ICAR–National Bureau of Agricultural Insect Resources

P.O. Box 2491, H.A. Farm Post, Hebbal, Bengaluru 560 024, India

Phone: +91 80 2341 4220 ✦ Fax: +91 80 2341 1961 ✦ Website: www.nbair.res.in

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Annual Report 2019

ICAR-National Bureau of Agricultural Insect Resources

Bengaluru, India

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ICAR–NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES

Bengaluru, India

राष्ट्रीय कृषि कीट संसाधन ब्यूरो

बेंगलूरु, भारत

Annual Report 2019

ICAR–NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES
Bengaluru 560 024, India

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The Director
ICAR–National Bureau of Agricultural Insect Resources
P.O. Box 2491, H.A. Farm Post, Hebbal, Bengaluru 560 024, India
Phone: +91 80 2341 4220; 2351 1998; 2341 7930
Fax: +91 80 2341 1961
E-mail: director.nbair@icar.gov.in
Website: www.nbair.res.in

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Compiled and edited by
Prakya Sreerama Kumar
Amala Udayakumar
Mahendiran, G.
Salini, S.
David, K.J.
Bakthavatsalam, N.
Chandish R. Ballal

Cover and layout designed by
Prakya Sreerama Kumar

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(Courtesy: Amala, U. & Shivalingaswamy, T.M.)

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Main image: pupae

Insets (left to right): adult; compost produced; pelletised feed for fish

(Courtesy: Mahendiran, G. & Mahesh Yandigeri)

PREFACE

The ICAR–NBAIR Annual Report 2019 attempts to connect the activities and accomplishments of this organisation to its final goals and vision. The focus during this period was on strengthening the National Insect Museum and Live Repository, monitoring for entry of new invasives, fine-tuning the measures identified to tackle notorious pests, both indigenous and invasive, and on creating awareness on the validated NBAIR technologies.

The three Divisions of NBAIR – Germplasm Collection and Characterisation (GCC), Genomic Resources (GR) and Germplasm Conservation and Utilisation (GCU)–focussed on the committed mandates of the bureau. A total of 7,274 specimens and 24 types were added to the NBAIR Museum, thus bringing the total number to 1,97,233 specimens and 1,073 specimens of 327 types. The 26 databases developed on insect genetic resources meant for farmers, public, researchers and students (recording 10,53,452 hits) are being widely accessed nationally and internationally. The identification services provided by the NBAIR taxonomists is worth more than Rs 1 crore per year (calculated based on the charges levied for identification services by the Natural History Museum, London). During the period under report, 187 identification services were provided, through which 585 species were identified. The GR Division characterised 230 insects and 128 barcodes were generated during the year. The GCU Division focussed on reaching out to the farmers with novel, farmer-friendly, non-chemical pest management technologies. Holding the largest 'Live Insect and Insect-Derived Resources Repository' with 132 live insect germplasms and 900 microbial isolates, NBAIR supplied 1,084 lakh live insects in 1,451 shipments and 82 shipments of microbials, thus relentlessly serving researchers and the farming community. Awareness on non-chemical modes of pest management was created either by directly interacting with the farmers in the 35 adopted villages or by licensing the NBAIR technologies to commercial entrepreneurs. Last year, seven NBAIR technologies were licensed to ten licensees, including commercial entrepreneurs and government organisations. A total of 29 training programmes were organised for 219 trainees, besides exposure visits for farmers, and students from various colleges and universities.

NBAIR scientists published 146 research publications and were recognised at the national level for their scientific excellence. By conducting joint workshops / symposia with UAS, Raichur; Loyola College, Chennai; St. Joseph's College, Bengaluru; and Calicut University, we could reach out to the student community and young researchers and create interest in them to work on insect taxonomy and biological control. Efficient networking with all stakeholders could be achieved through two important meetings held in June: the AICRP Biocontrol Workshop at AAU, Anand, and the NBAIR Institute–Industry meet held at the Yelahanka campus of NBAIR.

The extensive exploratory surveys conducted by NBAIR taxonomists for the documentation of arthropod biodiversity in the states of Assam, Arunachal Pradesh, Meghalaya, Uttarakhand, Himachal Pradesh, Manipur, Nagaland, Kerala, Karnataka and Tamil Nadu led to the description of 21 new taxa from India, besides new distributional records for India, new distributional records for other countries, viz. various provinces of the Palearctic region, Iran and China. Besides important revisionary works and publication of diagnostic keys, taxonomists provided 187 identification services which is a great service to students, researchers and farmers. Molecular characterisation and DNA barcoding of 230 agriculturally important insect pests, natural enemies, invasive pests and veterinary pests were completed and accession numbers were obtained from GenBank.

Focus has been on monitoring for new invasives and searching for potential indigenous bioagents for some of the notorious pests, both indigenous and invasive. Besides the earlier identified whitefly species *Bemisia tabaci, Aleurodicus dispersus, A. rugioperculatus* and *Aleurothrixus trachoides,* new whitefly species were reported, Bondar's nesting whitefly*, Paraleyrodes bondari*; *P. minei*; *Pealius nagarcoilensis*; and woolly

whitefly, *Aleurothrixus floccosus;* palm-infesting whitefly, *Aleurotrachelus atratus.* For two of the potential NBAIR microbial isolates, Ma4 to target sugarcane root grubs and BtG4 for pulse crop pests, the complete dossiers have been prepared for CIB&RC registration and commercialisation. It is thus ensured that these promising biopesticides would soon become available for Indian farmers. Indigenous strains of *Spodoptera frugiperda* NPV, *Metarhizium rileyi* and *Beauveria felina* have been isolated from field-infected larvae of fall armyworm (FAW). Field trials have also clearly indicated the effectiveness of indigenous NBAIR microbial isolates Ma-35, Bt-25, *Spfr*NPV01 and EPN (*Hi*101& *H*38), which could cause up to 86% reduction in FAW infestation. As an emergency measure, NBAIRMa35 and NBAIRBt25 have been submitted for CIB&RC registration.

A new area of work has been on *in situ* conservation of non-apis bees, viz. leaf cutter bee, *Megachile laticeps,* and buzz pollinating bee, *Amegilla violacea,* through creating artificial nesting sites. A novel predator, *Dortus primarius,* was recorded as an efficient predator of thrips and *Tuta absoluta*. The predatory mite *Neoseiulus indicus* was found to be effective against broad mites infesting mulberry and red spider mites infesting roses. Selected strains of entomopathogens (*Metarhizium anisopliae, Bacillus albus, Pseudomonas fluorescens*) proved to be highly effective for the management of thrips infesting *Capsicum annuum*, watermelon and *Gerbera* sp. under polyhouse and field conditions with significant increase in yield. The NBAIR technology on rearing black soldier fly (BSF) for bioconversion of kitchen waste into organic compost is in great demand and commercialised to five companies. Besides, a research highlight is the standardisation of BSF-based fish feed, wherein the field trials are in progress as a last step towards commercialisation of this dual technology.

The staff members of NBAIR – 32 scientists, 15 technical staff, 6 administrative staff, 3 supporting staff and around 90 temporary staff who have contributed immensely, are responsible for the significant achievements of this organisation. Annual Report is thus a compilation of our efforts and contributions in the area of basic research paving the way for applied research. The focus on identifying and documenting Indian insect and beneficial microbial fauna has led to the conservation and utilisation of the appropriate ones for the benefit of the Indian farmer to tackle the pests in a sustainable manner. Considering the large number of challenges faced by Indian agriculture, we cannot afford to be complacent, but should continue to search for solutions and strive to see that the validated solutions reach the end users – the Indian farmers.

Bengaluru
31 May 2020

Chandish R. Ballal
Director

1. EXECUTIVE SUMMARY

The ICAR–National Bureau of Agricultural Insect Resources is the only institution under ICAR to be recognised as a 'Designated Repository' for agriculturally important insects, mites and spiders. This bureau is committed to the collection, cataloguing and conservation of insects and other related organisms including mites, spiders, nematodes and microbes associated with arthropods in various agroecosystems of our country. Research work in the bureau is undertaken in three divisions: Germplasm Collection and Characterisation; Genomic Resources; and Germplasm Conservation and Utilisation. The work related to biological control is formulated and coordinated under the All-India Coordinated Research Project on Biological Control of Crop Pests. The results of the research for April–December 2019 are summarised hereunder:

ICAR–National Bureau of Agricultural Insect Resources

Germplasm Collection and Characterisation

Exploratory surveys for the documentation of arthropod biodiversity in India during April–December 2019 yielded 94 species of dung beetles in 23 genera; 75 species of parasitic and predatory wasps in 50 genera and 15 families; 55 species of Pentatomidae in 46 genera; 42 species of fruit flies belonging to 27 genera; 876 specimens of trichogrammatids in 8 genera; 16 species of weevils; 350 specimens of sphecid wasps in 18 genera; 16 species of leafcutter bees in 4 genera; and 85 specimens of spiders in 10 families. Most of the samples originated from Arunachal Pradesh, Assam, Himachal Pradesh, Karnataka, Kerala, Manipur, Meghalaya, Nagaland, Tamil Nadu and Uttarakhand.

Nearly 300 permanent slides of scales, mealybugs and aphids were prepared and preserved.

Mite samples originated from 55 places in 12 districts across eight states. More than 8,220 mites were sampled and processed. Totally, 1,112 permanent slides were prepared.

Two isolates of entomopathogenic nematodes, *Steinernema carpocapsae* and one isolate of *Heterorhabditis bacteriophora* were identified and added to NBAIR's repository of entomopathogenic nematodes. Totally, 124 isolates/species of *Steinernema*, *Heterorhabditis* and *Oscheius* nematodes were maintained on wax moth larvae.

Fifteen new taxa across the country were described: in Hemiptera, a new species of mealybug, *Formicococcus tectonae*, and a new species of a pentatomid bug, *Halys mudigerensis*; in Coleoptera, nine new species of tribe Sericini, viz. *Maladera viraktamathi*, *M. naveeni*, *M. sujitrae*, *M. thirthahalliensis*, *Neoserica reuteri*, *Oxyserica goertzae*, *Selaserica hosanagarana, Serica eberlei* and *S. tashigaonensis*; in Hymenoptera, a new pteromalid wasp species, *Callocleonymus indiaensis*; in Diptera, three new species of fruit flies, viz. *Acrotaeniostola connexa*, *Dacus jacobi* and *D. viraktamathi*. Additionally, six species of braconids, viz. *Cotesia elongata*, *Cotesia khuzestanesis* and *Cotesia zagrosensis*, *Deuterixys tenuiconvergens*, *Iconella mongashtensis* and *Iconella similus* from Iran were described.

New distributional records for India include two genera and 83 species of insects. Genus *Ceratitella* of Tephritidae and *Opimothrips* of Thysanoptera were recorded for the first time from India. New distributional records of species include 59 species of parasitic wasps belonging to Braconidae, Chalcididae and Vespidae; two species of aphids, *Patchiella reaumuri* and *Microparsus desmodiorum*; one soft scale species, *Hemilecanium theobromiae*; one mealybug species, *Pseudococcus caleceolariae*; four species of thrips, viz. *Opimothrips tubulatus*, *Helionothrips cephalicus*, *Helionothrips mube* and *Helionothrips unitatus*; 17 species of dung beetles; and three species of fruit flies, *Ceratitella sobrina*, *Acroceratitis incompleta* and *Dacus maculipterus*.

New distributional records from other countries include 12 species of braconids: *Cotesia cynthiae*, *C. glabrata*, *Iconella meruloides*, *Iconella myeloenta* and *I. subcamilla* from various provinces of the Palearctic region; three species from Iran and four species from China. New distributional records for the states in India were: the trichogrammatid *Megaphragma* from Maharashtra and Meghalaya; the sac spider, *Clubiona analis*, from Tamil Nadu; and the green lynx spider, *Peucetia yogeshi*, from Karnataka.

New host records for Braconidae documented were: *Cotesia ruficrus* on larvae of *Spodoptera frugiperda* and *Coccygidium* sp. on *Graphium nomius*.

Revisionary works include designation of a lectotype for *Gynaikothrips microchaetus*; publication of four synonymies for *Halys sulcatus*, and one synonym for *H. serrigera*; redescription of genus *Halys* based on male postabdominal structures; two species of thrips, viz. *A. asiaticus* and *G. microchaetus*; four species of beetles, viz. *Anomala communis, Anomalochela bicolor, Maladera indica* and *Holotrichia nilgiria*.

Diagnostic keys were published for several insect taxa: Indian fauna of *Helinothrips* and *Astrothrips*; generic keys to Asopinae and Podopinae from India; Indian species of *Paraputo* and *Formicococcus*; and Oriental species of *Hemilecanium*. Checklist of Vespidae from Goa was published with 33 species belonging to 22 genera and four subfamilies. The checklist for *Amblyrhinus*, *Corigetus*, *Desmidophorus* and *Peltotrachelus* of Curculionidae was prepared.

A total of 187 identification services were provided to various agricultural universities and ICAR institutes, wherein 310 species in 60 families belonging to Araneae, Coleoptera, Diptera, Hemiptera, Hymenoptera and Thysanoptera were identified.

Genomic Resources

Molecular characterisation and DNA barcoding of 160 agriculturally important insect pests, natural enemies, invasive pests and veterinary pests were completed and accession numbers were obtained from GenBank, NCBI, for 73 agriculturally important insect pests, parasitoids and predators, 20 populations of *Spodoptera frugiperda*, 7 veterinary pests, 13 whitefly strains, 10 populations of *Telenomus remus*, 20 wasps and 4 pollinators.

