends for creation of two new divisions i.e. Division of agricultural acarology and Division of biosecurity and quarantine as recommended by RAC.
30. And additional laboratory work space at NBAII in future plan periods from 951.92 sq. m to 2000 sq. m. and additional manpower of 50 scientists from the present 30, 36 technical staff from the present 18, 14 administrative staff from the present 7 and 12 supporting staff from the present 6.
31. Enhance plan budget from 1200 to 2800 lakhs (2.5 times) and non-plan budget from 2072 to 5180 lakhs (2.5 times) in the XII plan.
32. There is a need for 5-10 acres of land with assured irrigation facility for field work in any of the ICAR institutes located in Bangalore like NDRI.

Research Advisory Committee (RAC)

The 17th meeting of the Research Advisory Committee (RAC) was held on 12-13th March was held at NBAII. The meeting was chaired by Dr B Senapati and attended by the members Dr R Ramani, BV David, SK Gupta, HK Bajaj, BS Bhumannavar and the Scientists of the NBAII. All three discipline heads presented the salient achievements of the research progress made during 2012-13. The chairman and the members appreciated the research progress made by the scientists. The following suggestions were made and endorsed by the chairman.

1. Focused research with minimum number of projects was advocated. The thrust areas of research suggested were: Biodiversity of arthropod vectors, vector-disease dynamics, soil arthropod diversity, diversity of spiders and predatory mites, pest dynamics under organic farming, studies on insect pollinators, functional significance of insect endosymbionts, research on storage stability of insect pheromones, multilocation testing of microbial biopesticides especially *Bacilluis thuringiensis*, mycoentomophagous nematodes in addition to EPN.
2. Suggested for reviewing scientific cadre strength and consideration for flexi-discipline approach.
3. Creation of few more divisions in a phased manner were suggested
4. Human resource development through training and exposure visits to International research Institutes.
5. The committee strongly felt the need of scanning electron microscope for biosystematic studies.
6. The other recommendations include, biodiversity exploration in hot spot areas, preparation of field guides and data bases of selected group of insects, research on molecular mechanisms of insecticide resistance, genomic studies on sucking pests, storage insects and EPN, studies on pollinator ecology and climate change and pests dynamics.

Institute Research Council Meeting

The Institute Research Council (IRC) meeting was held on 3rd September 2012 under the chairmanship of Dr. B.S. Bhumannavar, Director, NBAII. Two new Research Project Proposals (RPP) were presented by M. Mohan (Mechanism of insecticide resistance in *Leucinodes orbonalis* and *Leucopholis coneophora)* and Mahesh Yendigeri (Role of microflora of aphids in insecticide resistance) and the meeting was attended by all the Scientists. Both the projects were approved and the following IRC decisions were made.

1. In view of transfer of Dr Rajkumar, the project on “Diversity and distribution of entomopathogenic nematodes in temperate and gangetic plains of India”was transferred to Dr. Jagadeesh Patil, Scientist (Nematology).
2. Since Ms Shalini is on study leave, her project “Taxonomic studies on pentatomid fauna (Hemiptera: Heteroptera) of India with special reference to Pentatominae” was kept in abeyance.
3. In view of changes in Institute’s mandate, the project on “Bio-intensive management of root knot nematode and Fusarium disease complex in tomato and okra using PGPR handled by Dr Rajkumar was closed and asked to submit RPP2 and RPP3.
4. The IRC recommended to extend the project on “Polymorphism on pheromone reception in *Helicoverpa armigera*” handled by Dr Bakthavatchalam up to 31st March 2013.