Next-generation sequencing-based transcriptome analysis of tritrophic relationship among the insect host, entomopathogenic nematode and bacterium unravelled several upregulated and downregulated genes related to insect metabolism and immunity-related pathways under stress.

Genetic analysis of rice white stem borer complex indicated a potential divergence of white-coloured *Scirpophaga* spp. from yellow-coloured *S. incertulas* through a common ancestor. Twenty-six cultivated/wild plant species belonging to Poaceae and Cyperaceae were documented as hosts for the white stem borers as compared with monophagy nature of *S. incertulas*.

Mobile apps on management aspects of rice and sugarcane pests were developed. These mobile apps aid famers in correctly identifying some of the prevailing serious pests and provide advice on adopting non-chemical methods for their management. These apps can also act as ready reckoners as they contain details of all important pests along with photographs. Docking studies were carried out for cytochrome P450 of *Tribolium castaneum* and cytochrome c oxidase of *Callosobruchus chinensis* with phosphine ligand. The crystal protein templates were derived through Swiss-Model and docking of protein–ligand carried out by using CDOCKER protocol using Discovery Studio software.

Enzyme assays were conducted for field populations of the pink mealybug, *Maconellicoccus hirsutus*, using sublethal doses of agrochemicals, viz. gibberellic acid, buprofezin and imidacloprid to know the induced hormesis effect. Results indicated that the sublethal doses increased the level of enzymes in *M. hirsutus* population. It also revealed that the agrochemical gibberellic acid has positive effect on the biological attributes of pink mealybug and very less effect on its predator.

Germplasm Conservation and Utilisation

Surveys were conducted in several Indian states to document the incidence of the fall armyworm, *Spodoptera frugiperda*. The pest was observed on maize in Telangana, Maharashtra, Tamil Nadu, Gujarat, West Bengal, Bihar, Uttar Pradesh and the northeastern states, indicating its extent of spread across the length and breadth of the country.

Seven samples of diseased larvae of *S. frugiperda* that showed characteristic viral infection symptoms were collected from various parts of Tamil Nadu and Karnataka. Nucleopolyhedroviruses (NPVs) were extracted from all the samples and the occlusion bodies of NPV were confirmed through phase-contract microscopy. In the field, prophylactic spray of an aqueous suspension of *Spfr*NPV NBAIR1 (3 ml/litre) twice at a concentration of 1.5×10^{12} POBs/ha at 20 and 35 days after sowing reduced the pest infestation by 80.4% during kharif. Better growth and yield were also observed in the treated plants.

Metarhizium anisopliae isolates were evaluated against four phytophagous mite species, including the green and red forms of *Tetranychus urticae*. For the first time, a mycoacaricide was effectively used against the broad mite on mulberry. Five field trials on mulberry and one on rose were conducted. Several predatory mites were successfully mass produced.

Around 200 samples of cotton whitefly, *Bemisia tabaci*; rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus*; spiralling whitefly, *A. dispersus*; solanum whitefly, *Aleurothrixus trachoides*; Bondar's nesting whitefly, *Paraleyrodes bondari*; nesting whitefly, *P. minei*; *Pealius nagarcoilensis*; woolly whitefly, *Aleurothrixus floccosus*; and palm-infesting whitefly, *Aleurotrachelus atratus*, were identified through morphological and molecular characterisation. Natural parasitism of RSW by *Encarsia guadeloupae* on coconut and other crops was quantified through regular monitoring.

The diversity of beetles and termites was assessed with respect to the type of soil, cropping pattern and the climatic conditions of the geographic location. The species belonging to Rutelinae and Scarabinae were more abundant than others. *Leucopholis lepidophora* was the predominant species in the Malenadu region. Thirteen species of termites belonging to subfamily Macrotermitinae were recorded in Karnataka. Diversity indices for the populations of scarabaeid beetles were worked out.

Diversity and the role of bee pollinators was studied on medicinal and aromatic lamiaceous plants, namely, *Rosmarinus officinalis*, *Mentha longifolia*, *Ocimum gratissimum*, *O. basilicum*, *Nepeta cataria* and *Leucas aspera*.

The leaf cutter bee, *Megachile laticeps*, preferred pruned hollow petioles of papaya for nesting with marked foraging preference to the pollen of fabaceous plants for provisioning its developing broods. Buzz pollinating bee, *Amegilla violacea*, was observed to be a potential pollinator of brinjal under field conditions.

Dortus primarius was found to be an efficient predator of thrips and *Tuta absoluta*. *Neoseiulus indicus* was found to be effective against the broad mite on mulberry and red spider mites on roses. An IPM trial in a farmer's field on the fall armyworm showed 75.9% reduction in larval population.

Nanogel-based slow-release formulations of pheromones were developed using supramolecular self-assembly principles to increase the longevity of pheromones that can disrupt the life cycle of pests such as *Spodoptera frugiperda, Chilo sacchariphagus indicus, Scirpophaga excerptalis, Plutella xylostella, Bactrocera dorsalis*. LoRa transmitter/receiver as a part of drone-assisted pheromone detection and remediation for pests was developed and an efficacy of wireless data transmission up to 500 m was achieved.

Metarhizium anisopliae, Bacillus albus and *Pseudomonas fluorescens* strains were used to effectively manage *Scirtothrips dorsalis* on *Capsicum annuum*, *Thrips palmi* on watermelon and *Thrips hawaiiensis* on *Gerbera* sp. under polyhouse and field conditions with significant increase in yield in comparison with untreated control.

In greenhouse studies, endophytic isolates of *Beauveria bassiana* (ICAR–NBAIR Bb-5a & Bb-45) and *M. anisopliae* (ICAR–NBAIR-Ma-4 & Ma-35) caused up to 76% mortality of *Plutella xylostella* when applied through different inoculation methods like seed treatment, root inoculation and foliar spray. Under field conditions, 56.1–93.5% of pest reduction was observed with the endophytic isolates. Among the four isolates tested, Ma-35 showed the highest pest reduction when applied as a foliar spray (1×10^8 cfu/ml) at 15 days after transplantation.

Metarhizium rileyi and *Beauveria felina* were isolated from *S. frugiperda* and identified through molecular characterisation. Field evaluation of *B. bassiana* (ICAR-NBAIR Bb-45) and *M. anisopliae* (ICAR-NBAIR Ma-35) against *S. frugiperda* on maize conducted during kharif 2019 in Bengaluru and Chikkaballapura, Karnataka, showed 53–86% of pest reduction.

The influence of artificial light sources on oviposition of black soldier fly (BSF)was evaluated. Microbial composition of black soldier fly was studied. Shelf-life of BSF was evaluated for 12 months. Pangas fish, *Pangasianodon hypophthalmus*, fed with BSFmeal recorded significantly higher gain in weight, lowest feed efficiency ratio (FCR) and specific growth rate (SGR) compared with control meal.

All-India Coordinated Research Project on Biological Control of Crop Pests

Biodiversity of biocontrol agents from various agroecological zones

A total of 876 trichogrammatids were collected from the states of Karnataka, Maharashtra, Tamil Nadu, Gujarat and Meghalaya. Eight genera of trichogrammatids, viz. *Chaetostricha*, *Lathromeroidea*, *Megaphragma*, *Oligosita*, *Paracentrobia*, *Trichogramma*, *Trichogrammatoidea* and *Tumidiclava* were collected. Field parasitism by *Trichogramma achaeae*, which ranged 18.0–47.5%, reduced the population of larvae and pupae of *Tuta absoluta*, resulting in fewer leaf mines. Eighty-one spider species from the families Salticidae, Thomisidae, Tetragnathidae, Araneidae and Gnaphosidae were added to the collection.

Surveillance for alien insect pests

The population of Bondar's nesting whitefly (*Paraleyrodes bondari*) was found as high as 4 colonies per leaflet in September 2019, which subsequently reduced to 0.5 colonies. The non-native nesting whitefly (*Paraleyrodes minei*) that coexisted with *P. bondari* and the rugose spiralling whitefly during 2018 was not observed and was completely displaced by the other exotic whitefly species.

Invasive mealybug species *Pseudococcus jackbeardsleyi* and *Paracoccus marginatus* were recorded on custard apple and papaya, respectively, in Pune, Nadurbar, Dhule and Jalgaon districts. *Spodoptera frugiperda* was recorded in all maize-growing areas of Maharashtra; northeastern Karnataka; districts of Karimnnagar, Siddipet, Sangareddy and Mahbubnagar in Telangana; and districts of Udaipur, Chittorgarh, Banswara and Dungapura in Rajasthan.

Biological control of sugarcane pests

Plants treated with the entomopathogenic nematode *Heterorhabditis indica* in the form of a WP formulation recorded the lowest plant damage (8.5%) due to white grub in Raichur.

Biological control of cotton pests

Biointensive pest management module recorded lower green boll damage (19.2%) and locule damage (6.1%) than insecticide treatment (24.7% and 7.1%, respectively) in Hyderabad.

Biological control of rice pests

Spray of *Lecanicillium saksenae* (1×10^7 spores/ml) twice at the panicle initiation and milky stages of the crop significantly reduced the population of *Leptocorisa acuta* in Vellayani, Kerala. Per cent reduction of stem borer was the highest in insecticide treatment (78.3%) followed by *Bt* treatment (56.5%) in Andhra Pradesh.

Biological control of maize pests

The number of dead larvae of *Spodoptera frugiperda* per plot was the highest in insecticidal check (50.4) followed by *Trichogramma pretiosum* release plus *Metarhizium anisopliae* spray (42.9) and *T. pretiosum* release plus NBAIR *Bt* (41.9) in Andhra Pradesh.

Biological control of pests of pulses

Spray of NBAII-BTG4 formulation recorded the lowest per cent pod damage (10.2%) with a grain yield of 10.7q/ha in Raichur.

Biological control of pests of tropical fruit crops

NBAIR strains of *M. anisopliae* and *B. bassiana* caused reduction of mango leafhoppers (0.25 and 0.75/tree) after the second spray in Ambajipeta, Andhra Pradesh. Significant reduction in the population of mealybug (45.9%) and scale (44.6%) was recorded on guava trees treated with NBAIR isolates of *B. bassiana* in Jammu.

Biological control of pests of temperate fruit crops

Application of *Metarhizium anisopliae* (1×10^8 conidia/g) at 30 g/tree basin mixed in well-rotten farmyard manure during July–August, i.e. at the time of egg hatching and emergence of new/young grubs resulted in 62.1–73.4% mortality of apple root borer in Solan.

Biological control of pests in plantation crops

Two sprays of NBAIR *Isaria fumosorosea* (NBAIR-Pfu 5) recorded up to 75.5% reduction in rugose spiralling whitefly population on coconut in Anakapalle, Andhra Pradesh. In Kerala, neem oil (5%) plus water spray significantly reduced the population of the whitefly. Up to 56.7% reduction

in the pest population was achieved through *I. fumosorosea*.

Biological control of pests of vegetable crops

Tomato

Percent fruit damage in terms of numbers (15.8%) and weight (14.1%) recorded in biointensive pest management module was on par with the chemical treatment (20.6 % and 17.2%, respectively) in Pune.

Brinjal

Fruit damage by *Leucinodes orbonalis* was 21.8% in BIPM plots [Azadirachtin 1,500 ppm @ 2 ml/litre + *Lecanicillium lecanii* + *Trichogramma pretiosum* (8 releases) + pheromone traps @ 20/ha + cowpea as bund crop] in Coimbatore.

Okra

Spray of NBAIR *Bt* (5 g/litre of water) at fortnightly intervals three times or six releases of *Trichogramma chilonis* (50,000/ha) at weekly intervals effectively reduced the damage by fruit borer on okra in Gujarat.

Cabbage

Significant reduction (37%) in mustard aphid population was recorded in the plants treated with *Lecanicillium lecanii* (Vl-8 strain) in Uttar Pradesh.

Biological control of pests of oilseed crops

Spray of *Lecanicillium lecanii* (NBAIR strain) (5 g/litre) and *Beauveria bassiana* (AAU-J culture) significantly reduced the population of mustard aphid (10 and 11.19 /10-cm twig, respectively) in Assam.

Biological control of pests of polyhouse and flower crop pests

Two releases of *Blaptostethus pallescens* (400/plant) resulted in 34.1% and 68.5% reduction in populations of European red mite and two-spotted spider mite, respectively, over control on apple in Srinagar. Spray of *Beauveria bassiana* (NBAIR Bb5a) (5g/litre) followed by *Lecanicillium lecanii* (NBAIR Vl8) (5 g/litre) significantly reduced aphids on capsicum under polyhouse conditions in Karnataka.

Biological control of plant diseases

Microbial consortium (Th17 + Psf173) recorded the minimum mature plant wilt (3.24) in chickpea after 120 days of sowing in Uttarakhand.

Tribal Sub-Plan programme (TSP)

Tribal farmers were trained on ecofriendly management of various pests in Gujarat, Andhra Pradesh, Tamil Nadu, Himachal Pradesh, Chhattisgarh, West Bengal and in the northeastern region. Field demonstrations, awareness-cum-training programmes and farmers' meetings were also held in various places to popularise biological control. Inputs were also supplied to the trained farmers.

2. INTRODUCTION

The National Bureau of Agricultural Insect Resources (NBAIR) came into existence on 9 October 2014. Insects not only constitute the bulk of living organisms in our world but also render a host of ecosystem services like pollination, natural pest control, recycling of organic matter, dispersal of seeds, maintenance of soil fertility and so forth. Their notoreity as pests of agricultural crops, however, has drawn the maximum attention of entomologists. It is only with the knowledge of the insect fauna in agricultural and adjacent ecosystems that we can formulate pest management strategies to ensure the productivity and sustainability of our agricultural systems.

This shifting perspective on insects in agriculture has been mirrored in the evolution of this bureau. When the possibility of using insects instead of harmful chemicals for the management of insect pests in agriculture was realised, the Indian Council of Agricultural Research (ICAR) initiated the All-India Coordinated Research Project (AICRP) on Biological Control of Crop Pests and Weeds in 1977.

Though initially funded by the Department of Science and Technology, Government of India, ICAR began extending full financial support to the programme from 1979. To further strengthen research on biological control the Project Directorate of Biological Control was established on 19 October 1993. With the growing realisation that effective biological control was predicated on sound taxonomic and ecological knowledge, the National Bureau of Agriculturally Important Insects (NBAII) was created on 29 June 2009, and the transition of NBAII to NBAIR happened in 2014.

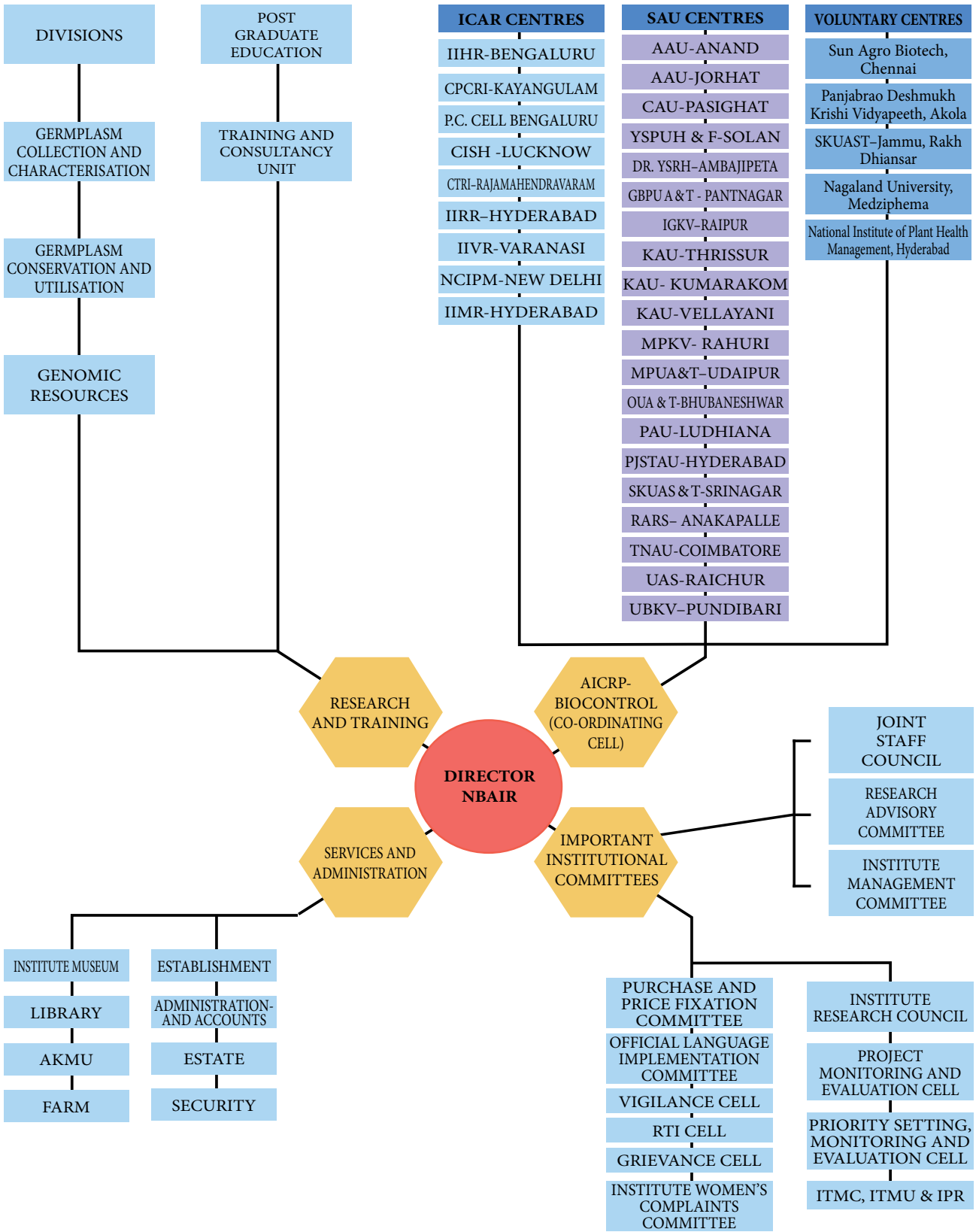
This bereau was recognised by the Ministry of Environment & Forests (presently MoEF&CC) in 2012 as the designated National Repository for preservation of insects, spiders and mites. The repository currently holds nearly 1,88,830 specimens, and 327 types. This is the only national bureau under the National Agricultural Research System (NARS) that acts as the nodal agency for collection, characterisation, documentation, conservation, exchange, research and utilisation of agriculturally important insect resources (including mites, spiders and related arthropods) for sustainable agriculture. Most of the specimens in the collection are Indian, but there is a unique representation of exotic beetles, wasps, flies and moths from various countries, including Australia, Argentina, the West Indies, Japan and USA. The museum is also unique in having one of India's largest collections of economically important taxa, including various biological control agents, viz. parasitic Hymenoptera (parasitoids), Coleoptera (Coccinellidae), along with major collections of groups with members which are pests, viz. Coleoptera, Hemiptera, Diptera, Lepidoptera and Orthoptera. Besides holding the world's smallest insect, *Kikiki huna,* in its collection, the museum also holds many undescribed species, and some species found in no other collections in the world. Online web diagnostic portals/web pages are prepared and maintained by the museum researchers under the NBAIR domain. Presently there are 26 major databases on the NBAIR website.

ICAR–NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES
To act as a nodal agency for collection, characterisation, documentation, conservation, exchange, research and utilisation of agriculturally important insect resources (including mites, spiders and related arthropods) and insect–derived resources for sustainable agriculture. Capacity building, development of technologies for non-chemical pest management, dissemination of technologies and forging linkages with stakeholders
AICRP ON BIOLOGICAL CONTROL OF CROP PESTS
Promotion of biological control as a component of integrated pest and disease management in agriculture and horticultural crops for sustainable crop production. Demonstration of usefulness of biocontrol in IPM in farmers' fields.

Organisational set-up

Research is undertaken in the Divisions of Germplasm Collection and Characterisation; Genomic Resources; and Germplasm Conservation and Utilisation. Basic and applied research on biocontrol is addressed under the AICRP on Biocontrol. The organogram is given on page 7.

Organogram


DIVISIONS
GERMPLASM COLLECTION AND CHARACTERISATION
GERMPLASM CONSERVATION AND UTILISATION
GENOMIC RESOURCES
POST GRADUATE EDUCATION
TRAINING AND CONSULTANCY UNIT
ICAR CENTRES
IIHR-BENGALURU
CPCRI-KAYANGULAM
P.C. CELL BENGALURU
CISH -LUCKNOW
CTRI-RAJAMAHENDRAVARAM
IIRR–HYDERABAD
IIVR-VARANASI
NCIPM-NEW DELHI
IIMR-HYDERABAD
SAU CENTRES
AAU-ANAND
AAU-JORHAT
CAU-PASIGHAT
YSPUH & F-SOLAN
DR. YSRH–AMBAJIPETA
GBPU A&T - PANTNAGAR
IGKV–RAIPUR
KAU-THRISSUR
KAU- KUMARAKOM
KAU-VELLAYANI
MPKV- RAHURI
MPUA&T–UDAIPUR
OUA & T-BHUBANESHWAR
PAU-LUDHIANA
PJSTAU-HYDERABAD
SKUAS & T-SRINAGAR
RARS– ANAKAPALLE
TNAU-COIMBATORE
UAS-RAICHUR
UBKV–PUNDIBARI
VOLUNTARY CENTRES
Sun Agro Biotech, Chennai
Panjabrao Deshmukh Krishi Vidyapeeth, Akola
SKUAST–Jammu, Rakh Dhiansar
Nagaland University, Medziphema
National Institute of Plant Health Management, Hyderabad
RESEARCH AND TRAINING
AICRP-BIOCONTROL (CO-ORDINATING CELL)
DIRECTOR NBAIR
SERVICES AND ADMINISTRATION
IMPORTANT INSTITUTIONAL COMMITTEES
JOINT STAFF COUNCIL
RESEARCH ADVISORY COMMITTEE
INSTITUTE MANAGEMENT COMMITTEE
INSTITUTE MUSEUM
LIBRARY
AKMU
FARM
ESTABLISHMENT
ADMINISTRATION-AND ACCOUNTS
ESTATE
SECURITY
PURCHASE AND PRICE FIXATION COMMITTEE
OFFICIAL LANGUAGE IMPLEMENTATION COMMITTEE
VIGILANCE CELL
RTI CELL
GRIEVANCE CELL
INSTITUTE WOMEN'S COMPLAINTS COMMITTEE
INSTITUTE RESEARCH COUNCIL
PROJECT MONITORING AND EVALUATION CELL
PRIORITY SETTING, MONITORING AND EVALUATION CELL
ITMC, ITMU & IPR

Significant achievements

Basic research

- Four new species of fruit flies were described, viz. *Bactrocera* (*Bactrocera*) *prabhui*, *Bactrocera* (*Parazeugodacus*) *conica*, *Coelotrypes merremiae* and *Coelotrypes paralatilimbatus*.
- Five new species of Hymenoptera, viz. *Rhogadopsis gratia*, *Rhogadopsis macrusa*, *Klabonosa indica*, *Neastymachus notialis* and *Ooencyrtus xenasteiae*, were described.
- Revision of the genus *Acrozangis* from India was made with description of a new species, *Acrozangis dakshinae*, from southern India.
- Two terebrantian thrips species, *Asprothrips bimaculatus* and *Pseudodendrothrips darci*, were recorded for the first time from India.
- Entomopathogenic nematode *Oscheius rugaoensis* was reported for the first time from India.
- *Polistes* (*Polistella*) *dawnae* (Hymenoptera: Vespidae : Polistinae) was recorded for the first time from Arunachal Pradesh.
- A new terebrantian thrips species, *Thrips laurencei,* from flowers of *Hydrangea macrophylla* was described.
- *Heterorhabditis pakistanense* and *Steinernema huense* were reported for the first time from India.
- *Anagyrus amnestos,* a potential parasitoid of the invasive Madeira mealybug was described.
- Two aphids, *Tuberaphis xinglongensis* and *Lepidosaphes laterochitinosa,* were recorded for the first time from India.
- The natalicoline bug, *Empysarus depressus*, was recorded for the first time from Maharashtra and Karnataka.
- The natural enemy complex of the invasive pest *Spodoptera frugiperda*, the fall armyworm, was reported for the first time from India with the parasitoids identified as *Glyptapanteles creatonoti*, *Campoletis chlorideae*, *Phanerotoma* sp., *Chelonus* sp. and *Trichomalopsis* sp.
- The population genetic diversity of 20 populations of the pink stem borer, *Sesamia inferens*, were studied using SSR primers. Clustering and principal component analysis suggested a low level of inter-population gene flow.
- The *Bacillus thuringiensis* isolate NBAIR-BT25 was characterised as a new strain to combat the invasive pest *S. frugiperda*. It showed an LC_{50} of 44.7 *µg/ml.* Field trials showed 69–81% pest reduction.
- Strain NBAIR-BTAN4 of *Bacillus thuringiensis* was characterised as a novel isolate capable of expressing crystal proteins toxic to both lepidopteran and coleopteran pests.

Applied research (Biological control)

- Surveys were conducted in several districts of Karnataka to record the incidence of *S. frugiperda* on maize. The incidence ranged from 9.0–62.5%.
- IPM field trials using parasitiods, predators, *Bt*, pheromone traps and *Beauveria bassiana* (Bb-45) and *Metarhizium anisopliae* (NBAIR-Ma-35) were carried out against *S. frugiperda* in a 30-day-old maize crop.
- *Spodoptera frugiperda* nucleopolyhedrovirus (*Sf*NPV) was isolated and characterised.
- Whiteflies such as *Bemisia tabaci*, *Aleurodicus rugioperculatus*, *A. dispersus*, *Aleurotrachelus trachoides, Paraleyrodes bondari, P. minei, Pealius nagarcoilensis* and *A. atratus* were identified through morphological as well as molecular characterisation.
- Anthocorid predators collected on different host plants were studied for their feeding potential and amenability for culturing indoors in the search for effective agents for use in biocontrol programmes.
- An interactive mobile app on non-chemical methods for management of arthropod and other pests of coconut was developed.
- Biology and feeding potential of *Dortus primarius* and *Termatophylum orientale* were studied on *Corcyra cephalonica* eggs.

- Plant growth-promoting rhizobacteria (PGPR) *Pseudomonas fluorescens* strain NBAIR-PFDWD was effectively used to manage the sucking pest *Scirtothrips dorsalis* on capsicum under polyhouse and field conditions with significant increase in yield when compared with untreated control plants.
- Soil application of *Heterorhabditis indica* (or *Steinernema* sp.), *Metarhizium anisopliae* (or *Beauveria bassiana*) in sugarcane after the onset of monsoon rains was found to be effective in reducing white grub damage, which resulted in higher yield compared with phorate treatment.
- The nesting sites of the native ground nesting bee, *Hoplonomia westwoodi*, were augmented in new sites by splitting the nest with viable broods and seeding in new sites for its propagation.
- Spray of the entomopathogenic fungus *Isaria fumosorosea* (NBAIR Pfu-5) recorded significant reduction in the live colonies of whiteflies on coconut in Kerala.
- Spray of NBAII-BTG4 formulation recorded the higher grain yield of 625 kg/ha with a C:B ratio of 2.13 in pigeonpea. Both *Hear*NPV NBAIR and *Hear*NPV UAS-R (2 ml/litre) were on par with regard to reducing the pod damage in chickpea.
- Bioecology of black soldier fly was studied by rearing it on various substrates. A mass rearing protocol for the insect was standardised using kitchen/ farm wastes, and a patentable technology was developed.