18. PARTICIPATION OF SCIENTISTS IN CONFERENCES, MEETINGS, WORKSHOPS, SYMPOSIA ETC, IN INDIA AND ABROAD

Symposia/conference/seminars attended by scientists	Name(s) of scientist
Classical Biological Control of Papaya mealy bug 20th October 2012 at Bangalore	All the scientists
International Conference on Plant Health Management for Food Security organised by Plant protection Association of India, Hyderabad, November 28-30, 2012	Dr. M. Mohan
International Conference on Insect Science, Indian Society for Advancement of Insect Science, Bangalore, February 14-17, 2013.	Dr. M. Mohan, Dr. Deepa Bhagat, Dr. N. Bakthavatsalam, Dr. Chandish Ballal, Dr. Chandrika Mohan (CPCRI), Dr. Ganga Visalakshy (IIHR), Dr. Naveen Aggarwal (PAU), Dr. Rabinder Kaur (PAU)
Group Meeting of AICRP on Biological Control of Crop Pests and Weeds, 22-23rd May 2012. Acharya NG Ranga Agricultural University, Hyderabad.	All the scientists
National Symposium on Plant Protection in Horticultural Crops, Indian Institute of Horticultural Research, Bangalore 25-28 April 2012.	Dr. N. Bakthavatsalam, Dr. Chandish Ballal, Dr. T. Venkatesan, Dr. B. Ramanujam, Dr. Ganga Visalakshy (IIHR), Dr. A. Krishna Murthy (IIHR)
Genotyping and Marker Aided Selection on 13th February 2012. Organized by Genotypic Technology Pvt. Ltd., at UAS Veterinary College, Bangalore.	Dr. T. Venkatsan Dr. K. Srinivasa Murthy

Brainstorming session on DNA Barcoding for Biodiversity Management, held at Central Institute for Fisheries Education (CIFE), Mumbai during Dec. 2012.	Dr. T. Venkatesan
Brainstorming Session - Roadmap for Entomopathogenic Nematode on 20.04.2012 at NBAII, Bangalore	All the scientists
Annual Workshop-cum-Meeting (2012-13) of al Technology Management-Business Planning and Development (ZTM-BPD) Unit, South Zone at NAARM and DOR, Hyderabad during 28th February 2013 to on 05 March 2013 "NAIP Workshop under component 4 project "Effect of Abiotic stresses on the Natural Enemies of Crop Pests: *Trichogramma, Chrysoperla, Trichoderma & Pseudomonas* & mechanism of tolerance to these stresses" at Virology Auditorium, IARI, New Delhi during 25 and 26th March 2013. Attended "International conference on Increasing Agriculture Productivity and Sustainability in India: The future we want" held at National Institute of Advanced Studies, IISC, Bangalore-12 during 8th and 9th 2013 Attended Meeting on NABG-Phenomics and Basic and strategic research on allele mining from 19th-21st July 2012 at IASRI, New Delhi.	Dr. T. Venkatesan
National Consultation Meet on Nano Agriculture Mission 12th March, 2012 at National Agricultural Science Centre (NASC Complex), New Delhi. Formation of Umbrella for Gas Sensor Platform" at IISc, Bangalore, on November 2, 2012. Chemists conclave-brainstorming session was organized at Division of Agricultural Chemicals, IARI, New Delhi on January 14-15, 2013.	Dr. Deepa Bhagat
National Seminar on Biotechnological Approches in Pest Management, PAU, Ludhiana. May 4–5, 2012.	Dr. Naveen Aggarwal (PAU), Dr. Neelam Joshi (PAU)

Kisan Mela. PAU, Ludhiana, September, 21–22, 2012.	Dr. Naveen Aggarwal (PAU), Dr. Neelam Joshi (PAU), Dr. Rabinder Kaur (PAU)
International Conference Sustainable Agriculture for Food and Livelihood Security, PAU, Ludhiana, November, 27–28, 2012.	Dr. Naveen Aggarwal (PAU), Dr. Neelam Joshi (PAU), Dr. Rabinder Kaur (PAU)

19. WORKSHOPS, SEMINARS, SUMMER INSTITUTES, TRAINING PROGRAMMES ETC.

NBAII

Training programme on "Biodiversity, Biosystematics & Biocontrol" (21.1.2013-10.2.2013), NBAII, Bangalore.

Special Training Programme on Integrated Pest and Disease Management in horticultural crops (16-23rd October 2012) for officers from Department of Horticulture and KVKs. (22-10-2012)

For BSc (Hort.) students from College of Horticulture, University of Horticultural Sciences, Bagalkot (5-10-2012).