FINANCIAL STATEMENT (2018-19)

ICAR–National Bureau of Agricultural Insect Resources

Head	Amount (₹ in lakhs)
Pay & allowance	924.27
TA	29.89
Other charges, including equipment and office buildings	242.08
Information technology	0.00
Works and petty works	5.68
HRD	2.24
Pension	56.13
Loan	0.00
Total	**1,252.77**

All-India Coordinated Research Project on Biological Control of Crop Pests

Name of the centre	Salary	TA	RC	TSP	**Total** (₹ in lakhs)
AAU, ANAND	19.32	1.80	12.00	2.25	**35.37**
AAU, JORHAT	20.25	3.75	18.75	6.00	**48.75**
RARS, ANAKAPALLE	7.20	1.50	10.50	3.75	**22.95**
PJSTAU, TELANGANA	13.48	1.13	3.91	0.00	**18.52**
DR.YSPUH&F, SOLAN	18.45	1.50	5.25	0.75	**25.95**
GBPUAT, PANTNAGAR	9.18	1.50	8.10	3.75	**22.53**
KAU, THRISSUR	9.18	0.75	13.23	2.25	**25.41**
MPKV, PUNE	19.06	1.50	8.10	0.00	**28.66**
PAU, LUDHIANA	19.95	1.50	12.00	0.00	**33.45**
SKUAST, SRINAGAR	19.20	1.50	9.00	5.25	**34.95**
TNAU, COIMBATORE	13.80	1.50	8.10	0.00	**23.40**
MPUAT, UDAIPUR	0.00	1.14	1.50	2.25	**4.89**
OUAT, B'WAR	0.00	1.13	1.50	0.00	**2.63**
CAU, PASIGHAT	0.00	1.00	5.00	1.50	**7.50**
UAS, RAICHUR	0.00	1.14	7.50	0.00	**8.64**
ICAR–CPCRI, KAYANKULAM	0.00	0.75	3.00	0.00	**3.75**
ICAR–IIHR, BENGALURU	0.00	0.75	3.00	0.00	**3.75**
ICAR–P.C.CELL, BENGALURU	0.00	4.5	25.67	0.00	**30.17**
ICAR–CISH, LUCKNOW	0.00	1.50	2.25	0.00	**3.75**
ICAR–CTRI, RAJAHMUNDRY	0.00	0.75	1.50	0.00	**2.25**
ICAR–IIRR, HYDERABAD	0.00	0.75	2.25	0.00	**3.00**
ICAR–IIMR, HYDERABAD	0.00	0.75	2.25	0.00	**3.00**
ICAR–IIVR, VARANASI	0.00	0.75	3.00	0.00	**3.75**
ICAR–NCIPM, NEW DELHI	0.00	0.75	1.50	0.00	**2.25**
IGKV, RAIPUR	0.00	0.75	3.00	7.50	**11.25**
KAU, KUMARAKOM	0.00	0.93	4.23	0.00	**5.16**
KAU, VELLAYANI	0.00	0.39	4.80	0.00	**5.19**
DR YSRHU, AMBAJIPETA	0.00	1.14	3.00	0.00	**4.14**
UBKV, PUNDIBARI	0.00	0.75	1.50	2.25	**4.50**
Total	**169.07**	**37.55**	**185.39**	**37.50**	**429.51**

3. RESEARCH ACHIEVEMENTS

ICAR–National Bureau of Agricultural Insect Resources

Division of Germplasm Collection and Characterisation

Surveys and explorations

Extensive surveys were undertaken to document the fauna of insects, spiders, mites and entomopathogenic nematodes across India. States surveyed include Kerala, Karnataka, Tamil Nadu, Odisha, Gujarat, Sikkim, Assam, Arunachal Pradesh, Goa, West Bengal Nagaland, Manipur, Meghalaya, Himachal Pradesh and Uttarakhand. Collection methods employed include sweep netting (Figs 1 & 2), host plant rearing and various traps, viz. malaise trap (Fig. 3), yellow pan trap (Fig. 4), light trap, parapheromone traps and soil baiting technique using waxmoth larvae. Expeditions undertaken yielded several species of insects namely, 75 species of parasitic and predatory Hymenoptera in 50 genera and 15 families; 94 species of Scarabaeidae in 23 genera; 55 species of Pentatomidae in 46 genera; 42 species of Tephritidae belonging to 27 genera; nearly 876 specimens of trichogrammatids in 8 genera; 16 species of Curculionidae, 350 specimens of Sphecidae in 18 genera, 16 species of Megachilidae in 4 genera, 85 specimens of spiders in 10 families and two species of entomopathogenic nematodes namely, *Steinernema carpocapsae* and *Heterorhabditis bacteriophora*

Description of new species

Twenty one species of insects were described across various insect orders namely Coleoptera, Diptera, Hemiptera and Hymenoptera. 9 species of Scarabaeidae in 5 genera were described from Indian subcontinent; 3 species of fruit flies (Tephritidae) in two genera, one each of Pseudococcidae, Pteromalidae and Pentatomidae from India and six species of Braconidae in three genera from Iran (Table 1)

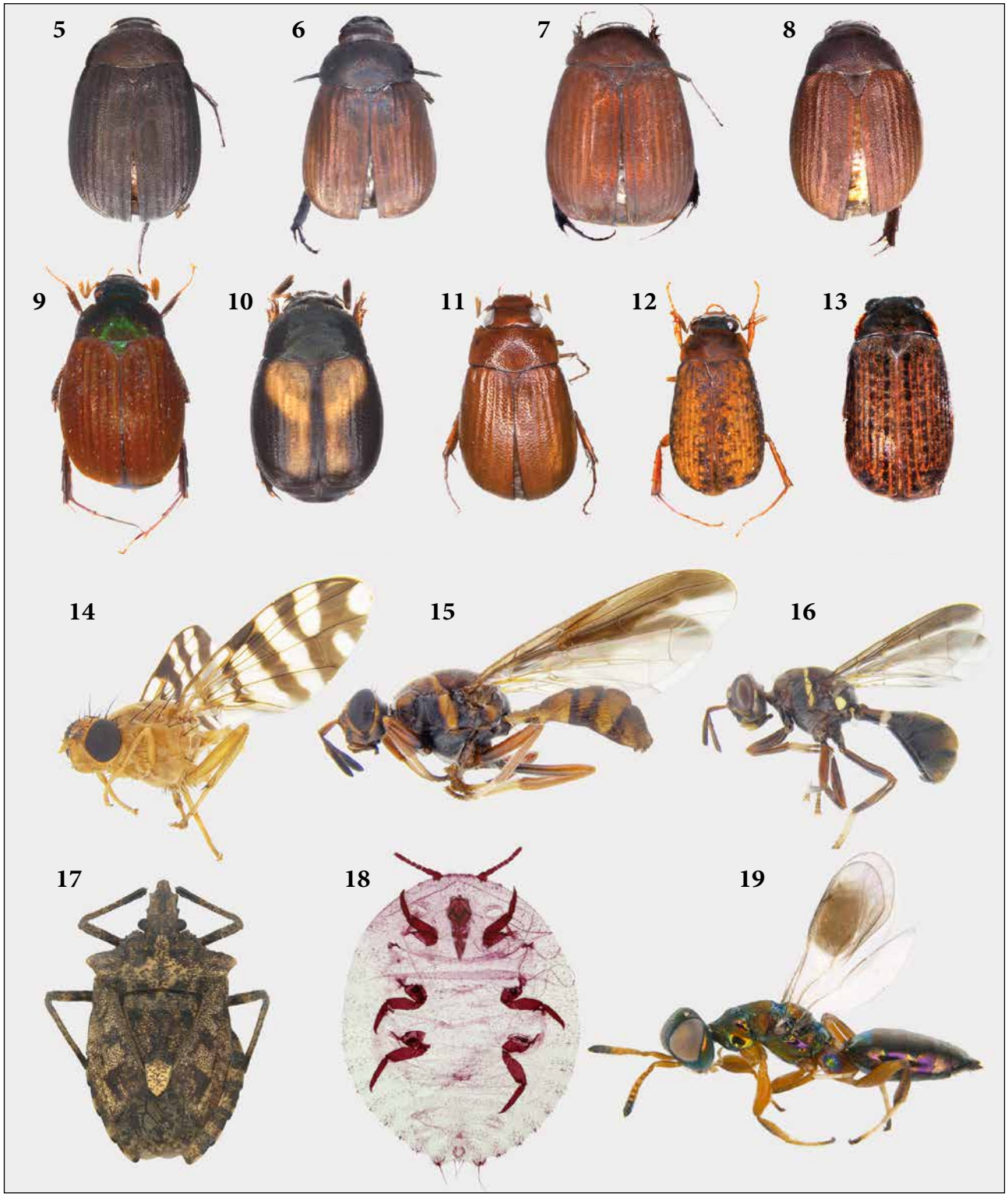
Figs. 1–4. Methods employed for insect collection. 1 & 2, Sweep netting; 3, Malaise trap; 4, Yellow pan traps

Table 1. List of new species described

S. No	Scientific name	Family	Holotype deposited
Coleoptera			
1	*Maladera viraktamathi* Sreedevi *et al.* (Fig. 5)	Scarabaeidae	NBAIR, Bengaluru
2	*M. naveeni* Sreedevi *et al.* (Fig. 6)	Scarabaeidae	NBAIR, Bengaluru
3	*M. sujitrae* Sreedevi *et al.* (Fig. 7)	Scarabaeidae	NBAIR, Bengaluru
4	*M. thirthahalliensis* Sreedevi *et al.* (Fig. 8)	Scarabaeidae	NBAIR, Bengaluru
5	*Neoserica reuteri* Sreedevi *et al.* (Fig. 9)	Scarabaeidae	NME, Germany
6	*Oxyserica goertzae* Sreedevi *et al.* (Fig. 10)	Scarabaeidae	ZFMK, Germany
7	*Selaserica hosanagarana* Sreedevi *et al.* (Fig. 11)	Scarabaeidae	NBAIR, Bengaluru
8	*Serica eberlei* Sreedevi *et al.* (Fig. 12)	Scarabaeidae	NME, Germany
9	*S. tashigaonensis* Sreedevi *et al.* (Fig. 13)	Scarabaeidae	NME, Germany
Diptera			
10	*Acrotaeniostola connexa* David, Sachin & Hancock (Fig. 14)	Tephritidae	NBAIR, Bengaluru
11	*Dacus jacobi* David & Sachin (Fig. 15)	Tephritidae	NBAIR, Bengaluru
12	*Dacus viraktamathi* David & Hancock (Fig. 16)	Tephritidae	NBAIR, Bengaluru
Hemiptera			
13	*Formicococcus tectonae* Joshi, Bindu & Gullan (Fig. 18)	Pseudococcidae	NBAIR, Bengaluru
14	*Halys mudigerensis* Salini (Fig. 17)	Pentatomidae	UAS, Bengaluru
Hymenoptera			
15	*Callocleonymus indiaensis* Gupta *et al.* (Fig. 19)	Pteromalidae	NBAIR, Bengaluru
16	*Cotesia elongata* Zargar & Gupta	Braconidae	NBAIR, Bengaluru
17	*Cotesia khuzestanesis* Zargar & Gupta	Braconidae	NBAIR, Bengaluru
18	*Cotesia zagrosensis* Zargar & Gupta	Braconidae	NBAIR, Bengaluru
19	*Deuterixys tenuiconvergens* Zargar & Gupta	Braconidae	NBAIR, Bengaluru
20	*Iconella mongashtensis* Zargar & Gupta	Braconidae	NBAIR, Bengaluru
21	*Iconella similus* Zargar & Gupta	Braconidae	NBAIR, Bengaluru

New distributional records

New distributional records for India includes 17 species of Scarabaeidae belonging to subfamilies Melolonthinae and Rutelinae; 59 species of wasps belonging to Braconidae, Chalcididae and Vespidae; three species of fruit flies, *Ceratitella sobrina* (Zia) (Fig. 20), *Acroceratitis incompleta* Hardy (Fig. 21) and *Dacus maculipterus* White, of which tribe Ceratitidini and genus *Ceratitella* were new records for India. In Hemiptera, one species each of aphid, soft scale and mealybug, *Patchiella reaumuri* (Kaltenbach), *Hemilecanium theobromiae* Newstead (Fig. 22) and *Pseudococcus caleceolariae* (Maskell) were recorded. In Thysanoptera, genus *Opimothrips* was newly reported from India with a note on *Opimothrips tubulatus* Nonaka and Okajima (Fig. 23); three



Figs. 5–19. New taxa described from India. 5, *Maladera viraktamathi* Sreedevi *et al.*; 6, *M. naveeni* Sreedevi *et al.*; 7, *M. sujitrae* Sreedevi *et al.*; 8, *M. thirthahalliensis* Sreedevi *et al.*; 9, *Neoserica reuteri* Sreedevi *et al.*; 10, *Oxyserica goertzae* Sreedevi *et al.*; 11, *Selaserica hosanagarana* Sreedevi *et al.*; 12, *Serica eberlei* Sreedevi *et al.*; 13, *S. tashigaonesis* Sreedevi *et al.*; 14, *Acrotaeniostola connexa* David *et al.*; 15, *Dacus viraktamathi* David & Hancock; 16, *Dacus jacobi* David & Sachin; 17, *Halys mudigerensis* Salini; 18, *Formicococcus tectonae* Joshi, Bindu & Gullan; 19, *Callocleonymus indiaensis* Gupta *et al.*

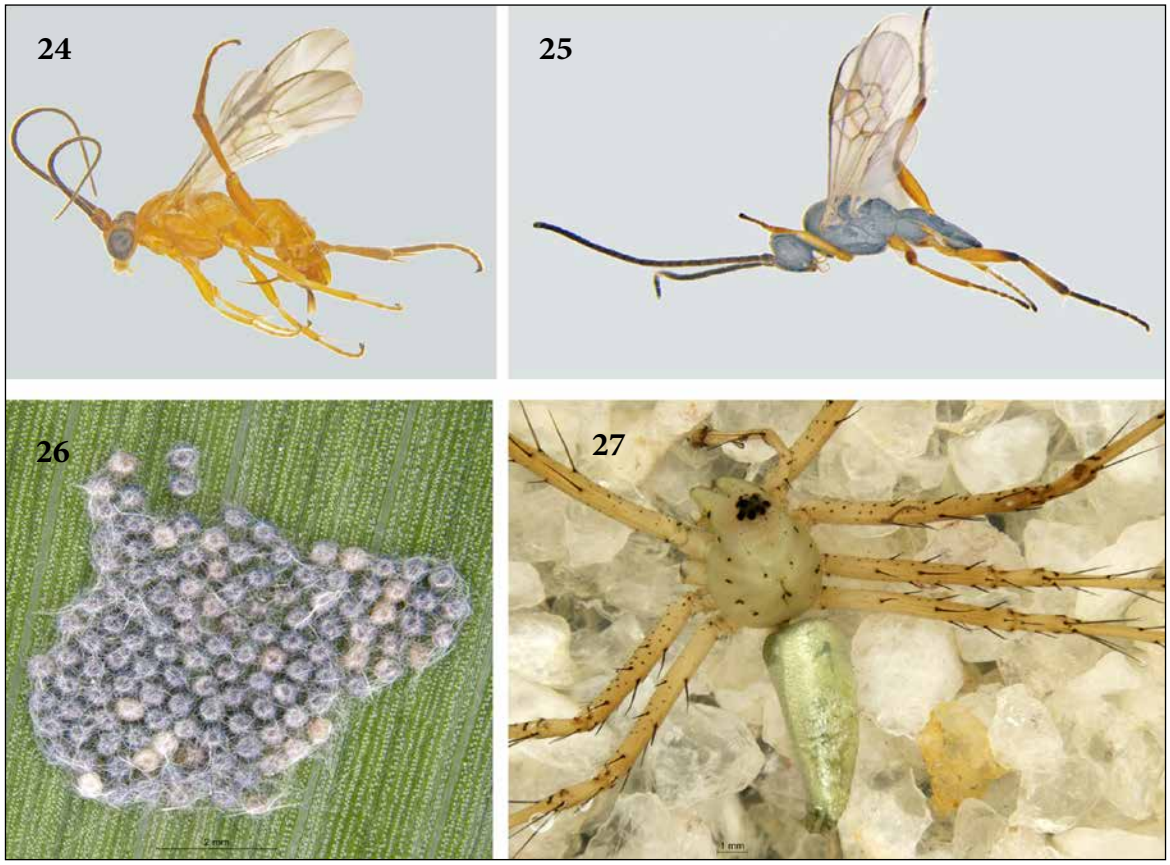
species of terebrantian thrips namely, *Helionothrips cephalicus* Hood, *Helionothrips mube* Kudo and *Helionothrips unitatus* Chen were also documented. *Cotesia cynthiae* (Nixon), *C. glabrata* (Telenga), *Iconella meruloides* (Nixon), *Iconella myeloenta* (Wilkinson) and *I. subcamilla* (Tobias) were recorded from various provinces of the Palearctic region. New distributional records of braconid wasps from other countries include four species from China and three species from Iran. Regarding new distribution records for the state; genus *Megaphragma* Timberlake was recorded from Maharashtra; Sac spider, *Clubiona analis* (Family: Clubionidae) from Tamil Nadu and green lynx spider, *Peucetia yogeshi* (Fig. 27) (Family: Oxyopidae) from Karnataka.

Figs. 20–23. New distrbutional records for India. 20, *Ceratitella sobrina* (Zia); 21, *Acroceratitis incompleta* Hardy; 22, *Hemilecanium theobromiae* Newstead; 23, *Opimothrips tubulatus* Nonaka and Okajima

New host records

Field surveys conducted during 2018-2019 in the maize fields infested with *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) in Karnataka, Tamil Nadu, Rajasthan and Meghalaya revealed that *Cotesia ruficrus* (Haliday) (Hymenoptera: Braconidae) was the common gregarious larval parasitoid in the maize fields parasitizing *S. frugiperda*. This is the first report of *C. ruficrus* (Fig. 25) parasitizing *S. frugiperda* in India, earlier reports being from Trinidad and Tobago. Also *Coccygidium* sp. (Braconidae) (Fig. 24) was also recorded as a new addition to *S. frugiperda* parasitoid complex. *Distatrix papilionis* (Viereck) (Hymenoptera: Braconidae) was reported to parasitize caterpillars of *Graphium nomius* (Esper) (Lepidoptera: Papilionidae) in southern India. This is the first association of *D. papilionis* being recorded as a gregarious endoparasitoid of *G. nomius*, hitherto

commonly collected from *Papilio demoleus* L. in Bengaluru. Parasitism of *Trichogramma chilonis* Ishii (Fig. 26) was recorded on eggs of *Spodoptera frugiperda* (J.E. Smith) for the first time in India.



Figs. 24–27. New host records and distributional records. 24, *Coccygidium* sp.; 25, *Cotesia ruficrus*; 26, Eggs of *Spodoptera frugiperda* parasitised by *Trichogramma chilonis*; 27, *Peucetia yogeshi*

Redescriptions/revision of taxa

The previously unknown male of *Aduncothrips asiaticus* (Ramakrishna and Margabandhu) (Thysanoptera: Aeolothripidae) was described and the female was redescribed with illustrations (Fig. 28, 29) based on specimens collected on *Moringa oleifera* Lam. Lectotype was designated (Fig. 30) for *Gynaikothrips microchaetus* Ananthakrishnan and Jagadish (Thysanoptera: Phlaeothripidae) and the species was redescribed with illustrations. Revised genus *Halys* Fabricius (Hemiptera: Pentatomidae) and resolved taxonomic confusions pertaining to the identity of *Halys fabricii* Memon, Ahmad & Perveen (= *Halys dentatus* (Fabricius)) from India by synonymising it with *Halys serrigera* Westwood; published four synonymies for *Halys sulcata* (Thunberg) namely *Halys sindillus* Memon, Meier & Manan, *Halys spinosus* Shaikh, Memon & Shah, *Halys mulberriensis* Memon, Parveen, Ahmad & Shaikh, *Halys noakoatensis* Memon, Parveen, Ahmad & Shah; established *Halys fabricii* Memon, Ahmad & Perveen (= *Halys dentatus* (Fabricius)) as a synonym of *Halys serrigera* Westwood. Male aedeagus of *Maladera murzini* Ahrens, 2004 (Coleoptera: Scarabaeidae) was illustrated for the first time as the holotype was described from an immature specimen. Adult taxonomic characters of *Anomala communis*, *Anomalochela bicolor*, *Maladera indica, Holotrichia nilgiria* collected from south India have been studied and redescribed. 18 genera of Sphecidae viz., *Stigmus, Carinostigmus, Sphex, Bembix, Bembicinus, Chalybion, Sceliphron, Chlorion, Psen, Lara, Liris, Tzustigmus, Carbro, Diodontus, Ammophila, Cerceris, Tachysphex* and *Gorytes* have been morphologically characterised. The green lynx spider, *Peucetia yogeshi* (Family: Oxyopidae) newly recorded from Karnataka in rice ecosystem has been redescribed.

Figs. 28–30. Redescriptions and revisions. 28 & 29, male and female of *Aduncothrips asiaticus* (Ramakrishna and Margabandhu); 30, lectotype of *Gynaikothrips microchaetus* Ananthakrishnan and Jagadish

Development of diagnostic keys/ tools/websites/ checklists

Diagnostic keys to the following taxa have been published:

* Indian species of *Paraputo* Laing and *Formicoccus* Takahashi and Oriental species of *Hemilecanium* Newstead
* Five subfamilies, two tribes, 17 genera and 22 species of fruit flies (Diptera: Tephritidae) from India; 19 species of *Dacus* Fabricius from India, Sri Lanka and Bangladesh and four species of *Ceratitella* Malloch from south and southeast Asia
* Four subfamilies and 20 genera of Pentatomidae from India and Indian species of *Halys* Fabricius
* Four genera of Panchaetothripinae (*Astrothrips, Noathrips, Opimothrips* and *Tryphactothrips*) that are members of the Tribe Tryphactothripini, six Indian species of *Astrothrips* and *Helionothrips*.

Host plant list for 54 species of Pentatomidae from India was compiled and published. Checklist of Vespidae from Goa was published with 33 species belonging to 22 genera and four subfamilies. Of these, 26 species, 18 genera, and two subfamilies were newly recorded from Goa. The checklist for four genera of Curculionidae *viz., Amblyrhinus, Corigetus, Desmidophorus and Peltotrachelus* were prepared. Catalogued and digitized 268 specimens belonging to Buprestidae, 7 specimens each of Trogidae & Passalidae and 16 specimens of Lucanidae preserved in the Insect Museum NBAIR. Several phytoseiid and ascid mites collected this year were found to be hitherto undescribed species. Several specimens of *Aponychus corpuzae* and *A. sulcatus* were added to the repository.

Division of Genomic Resources

Molecular characterisation of agriculturally important insects

Molecular characterization and respective DNA barcodes were generated for 73 agriculturally important insect pests, parasitoids and predators based on CO1 (Cytochrome Oxidase 1) gene, collected from different crops from Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu, Tripura and West Bengal. Twenty populations of invasive pest, the fall army worm, *Spodoptera frugiperda*, were received from different locations pan India and also from Nepal, the neighbouring country. Using CO1 gene all the populations were examined and the respective sequences were deposited in NCBI and accession numbers were obtained. The samples received from the Nepal (Khumaltar) MN584899, (Nepal-Nawalpur) MN584900, MN584898 showed 100% similarity with the Indian population. Veterinary pests like *Culicoides peregrinus* (MK756032), *Ceratopogonidae* sp. (MK948082), *Culicoides oxystoma* (MK801125), *Tabanus indianus* (MN909749), *Tabanus biannularis* (MN969969), *Tabanus triceps* (MN969970), *Tabanus gertrudae* (MN969971) were molecularly characterised. The whiteflies occurring on tomato, brinjal and other crops like *Bemisia tabaci* (MH807440, MH823740, MN787203, MN787204, MK497172, MN840828, MN864047, MN864048, MH891617), *Trialeurodes vaporariorum* (MN840829), *Aleurodicus dispersus* (MK491179) were molecularly characterized. Different *Telenomus remus* (MN879314, MN879315, MN879316, MN913332, MN814077, MN879313, MN913333, MN913333, MN913335, MN116707), *Ichneumonidae* sp. (MN913336), *Chelonus* strain TRI188 (MN913334), and *Chelonus* sp. (MN584896) were characterized using CO1 gene and DNA barcodes were generated.

Molecular characterisation was done and DNA barcodes were generated for around 20 wasps belonging to 14 genera where the species level identity was established. Enzymes assays were conducted for field populations of *Maconellicoccus hirsutus* using sublethal doses of agrochemicals, *viz.* Gibberellic acid, Buprofezin and Imidacloprid to understand the induced hormesis effect. Results indicated that the sublethal doses increased the level of enzymes in the pink mealybug population.

Diversity in rice white stem borers

There is a complex of white stem borer species such as *Scirpophaga excerptalis*, *S. nivella, S. innotata, S. virginia, S. fusciflua* (Fig. 32), *S. magnella* and *S. gilviberbis* reported on rice from various parts of India. Representative samples of rice white stem borer were collected from Kerala, Karnataka, Odisha and West Bengal. The adults were identified morphologically and subjected to molecular diversity analysis using mitochondrial COI primer.

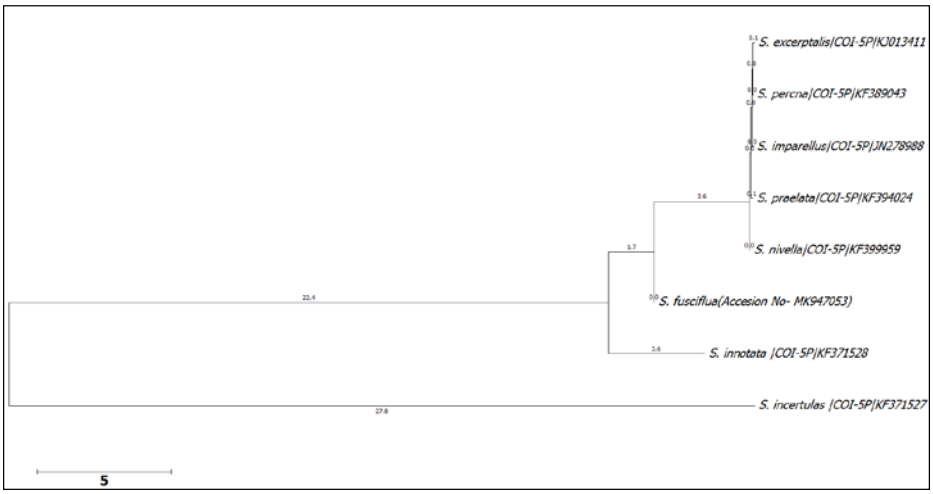


Fig. 31. Phylogenetic relationship among rice white stem borers

The results indicated a potential divergence of white coloured *Scirpophaga* spp. from yellow coloured *S. incertulas* through a common ancestor (Fig. 31). Twenty-six cultivated/wild plant species belonging to Poaceae and Cyperaceae were documented as host for the white stem borers as compared to monophagy nature of *S. incertulas*.