Training on "Demonstration on microbiological techniques" to the Agricultural officers of Karnataka (8th March, 2013).

Hands-on Training for AICRP Nematodes and their integrated management workers on Production, commercialization and utilization of beneficial organisms for the management of plant parasitic nematodes – 15 SAU & AICRP scientists (27th to 31st of August 2012).

Organized two hands-on training to three scientific officers each from Camson Biotech, C-7, 7th Floor, Corporate Block, Golden Enclave, Old Airport Road, Bangalore–17 and FARMER, Ghaziabad UP, on Entomopathogenic nematode, *Heterorhabditis indica* strain NBAII, *in vivo* production, downstream processing and wettable powder formulation and field use for biological control of white grubs, ash weevil grubs and cut worms, as a part of technology transfer to private entrepreneurs.

Meet on the success of the papaya mealybug management through classical biological control (19–20th October, 2012)

The papaya mealybug, *Paracoccus marginatus* a native to Mexico, was found in severe intensity in and around Coimbatore of Tamil Nadu during 2008 and has subsequently spread to nearby states like Kerala, Andhra Pradesh, Karnataka and Maharashtra. It has a wide host range of over 60 species of plants including pigeonpea, tapioca, okra, tomato, brinjal, cocoa, cotton, mulberry and rubber in addition to a host of weed plants including parthenium.

The NBAII imported the three species of parasitoids, *Acerophagus papayae, Anagyrus loecki* and *Pseudleptomastix mexicana* on

15th July 2010 with the help of United States Department of Agriculture Animal and Plant Health Inspection Services (USDA-APHIS) from their facility at Puerto Rico and completed all the mandatory safety and specificity tests in the quarantine facility. After following the requisite quarantine measures, the parasitoids were released to the field. The parasitoid, *Acerophagus papayae* could effectively suppress the populations of *P. marginatus* in several states within six months to one year of its release.

The success of the papaya mealybug management through Classical Biological Control was celebrated by NBAII on the Institute foundation day on 20th October, 2012. Dr. S. Ayyappan, Secretary DARE and DG ICAR participated. The farmers from different states, scientists from southern states and managers from private companies participated in the meeting. The meeting discussed the present status of the *P. marginatus* in different states on various crops and made an economic analysis of the profit accrued due to the release of parasitoids.

20. DISTINGUISHED VISITORS

NBAII

1. Dr. N. D. Raghavan, Former Vice Chairman, Central Adminstrative Tribunal, Bangalore on 28-4-2012.
2. Dr. T. K. Srinivasa Gopal, Director, CIFA Kochi on 1-5-2012.
3. Dr. G. Anand and Dr. Vanaja Ram Prasad, Green foundation on 2-7-2012.
4. Dr. C. D. Mayee, Ex chairman ASRB on 13-7-2012.
5. Dr. Mehrzadm Susans Roses, Andaman Nicobar islands 24-7-2012.
6. Dr. Deepa Dhankhar, Agricultural Specialist USDA/APHIS, U S Embassy, New Delhi 20-10-2012 and 27-02-2013.
7. Dr. N. Krishnakumar, Director, IFGTB, Coimbatore on 30-1-2013.
8. Dr. Hiroshi Honda, University of Tsuba, Japan. 18-2-2013
9. Mr. Scott Saxe, US Embassy, New Delhi 27-2-2013

AAU-Anand

Dr. Dolly kumar, Associate Professor, Dept. of Zoology, Faculty of Science, M.S.University, Baroda (Gujarat).

AAU-Jorhat

1. QRT team – Dr. G.K. Veeresh, Dr. B. S. Bhumannavar, Dr. N. Raghunathan and Dr. Basudev Rao, 15th June , 2012.
2. Team of students and teachers from different districts of Kamrup, Morigaon, Dibrugarh on 17.08.2012, 14.09.2012, and 18.03.2013.
3. A group of farmers under NGO (Sadbhavana) on 07.11.12.