Fig. 32. Rice white stem borer, *Scirpophaga fusciflua* Hampson (Schoenobiinae: Pyralidae: Lepidoptera)

Molecular analysis of tritrophic relationship among insect host, EPN and bacterium

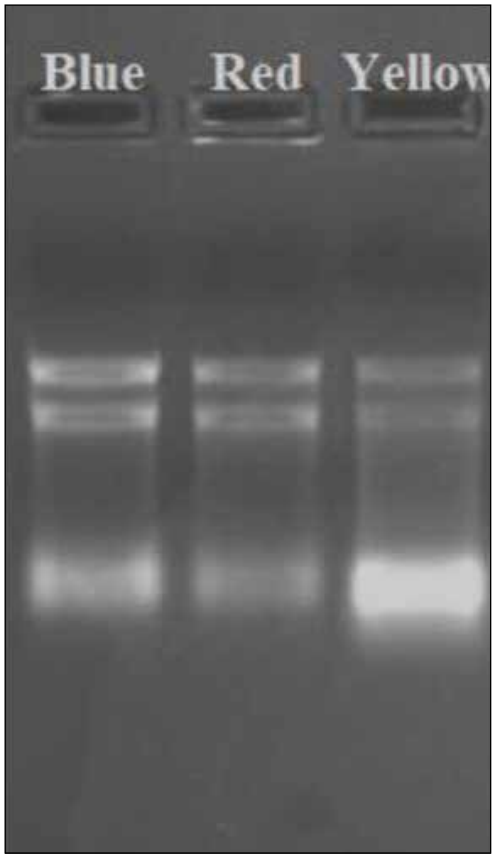


Fig. 33. RNA isolated from samples in 1% denatured agarose gel

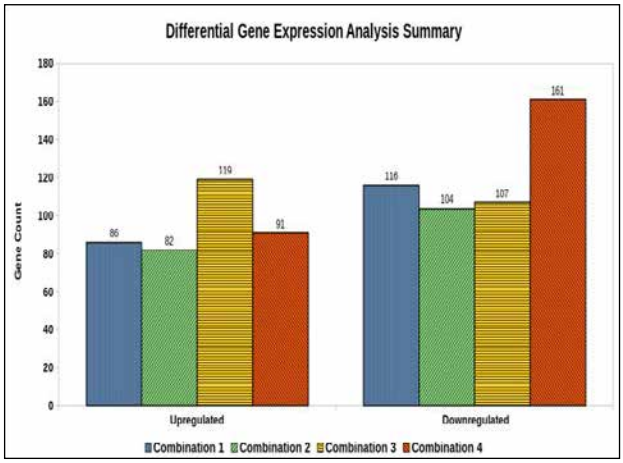


Fig. 34. Differential gene expression analysis in challenged or primed *G. mellonella* larva

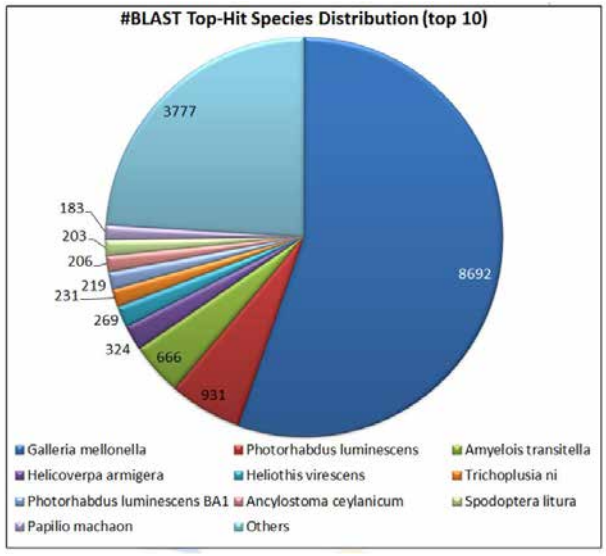


Fig. 35. Top Blast hit species distribution of pooled CDS; majority of the hits were found to be against *Galleria mellonella*

Next-generation sequencing-based transcriptome analysis of tritrophic relationship among insect host, EPN and bacterium (Fig. 33) unravelled several upregulated and down-regulated genes related to insect metabolism and immunity related pathways under stress (Fig. 34). Transcriptomes of treated *G. mellonella* primarily matched with *G. mellonella*, *H. armigera*, *Photorhabdus luminescens* and other lepidopterans (Fig. 35).

Morphological and molecular characterization of EPN: Four local isolates of EPN collected were identified as *Heterorhabditis indica, Steinernema carpocapsae* and *S. riobrave* based on molecular and

prominent morphological features. Sequences were submitted to NCBI for genbank accession numbers.

Development of mobile app for the management of rice and sugarcane pests

Mobile Application for the management of rice and sugarcane pests by using non-chemical methods was developed in English. It contains the information about the details of the pest, damage symptoms on crop and its management focusing on biological control methods. This mobile app will help the farmers to apply biological control measures and develop their skills in adopting non-chemical methods for the management of rice and sugarcane pests. This can be a ready reckoner tool to view the information about the relevant pests including photographs and helping adoption of non chemical methods of pest management.

Molecular docking studies of insecticide resistance gene of storage pests, *Tribolium castaneum* and *Callosobruchus* spp.

The storage pests *Tribolium castaneum* (Herbst), *Callosobruchus maculatus* (Fabricius.) and *Callosobruchus chinensis* (Linn.) have developed resistance against fumigants like phosphine. It is necessary to carry out the molecular docking studies to understand the molecular mechanism and binding site of a protein. Docking studies were carried out for Cytochrome P450 of *T. castaneum* and for *C. chinensis* with Cytochrome c oxidase gene with phosphine ligand. The crystal protein templates have been derived by using Swiss-Model and docking of protein-ligand carried out by using CDOCKER protocol by using Discovery Studio software.

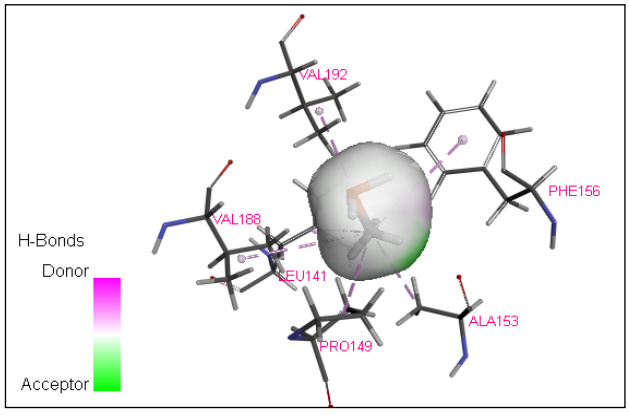


Fig. 36. Docking of cytochrome P450 of *Tribolium castaneum* with Phosphine

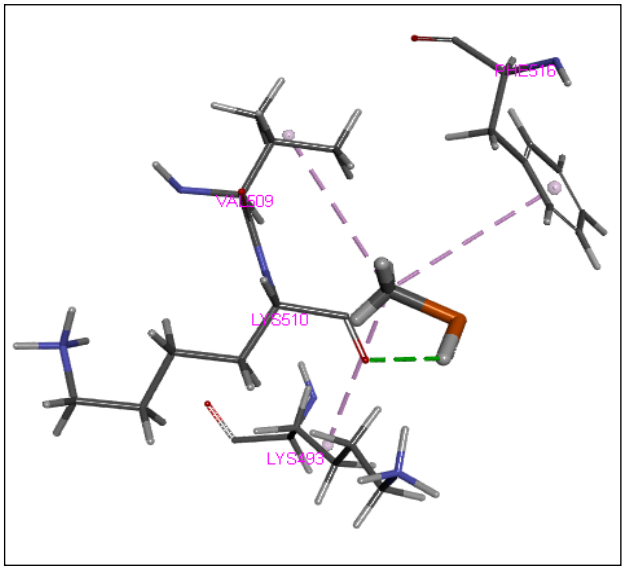


Fig. 37. Docking of cytochrome C oxidase of *Callosobruchus chinensis* with Phosphine

Collection of the different populations of the scarabaeids, termites and collembolans

A total of 82 scarabaeid beetles and 62 termites were collected from eight states viz., Andhra Pradesh, Arunachal Pradesh, Karnataka, Kerala, Meghalaya, Orissa, Tamil Nadu and Uttar Pradesh. Forty six collembolans were collected from marshy places, soil litter and decaying organic matter of Andhra Pradesh, Bihar, Karnataka Tamil Nadu and Uttar Pradesh.

Division of Germplasm Conservation and Utilisation

Studies on invasive fall armyworm (FAW), *Spodoptera frugiperda*

After invasion of fall armyworm (FAW), *Spodoptera frugiperda*, in 2018, surveys were conducted in major maize growing area of Karnataka state. The initial survey was conducted in the districts of Chikkaballapur, Hassan, Mandya, Chikkamagaluru, Shimoga, Davanagere, Chitradurga and Raichur. During the surveys, the incidence of fall armyworm was recorded on 20 to 60 days old crop coinciding with different phenological stages. The initial incidence of FAW ranged from 9 to 65% in the districts surveyed. In 2018, at initial stage of fall armyworm infestation in maize, the higher incidence of pest was recorded in Hassan (62.5%) followed by Davanagere (55.5%), Shimoga (48.5%) and Chikkaballapur (47.5%).

The larvae feeding on tassels were recorded, but no infestation on cob stages was observed. The early stage of maize crop was more vulnerable to pest infestation.

The incidence of fall armyworm was also observed on the maize from Telangana, Maharashtra, Tamil Nadu, Bharuch, Gujarat, West Bengal, North Eastern States, Bihar and Uttar Pradesh. Currently the infestation has spread to almost all the states of India.

Natural enemies

During survey, naturally infected or parasitized larvae of FAW were collected. From the eggs of fall armyworm egg parasitoids *Trichogramma* sp. and *Telenomus* sp. were collected. However, natural parasitism of larval parasitoids, *Campoletis chlorideae*, *Chelonus* sp., *Cotesia* sp., *Phenerotoma* sp., and *Eriborus* sp was recorded on the larval stage of fall armyworm. The natural infection of entomopathogenic fungi, *Metarhizium rileyi* (= *Nomuraea rileyi*) was also recorded on different larval stages of fall armyworm.

Several parasitoids were recorded from fall armyworm from Karnataka which included, *Trichogramma chilonis*, *Telenomus remus*, egg larval parasitoid *Chelonus* sp., *Chelonus formosanus* and larval parasitoids like *Glyptapanteles creatonoti Apanteles creatonoti*, *Campoletes chloridae* and several predators like earwig *Forficula* sp., predatory bugs like *Andrallus spinidens, Eocanthecona furcellata* were recorded. In addition, one dipteran parasitoid *Pseudgourax* sp., was recorded on the egg mass of fall armyworm. The maggots were found feeding on the eggs thereby showing a potential for management of FAW.

Mass rearing of *Chelonus* sp., an egg–larval parasitoid of fall armyworm *Spodoptera frugiperda*

Chelonus sp., an egg – larval parasitoid was recorded frequently from field samples collected from different districts of Karnataka. The parasitoid specimens were processed for both morphological and molecular identification and the genus was confirmed as *Chelonus* (Fig.38). Adults of *Chelonus* sp., (a) were exposed to the eggs of natural host, *S. frugiperda*, *Spodoptera litura* and on laboratory host, *Corcyra cephalonica* for a time period of 48 hours at a temperature of 25 ± 2°C and 65± 5% RH. The hatched neonates were reared on artificial diet media. Adult longevity varied from 2 to 7days. Developmental period was found to be 20 to 25 days on natural host and 25 to 50 days in *Corcyra*. Percent parasitism was 10 to 19.4% and 45 to 57.5 % of adults successfully emerged from the cocoons reared on natural host whereas 85 to 98% adult emergence was recorded from *Corcyra* eggs. Successful rearing on *Corcyra* eggs enabled mass rearing and release of *Chelonus* sp. for management of fall armyworm in maize during monsoon and post monsoon season in different villages of Karnataka.

Chelonus sp. (a) Small & arrehenotokous

Chelonus sp. (b) Big & arrehenotokous

Fig. 38. Two different species of egg larval parasitoid *Chelonus* sp. recorded on FAW in Karnataka

Pentatomid predators of *S. frugiperda*

Pentatomid predators, *Eocanthecona furcellata* and *Andrallus spinidens* were reared on different hosts like *Spodoptera frugiperda*, *S. litura*, *Samia cynthia ricini* and *Corcyra cephalonica* in the laboratory conditions. The predatory potential and numerical response of *E. furcellata* and *A. spinidens* on fall armyworm, *S. frugiperda* was studied (Fig. 39). Peak population of *E. furcellata* was observed during the 38th and 39th standard meteorological week from nymphal stages. Both the predators were amenable for mass production and can be effectively used in management of fall armyworm through augmentative techniques.

Egg parasitoid, *Trissolcus* sp. for the management of pentatomids preying on silkworm

E. furcellata is serious predator of early stage silkworm worm larvae causing a yield loss of about 10-15 per cent. *Trissolcus* sp. was recorded as the potential egg parasitoid against the pentatomid predator, *E. furcellata*. *Trissolcus* can be mass reared on pentatomid eggs and can be used in sericulture industry to reduce the predatory attack of *E. furcellata* on early instar silkworm larvae..