ANGRAU-Hyderabad

1. Director of Pesticide Formulation Technology Centre, Dr. S. K. Raza and Dr. Patanjali, Principal Scientist, on 23 August, 2012.
2. Dr. V. K. Yadav, PPA, Krishi Bhavan, New Delhi, on 16 October, 2012.
3. Scientists from Michigan State University
4. Dr. Sreedhar, Head (Plant Protection), CTRI Rajahmundry on 28 November, 2012.
5. Dr. Tripathi, Project Co–ordinator – AINP on Rodentology on 8 March, 2013.
6. Dr. K. S Varaprasad, Project Director, Directorate of Oilseed Research, on March 20, 2013.

MPKV-Pune

1. Dr. G. P. Gupta, National Consultant (PP), NPSM, DAC, GOI, New Delhi and

former Head, Division of Entomology, IARI, New Delhi on 10/5/2012.

2. Dr. M. Mani, Emeritus Scientist (Entomology), IIHR, Bangalore on 12/6/2012 and 05/10/2012.
3. Dr. A. G. Chandele, Head, Dept. of Entomology, MPKV, Rahuri on 18/5/2012, 25/6/2012, 13/7/2012, 20-21/7/2012, 17/8/2012, 03/9/2012, 15/10/2012.
4. Dr. Sandipa Kanitkar, Managing Director, Kanboysis Pvt. Ltd. Pune on 15/10/2012.
5. Dr. Subrato Sarkar, Research Advisor, M/S. Ajay Biotech Ltd., Pune 15/10/2012.
6. Monitoring Team: Dr. A. N. Deshpande, Chairman & Head, Dept. of Soil Science and Agril. Chemistry, Dr. K. J. Kamble, Dy. Director of Research (IV) & Member, MPKV, Rahuri, and Dr. S. B. Gurav, Associate Director of Research, NARP (PZ), Pune & Member Secretary on October 17-18, 2012.
7. Dutch-Expert Team, Greenport Holland International, Netherland of Dr. Jouke Campen, Mr. Prakash, Mr. Udayanarayan Bhat and Mr. Karst Weening on 20/11/2012.
8. Dr. G. B. Khandagale, Director of Research, Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra visited the lab. on 10/01/2013.
9. Dr. S. V. Sarode, Director of Research, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola on 10/01/2013.
10. Mr. Peter Davies, Professor of Plant Physiology, Cornell University, USA and 30 foreign students from the University on 11/01/2013.
11. Eight Agril. Officers and 7 progressive growers from Madhya Pradesh on 22/02/2013.
12. Dr. O. P. Veda, Professor & Head, Dept. of Entomology, JNKVV, Jabalpur, MP on 18/03/2013.

SKUAST-Kashmir

1. Dr. N.K. Krishna Kumar, Director, NBAII, Bangalore.
2. Dr. M.N. Azim. Head, Department of Zoology, University of Kashmir.

TNAU –Coimbatore

1. Dr. J.P. Michaud, Scientist from Kansas State University, USA, on 17-04-2012.
2. Dr. Kusumakar Sharma, ADG (HR) ICAR, on July 10, 2012.
3. Dr A.R Prasad, Pheromone Research Laboratory, IICT, Hyderabad, on 17.10.12.
4. Dr. Harish C Sharma, Principal Scientist, ICRISAT, on 21.2.2013.

CTRI-Rajahmundry

1. Mr. P.S.K. Prasad, Plant Protection Officer CIPMC, Govt. of India, Hyderabad, on 5.03.13.

PAU-Ludhiana

1. Pakistan delegation from University of Faisalabad, Pakistan on November 30, 2012.
2. B. Sc Agri students from the Baba Farid College, Bathinda on March 30, 2013.