Fig. 39. *Eocanthecona furcellata*

Natural parasitism of *Trichogramma chilonis* on *Spodoptera frugiperda* infesting maize and sorghum

A total of 1035 eggs were collected from the maize field from 15th day after sowing till harvesting of crop. The natural parasitisation of eggs of fall armyworm by *Trichogramma chilonis* ranged from 17.90 to 44. 50% in maize (Fig. 40 & 41). A total of 16 populations and six populations of *T. chilonis* from Karnataka and Maharashtra were collected from FAW eggs, respectively. In Maharashtra, The natural prasitisation range between 7 and 18% in maize.

Fig. 40. Fall armyworm eggs parasitised by *Trichogramma chilonis*

Fig. 41. *Trichogramma chilonis*

Egg parasitoids of *Spodoptera frugiperda*

Field parasitism by egg parasitoids, *Trichogramma chilonis* and *Telenomus remus* was studied in maize. The percent parasitisation by both the parasitoids was 33.5%, however greater parasitisation was recorded by *T. chilonis* compared to *T. remus*.

Evaluation of indigenous and exotic trichogrammatids against *Spodoptera frugiperda*

Six strains of Trichogrammatids *viz.*, *Trichogramma pretiosum* (thelytoky), *T. pretiosum* (thelytoky-France), *T. pretiosum* (arrhenotoky-Germany), *Trichogramma chilonis* (collected on FAW), *T. chilonis* (laboratory) and *Trichogrammatoidea armigera* were evaluated against fall armyworm in the laboratory. Results showed that *T. pretiosum* (thelytoky) and *T. chilonis* (collected on FAW) parasitised 17.60 ±0.74 and 25.90 ± 1.88 eggs of *S. frugiperda,* respectively.

Evaluation of entomopathogenic bacteria against *S. frugiperda*

Attempts were made to identify and develop indigenously isolated *Bt* for FAW management. Extensive surveys were conducted in the southern states of Karnataka, Tamil Nadu and Andhra Pradesh to collect the infected larvae. Initially there was no *Bt* infected larvae present as farmers used pesticides. However subsequent collections yielded few infections and *Bt* was isolated, purified as per standard protocols. The *Bt* isolate was tentatively identified as NBAIR-BT25 (GenBank MN327970) and the culture was also certified by ICAR-NBAIM, Mau (MN203620.1). *In vitro* studies showed that *B. thuringiensis* NBAIR-BT25 incited 100% mortality at 48h after treatment. The LC_{50} worked out to be 44.72 µg/ml.

Field evaluation of liquid formulation of ICAR-NBAIRBT25 against fall armyworm

Field evaluation of *B. thuringiensis* NBAIR-BT25 was carried out against *S. frugiperda* in maize during *rabi* season in 2018 & *kharif* in 2019 at Bengaluru and Chikkaballapur in Karnataka. There was 69.4% reduction in pest damage after two sprays at farmer's field in Chikkaballapur. At NBAIR research farm, NBAIR-BT25 recorded 81% decrease in pest based on larval mortality (Fig. 42).


Fig. 42. Dead larvae observed after foliar application

Area coverage

Bacillus thuringiensis (ICAR-NBAIRBT1) isolate was evaluated in different maize growing areas of the country covering an area of 40 hectares in Karnataka and Andhra Pradesh.

Evaluation of entomopathogenic fungi against fall armyworm

Two strains of *Metarhizium rileyi* were isolated from the fall armyworm cadavers (Fig. 43) collected from Chikkaballapur, Karnataka and Anantapur, Andhra Pradesh (ICAR-NBAIR NrSf-4 & NrSf-5) and *Beauveria felina* (ICAR-NBAIR Bf-1) (Fig. 44) collected in Chikkaballapur, Karnataka have been isolated and molecular characterized using ITS region and the sequences were deposited at NCBI GenBank. The accession numbers of two isolates, ICAR–NBAIR NrSf-4 & Bf-1 MN602591 and MN833071 were obtained.

Fig. 43. *Metarhizium rileyi* on FAW

Fig. 44. *Beauveria felina* on FAW

Field evaluation with *Beauveria bassiana* (ICAR-NBAIR Bb-45) and *Metarhizium anisopliae* (ICAR-NBAIR Ma-35) were carried out at NBAIR Yelahanka farm against *S. frugiperda* in maize (Var. BRMH-1 hybrid) during *Kharif* season (June, 2019 to Sept 2019). Three foliar sprays @ 5g/litre (Talc formulation containing $1x10^8$ CFU/g) were provided at 15, 30 & 45 days of the crop stage were given. ICAR-NBAIR-Bb-45 and Ma-35 recorded 79 and 86% of pest reduction respectively (Table 2).

Table 2. Field evaluation of entomofungal pathogens against *S. frugiperda* at Yelahanka farm (2019-20)

Isolate	Pre-count	No. of larvae/ plant (3 sprays)	% decrease over control	% leaves affected	No. of plants affected/ 10 plants	Average yield/10 plants (kg)
Bb-45	1.29	0.21[a]	79.0	3.57[a]	1.00[a]	5.34[a]
Ma-35	1.00	0.14[a]	86.0	5.95[a]	0.79[a]	6.16[a]
Control	1.57	1.00[b]	-	21.55[b]	2.57[b]	3.31[b]
CD@5%	NS	0.23	-	1.82	0.37	0.616

Field evaluation with *B. bassiana* (ICAR-NBAIR Bb-45) and *M. anisopliae* (ICAR-NBAIR Ma-35) were carried out at Bomanahalli in Chikkaballapur district, Karnataka on 30 day old crop against *S. frugiperda* in maize during *Kharif* season (July-Oct. 2019). Three foliar sprays @ 5g/litre (Talc formulation containing $1x10^8$ CFU/g) were provided at 30, 40 and 50 days of the crop stage. ICAR-NBAR Ma-35 and Bb-45 recorded 37.5 and 53.6% of pest reduction, respectively (Table 3).

Table 3. Field evaluation of entomofungal pathogens against *S. frugiperda* at Bomanahalli in Chikkaballapur a district, Karnataka

Isolate	Pre-count	No. of larvae / plant (3 sprays)	% decrease over control	% leaves affected	No. of plants affected/ 10 plants	Average yield/10 plants (kg)
Bb-45	10.00	5.71[a]	37.52	30.90[a]	3.00[a]	5.09[a]
Ma-35	11.71	4.24[a]	53.61	34.78[a]	2.81[a]	6.23[a]
Control	12.29	9.14[b]	-	59.71[b]	5.24[b]	3.10[b]
CD@ 5%	NS	0.958	-	0.413	0.321	0.296

Evaluation of indigenous EPN species against *Spodoptera frugiperda*

Efficacy of five indigenous EPN species, *Heterorhabditis indica*, *H. bacteriophora*, *Steinernema carpocapsae*, *S. abbasi* and *S. siamkayai* was tested against larval and pupal stages *S. frugiperda* under laboratory conditions. The results revealed that both third and fourth instar larval stages of *S. frugiperda* were susceptible to all five EPN species tested and third-instar larval stages were more susceptible than fourth-instar larvae. When a dose of 600 IJs larva^{-1} was applied, the greatest mortality of third-instar larvae was observed for *H. indica* (100%), *H. bacteriophora* (87%), *S. carpocapsae* (100%) and *S. abbasi* (93%), and the lowest was observed for *S. siamkayai* (66.7%). In case of fourth-instar larvae, the greatest mortality was observed for *H. indica* (100%), *S. carpocapsae* (96%) and *H. bacteriophora* (75%) and the lowest was observed for *S. siamkayai* (40%). The mortality percentage in third and fourth instar larvae increased significantly with the increase in the IJ concentrations of all EPN species. When pupal stages of *S. frugiperda* were treated with 600 IJs pupa^{-1} greatest mortality was observed in treatment. *H. indica* (85%) followed by *S. carpocapsae* (65%), *H. bacteriophora* (60%), and *S. abbasi* (35%), and the lowest mortality was observed for *S. siamkayai* (15%). The mortality percentage in pupal stages of *S. frugiperda* increased significantly with the increase in the IJ concentrations only for *H. indica* and *S. carpocapse*.

Integrated management of fall armyworm, *Spodoptera frugiperda*

IPM field trials using parasitoids, predators, *Bt*, pheromone traps, entomopathogenic fungi *Beauveria bassiana* (NBAIR Bb-45) and *Metarhizium anisopliae* (ICAR-NBAIR Ma-35) showed 93.46% and 75.87% reduction in the egg and larval population of *S. frugiperda* compared to control. Release of egg parasitoid, *Trichogramma chilonis* recorded 59.25 percent parasitization of eggs at Anantapur district (Fig. 45).

Fig. 45. Field survey for natural enemies of FAW at Anantapur

Survey and collection of diseased larvae of fall armyworm, *S. frugiperda*

Surveys were conducted in various parts of Tamil Nadu and Karnataka to collect the diseased larvae of *S. frugiperda*. Totally eight infected insect samples were collected out of which seven (Fig. 46) were collected from Chikkaballpura, Karur, Ariyalur, Erode and Royakottai from maize crop and one collected insect sample from Palakode areas in

sorghum. Nucleopolyhedroviruses (NPVs) have been extracted from all the samples and the occlusion bodies of NPV were observed under phase contrast light microscope.

Fig. 46. Diseased larvae of *Spodoptera frugiperda* showing characteristic viral infection symptoms

Field evaluation of *Spfr*NPV against fall armyworm

Field evaluation of *Spodoptera frugiperda* NPV (*Spfr*NPV) against fall armyworm *S.frugiperda* was carried out at Chikkaballapura, Karnataka. All the three concentrations of NPV (1.5×10^{12} POBs/ha, 1×10^{8} POBs/ha ,1×10^{4} POBs/ha) were found effective in reducing the larval population of armyworm. The number of larvae recorded per 10 plants at the concentrations of NPV ranged from 4.55 to 6.76 where as it was 1.85 in the insecticide (Emamectin benzoate@ 0.4g/l) treated plots. The concentration 1.5×10^{12} POBs/ha was found most effective in reducing the larval numbers from 38.35 to 4.55 followed by concentration 1×10^{8} POBs/ha which reduced from 39.15 to 6.45. Insecticidal treatment reduced the larval numbers from 42.05 to 1.85 (Table 4).

Table 4. Field evaluation of SpfrNPV against fall armyworm at Chikkaballapur

Concentrations (POBs/ha)	No of larvae/ 10 plants			
	Days after treatment			
	Pretreatment (20 days after sowing)	3	5	7
1.5×10^{12}	38.35	25.85	10.50	4.55
1.5×10^{8}	39.15	22.10	12.75	6.45
1.5×10^{4}	36.50	20.50	11.25	6.76
Emamectin benzoate (0.4 g/l)	42.05	12.50	6.55	1.85
Untreated control)	39.73	36.13	30.25	23.25
CD (P= 0.05)	--	5.68	4.02	3.23

Evaluation of entomopathogens for the management of sucking pest *Thrips palmi* infesting watermelon and suppression of watermelon bud necrosis tospovirus under field conditions

Effective use of entomopathogenic biopesticides under field conditions viz., *Metarhizium anisopliae* strain NBAIR-MaCB, *Pseudomonas fluorescens* strain NBAIR-PFDWD and *Bacillus albus* strain NBAIR-BATP either individually or in consortia form effectively managed *Thrips palmi* on watermelon compared to untreated control. These biopesticides were on par with the chemical control imidacloprid but the yield was at appreciable level in *B. albus*, followed by *P. fluorescens,* chemical check and *M. anisopliae*. Consortia of *B. albus* with *P. fluorescens* was very effective in reduction of *T. palmi* population compared to other consortia.

Management of *T. palmi* was correlated with the suppression of watermelon bud necrosis tospovirus in watermelon. The results of the experiment clearly indicated the suppression of *T. palmi* and watermelon bud necrosis tospovirus under field conditions (Fig. 47).

Field view of the experimental plot | Biopesticides treated | Control

Fig. 47 . Representative image to show field evaluation of entomopathogens against *Thrips palmi* on watermelon

Polyhouse view of Gerbera | Biopesticides treated | Control

Fig. 48. Representative image to show polyhouse evaluation of microbial biopesticides against *Thrips hawaiiensis* on *Gerbera*

Evaluation of entomopathogens for the management of sucking pest *Thrips hawaiiensis* infesting export quality *Gerbera* under polyhouse conditions

Severe infestation of *Thrips hawaiiensis* was observed in export quality of *Gerbera jamesonii* under polyhouse conditions (Fig. 48). Export quality flowers was severely affected by *T. hawaiiensis* as seen in representative image from control plots. Application of *P. fluorescens* strain NBAIR-PFDWD and *B. albus* strain NBAIR-BATP and its consortia effectively reduced the *T. hawaiiensis* populations from 45 thrips per plant to 6 thrips per plant within three days after application. Significant reduction in the population of thrips was observed after four applications at weekly intervals and quality of the flowers was superior in the treatment plot.

Characterization of biorationals for management of red flour beetle, *Tribolium castaneum*

Stored-product insects are of serious concern on dried, stored agricultural commodities, and value-added food products worldwide. Flour beetle, *Tribolium castaneum* is a major stored product pest of concern in India. Chemical insecticides are used as fumigants to manage the pest and this has led to development of insecticide resistance. Plant derived products from sweet basil oil and its major constituents like methyl chavicol and linalool caused cidal effects on flour beetle, *T. castaenum*. Methyl chavicol and linalool were more effective over the basil oil (Table 5). Exposure of *T. castaneum* to sublethal dose of basil oil caused a decline in carbohydrates and protein level in treated insects.