21. PERSONNEL

Scientists	
Dr. N. K. Krishna Kumar	Director (upto 9th August 2012)
Dr. B. S. Bhumannavar	Director (Acting) (from 9th August 2012)
Dr. N. Bakthavatsalam	Principal Scientist
Dr. Prashanth Mohanraj	Principal Scientist
Dr. B. Ramanujam	Principal Scientist
Dr. (Ms.) K. Veenakumari	Principal Scientist
Dr. (Ms.) J. Poorani	Principal Scientist
Dr. (Ms) Chandish R. Ballal	Principal Scientist
Dr. M. Nagesh	Principal Scientist
Dr. A. N. Shylesha	Principal Scientist
Dr. S. K. Jalali	Principal Scientist
Dr. T. Venkatesan	Principal Scientist
Dr. P. Sreerama Kumar	Principal Scientist
Dr. K. Srinivasa Murthy	Principal Scientist
Dr. Sunil Joshi	Principal Scientist
Dr. R. Rangeshwaran	Principal Scientist
Dr. T. M. Shivalingaswamy	Principal Scientist
Dr. G. Siva Kumar	Senior Scientist
Dr. M. Mohan	Senior Scientist
Dr. Mahesh Yandigeri	Senior Scientist
Ms. M. Pratheepa	Scientist SS
Dr. (Ms.) Deepa Bhagat	Scientist SS
Dr. Gandhi Gracy	Scientist
Dr. Ankita Gupta	Scientist
Mr. K.J. David	Scientist
Mrs. S. Salini	Scientist
Dr. Jagdeesh Patil	Scientist

Technicians	
Ms. Shashikala S. Kadam	Technical Officer T(7-8)
Dr. (Ms.) Y. Lalitha	Technical Officer T(7-8)
Mr. B. K. Chaubey	Technical Officer T(7-8)
Mr. Satendra Kumar	Technical Officer (T-6)
Mr. P. K. Sonkusare	Technical Officer (T-6)
Ms. B. L. Lakshmi	Technical Officer (T-6)
Ms. L. Lakshmi	Technical Officer (T-6)
Ms. S. K. Rajeshwari	Laboratory Technician (T-5)
Mr. H. Jayaram	Library Assistant (T-4)
Ms. K. V. Usha	Laboratory Technician (T-4)
Ms. R. Rajeshwari	Laboratory Technician (T-3)
Mr. P. Raveendran	Laboratory Technician (T-4)
Mr. P. Ramakrishna	Technical Assistant (T-3)
Mr. A. Raghavendra	Technical Assistant (T-3)
Mr. M. Chandrappa	Driver (T-2)
Mr.R. Narayanappa	Generator Operator (T-2)
Mr. P. Madanathan	Driver (T-2)
Administration	
Mr. J. N. L. Das	Administrative Officer
Mr. N. Chandrashekar	Finance and Accounts Officer

22. INFRASTRUCTURE DEVELOPMENT AT NBAII

During the current year, in an effort to strengthen the infrastructure facilities at NBAII, one new equipments were procured and added to enable the scientists to carry out experiments of international status. The particle size analyzer was purchased at a cost of Rs. 13 lakhs. This equipment is very crucial to identify the size of the particles synthesized, an important tool in nanotechnology.

A state of the art laboratory was constructed and dedicated to the Nation at Yelahanka campus. The two storey building can accommodate five laboratories and one conference hall with a seating capacity of 100 people in a serene environment, free from hustle of city life. This building will certainly facilitate the scientists to work more efficiently using modern technologies with the ultimate aim of developing technologies for the farmers.

23. EMPOWERMENT OF WOMEN

Empowering the farm women and women employees is of major consideration for NBAII.

Training exclusively meant for farm women was conducted at Thery Beeedi and Hosadoddi villages, near Kanakapura (Karnataka) where the technologies on the mass production of trichogrammatids and Pseudomonas were explained to the farm women. The participants were given details on the importance of using biocontrol agents, their mass production technologies and utilization. Around 30 farm women participated in the training which was followed by discussions.

A view of the farm women trainees

A large number of farm women were trained on the use pheromone, egg parasitoids, predators and antagonists at Arapalya, Tamil Nadu on 18-1-2013. The training included lectures and demostrations which were well received.

Scientists of NBAII explaining mass production technologies

The women employees were given preference in trainings, study leave and other official activities. Dr. Shalini, Scientist was granted study leave for pursuing Ph.D at University of Agricultural Sciences, Bangalore. She has been requested to pursue her studies on the aspects which falls within the mandate of the Institute.

The girl students of Delhi Public School were specially trained on the mass production techniques, utilization and conservation of biological control agents.

24. RESULTS FRAMEWORK DOCUMENT (RFD)

Annual Performance Evaluation Report (April 1, 2012 to March 31, 2013)

Sl. No	Objective (s)	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target / Criteria Value					Achieve-ments	Performance		Percent achieve ment against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw Score	Weigh ted Score		
1	Augmentation of genetic resources of agriculturally important insects, insect derived resources and bioagents	40	Field collection of germplasm	Number of explorations made	No.	10	1200	1080	960	840	720	1252	100	10	115.9	
			Identification of field collected specimens	Number of specimens identified	No	10	11600	10440	9280	8120	6950	12473	100	10	119.4	
			Electronic cataloguing	Number of entries added	No.	10	6750	6075	5400	4725	4050	8254	100	10	135.8	
			Molecular characteriza tion	No.of Gen Bank accessions, gene sequences, No. of Barcodes developed	No	10	450	405	360	315	270	513	100	10	126.6	
2	Conservation evaluation and utilization of beneficial insects in various agro-climatic situations	20	Ex situ conservation	Number of cultures	No	10	1500	1350	1200	1050	900	1342*	89.4	8.94	99.4	
			Evaluation	Number of experiments	No.	10	955	859	764	668	573	549	57.5	5.75	63.9	Two scientists on study leave and one scientist transferred

***Highest number of cultures conserved during the period**

3	Developing genomic/ nucleotide database for insects and biocontrol agents	13	Bioinformatics data mining for gene sequences of insect genetic resources	Sequences	No	13	14850	13365	11880	10395	8910	15721	100	13	117.6	
4	Commercialization and transfer of technology	15	Sale of bioagents	No of cultures	No.	5	740	666	592	518	444	1055	100	5	142.5	
			Transfer of Technology	Technologies transferred	No.	5	78	70	62	55	47	136	100	5	193.7	
			Patents filed	Patents	No.	5	2	1	1	0	0	1	50	2.5	100.0	
5	Efficient functioning of RFD	12	Timely submission of RFD for 2012-13	On-time submission	Date	2	April 30 2012	May 3 2012	May 4 2012	May 5 2012	May 6 2012	2	On time	2	On time	
			Timely submission of results for 2012-13	On-time submission	Date	2	May 1 2012	May 3 2012	May 4 2012	May 6 2012		2	On time	2	On time	
			Finalize a strategic plan for RC	Finalize the strategic plan for next 5 years	Date	2	Dec 10 2012	Dec.15 2012	Dec 20 012	Dec 24 2012	Dec 30 2012	2	On time	2	On time	
			Identify potential areas of corruption related to organizational activities and develop an action plan to mitigate them	Finalize an action plan to mitigate potential areas of corruption	Date	2	Dec 10 2012	Dec.15 2012	Dec 20 2012	Dec 24 2012	Dec 30 2012		0	0		
			Implementation of Sevottam	Create a Sevottam compliant system to implement, monitor and review Citizen's charter	Date	2	Dec 10 2012	Dec 15 2012	Dec 20 2012	Dec 24 2012	Dec 30 2012		0	0		
				Create a Sevottam Compliant system to redress and monitor public Grievances	Date	2	Dec 10 2012	Dec 15 2012	Dec 20 2012	Dec 24 2012	Dec 30 2012			0		
		100		Total weight		100										

Total Composite Score: 86.19

Procedure for computing the Weighted and Composite Score

1. Weighted Score of a Success Indicator = Weight of the corresponding Success Indicator x Raw Score / 100
2. Total Composite Score = Sum of Weighted Scores of all the Success Indicators.
3. Raw score for achievement = Obtained by comparing achievement with agreed target values. Example : Values between 80% (Good) and 70% (Fair), the raw score is 75%.

Departmental rating	Value of Composite score
Excellent	100-96%
Very Good	95-86%
Good	85-76%
Fair	75-66%
Poor	65% and below