Table 5. Toxicity of essential oils on flour beetle, *Tribolium castaneum*

Test material	LC_{50} mg/ cm^3	95% Confidence limits		Chi square
		Lower limit	Upper limit	
Basil oil	0.191	0.174	0.205	4.35
Methyl chavicol	0.028	0.025	0.033	4.9
Linalool	0.075	0.062	0.088	17.5

Development of controlled release formulations for major pests

Slow release pheromone nanogel formulations for several hazardous pests in the agricultural field as a measure of non-toxic and environment friendly approach towards modern agriculture were developed. Using the slow release pheromone formulation, traps have been developed for insect pests like *Spodoptera frugiperda, Chilo sacchariphagus*

indicus, Scirpophaga excerptalis, Plutella xylostella, Bactrocera dorsalis and *Holotrichia consanguinea* and supplied to several researchers and farmers (Figs. 49–51). Application of slow release pheromone nanogel formulation traps in the field and orchards significantly increased the catches of respective insects in every field trial compared to traps without nanogel. These low cost, nanogel formulation traps do not require any specialised storage facility.

Fig.49. Slow release pheromone nanogel formulation for *Holotrichia consanguinea*

Fig. 50. Slow release pheromone nanogel formulation for *Spodoptera frugiperda*

Fig. 51. Slow release pheromone nanogel formulation for *Bactrocera dorsalis*

Drone assisted Pheromone detection and remediation for pests

Experiments were conducted using LoRa transmitter/ receivers and an efficacy of wireless data transmission up to 500 mtrs was achieved. Efforts were made to embed the transmitter onto the drone to transmit latitude, longitude, Input from Device (Nanosensor) data. Further tests are under progress to send the signals for switching on the spray nozzles depending upon the input conditions (nanosensor).

Predatory potential of predatory mirid, *Dortus primarius*

Predation potential of mirid, *Dortus primarius* was evaluated against tomato pinworm, *Tuta absoluta.* The nymphs and adults of the mirid bug consumed 16-20 eggs and 22-24 eggs per day of *T. absoluta* respectively. Both male and female mirids preferred first instar larvae of *T. absoluta* for predation. Intraguild predation (IGP) study between *D. primarius* and *Nesidiocoris tenuis* showed that in both the predators IGP was higher than cannibalism when different stages were used though there was no significant difference between these parameters in both the predators however, both IGP and cannibalism is higher in *D. primarius*. Survival of both the female predators was low at higher density in absence of prey.

Biological control of thrips and mites

Three releases of predatory mite, *Neoseiulus indicus* recorded 90% reduction of broad mite, *Polyphagotarsonemus latus* in mulberry. Release of predatory mite, *Neoseiulus indicus* and anthocorid predator, *Blaptostethus pallescens* recorded 82% and 65% reduction, respectively in the red spider mite population infesting rose respectively. Six releases of *Dortus primarius* and *Blaptostethus pallescens* resulted in 70% reduction in thrips population in rose.

Biocontrol potential of social spider, *Stegodyphus sarasinorum*

Spiders are commonly known for their generalist predatory nature, are numerically more abundant than any other natural enemies and occupy various niches in a given agro-ecosystem. Longer life cycle and difficult laboratory rearing procedures for spiders, reduces the possibility of their inundative

release. Conservation strategies are mainly adopted in case of spiders to achieve the predatory role in crop fields. *Stegodyphus* (Eresidae), commonly called social spiders namely *S. mirandus*, *S. pacificus*, *S. sarasinorum* and *S. tibialis* have been reported from India. Out of these, *S. sarasinorum* is the predominant one depending upon the web size ranging between 100 and 1000. They are capable of capturing prey as large as 10 times their size and are advantageous from a biological control perspective. Females are 7-14 mm in length, exhibits communal nesting, predation, feeding and brood care. The social spiders collected from various places in south India were released into NBAIR farm for colonization. The established colonies were deployed in different places of mango fields in the crop boundary and non-crop habitats at NBAIR farm. Regular observations were undertaken by recording the pests trapped in the webs of these spiders. Though, non-target insects like bees, dragon flies, houseflies were observed, the number of mango pests faw outnumbered. Analysis of the prey composition pattern of *S. sarasinorum* along the non-crop habitats in mango orchard indicated that it can be used as a biocontrol agent.

Biology and functional variability among populations of *Heterorhabditis* and *Steinernema sp.*

Biology and lifetables of *H. indica, H. bacteriophora*, *S. abbasi* and *S. carpocapsae* were determined on grubs of four predominant Coleopteran species.

Compatibility of contact pesticides with EPN species and their bio-efficacy against FAW

Seven synthetic insecticides, emamectin benzoate, spinosad, imidacloprid, clothianidin, chlorantriniprole, thiamethoxam, spinetoram, and neem oil recorded compatibility with EPN isolates except *S. feltiae* (NBAII Sf01).

Field efficacy of EPN formulations for the management of fall armyworm

Field trial on doses, efficacy in combination synthetic insecticides and formulations of EPN against FAW (Kharif 2019-20) indicated dose dependent control of FAW larvae at an optimum dose of 4-6kg/ha either in the form of WP or granular formulation of *Heterorhabditis indica* NBAII Hi101. Split doses and combination of *H. indica* with emamectin benzoate at split doses could protected the crop upto 80-88% (Fig. 52-54). Another field trial in Pachora, Maharashtra in black cotton soils indicated that application of WP formulation of EPN to plant root zone in combination with whorl application in the first fortnight followed by split dose 30 days later prevented secondary infestation of field populations of FAW.

Fig. 52. Maize treated with wettable powder of *Heterorhabditis indica* NBAII Hi101 (Red arrow shows damaged leaf at the 3-4 leaves from top; yellow arrow shows healthy and undamaged cobs).

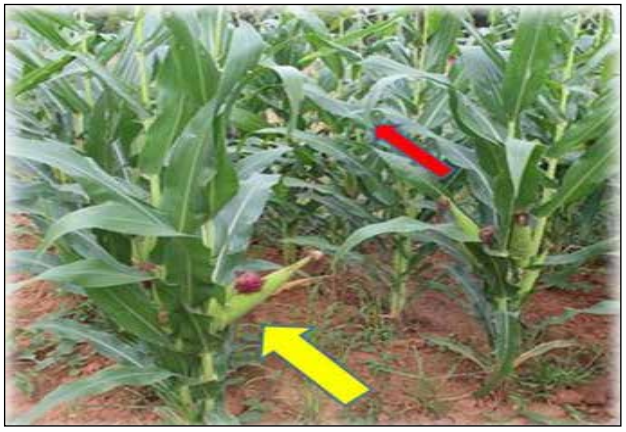


Fig. 53. Maize treated with granular formulation of *Heterorhabditis indica* NBAII Hi101 (Red arrow shows damaged leaf at the 3-4 leaves from top; yellow arrow shows healthy and undamaged cobs).

Fig. 54. Maize treated with emamectin benzoate as chemical check. (Red arrow shows damaged leaf at the 3-4 leaves from top; yellow arrow shows healthy and undamaged cobs).

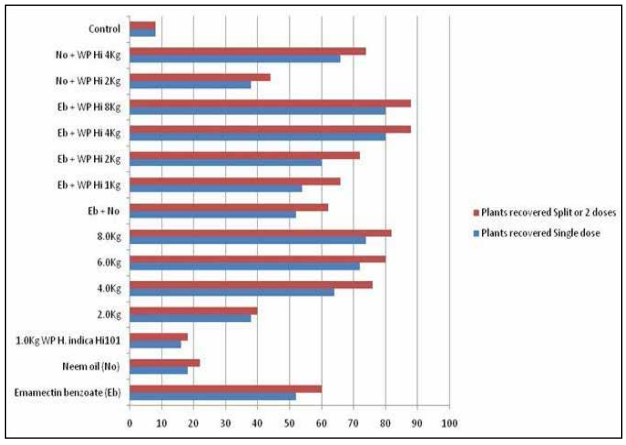


Fig. 55. Field evaluation of WP *H. indica* combinations with insecticides and their dosages (2019-20).

Biocontrol potential of entomopathogenic *Heterorhabditis* and *Steinernema* nematodes against *Phyllognathus dionysius* (Coleoptera: Scarabaeidae)

Biological control potential of two indigenous species of entomopathogenic nematodes (EPN), *Steinernema carpocapsae* NBAIISc05 and *Heterorhabditis indica* NBAIIH38 was tested against larval stages of *Phyllognathus dionysius* in field experiments. Application of *H. indica* at a rate of 1.25×10^9 IJ ha^{-1} significantly reduced percentage of grub population compared to that of *S. carpocapsae* and chlorpyrifos treatments. Chlorpyrifos application, however, was more effective in reducing the grub population compared to *S. carpocapsae* (6.25×10^8 IJ ha^{-1}) (Fig. 56). These experiments suggest *H. indica* NBAIIH38 to be a promising biocontrol agent against *P. dionysius* in turmeric production.

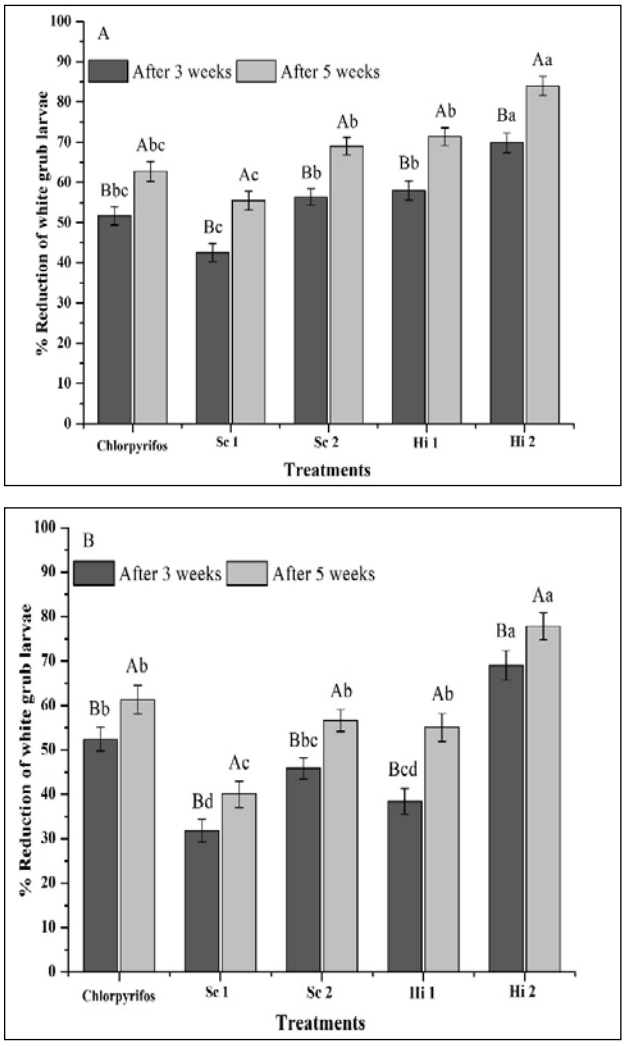


Fig. 56. Percentage reduction of *Phyllognathus dionysius* in turmeric fields with different treatments at 3 and 5 weeks after application in two field experiments at Belgaum (A) and Vijayapura (B), Karnataka, India. In both the experiments grubs were mainly in the second instar stage. Bars with different uppercase letters on the top of error bars indicate significant differences among the same treatment on different days after applications and with different lowercase letters indicate significant differences for different treatments ($P < 0.05$, Tukey's test). Sc, *Steinernema carpocapsae*; Hi, *Heterorhabditis indica*; 1 = 6.25×10^8 IJ ha^{-1}, 2 = 1.25×10^9 IJ ha^{-1}. Chlorpyrifos was used at the rate of 4000 ml ha^{-1} as a drench application.

Evaluation of entomopathogens against various insect pests

Glasshouse experiments

A glasshouse experiment was conducted to study the effect of endophytic isolates of *Beauveria bassiana* (Bb-5a & Bb-45) and *Metarhizium anisopliae* (Ma-4 & Ma-35) on *Plutella xylostella* in cabbage using detached leaf bioassay method when applied through seed treatment/ root inoculation/ foliar spray (@1 x 10^8 spores/ml).

All four isolates showed different mortalities during 15-30 DAT in different inoculation methods (Table 6). In seed treatment, all the four isolates showed 0-48.8% mortality of *P. xylostella* during 15DAT. In 30 DAT, all four isolates showed 28-48.8% mortality of *P. xylostella*. In root inoculation method, the isolates showed 8.4-48% mortality of *P. xylostella* during 15 DAT. In 30 DAT, all isolates showed 0-27.2% mortality of *P. xylostella*. In foliar application technique, all isolates showed 70-76.7% at15 DAT. In 30 DAT, all isolates showed 13.7-54.8% mortality of *P. xylostella*. No mortality was observed during 45 DAT in all the inoculation methods. Among all the isolates tested, Ma-35 isolate showed highest mortality when applied through foliar application.

Table 6. Effect of endophytic *B. bassiana* and *M. anisopliae* isolates against *P. xylostella* in cabbage by different inoculation methods

Isolate	Seed treatment (% mortality)		Root inoculation (% mortality)		Foliar application (% mortality)	
	15DAT	30DAT	15DAT	30DAT	15DAT	30DAT
Bb-5a	29.6^{c}	43.2^{b}	8.4^{c}	0.0^{c}	76.67^{a}	13.70^{bc}
Bb-45	41.8^{b}	29.2^{c}	26.0^{b}	21.2^{b}	76.67^{a}	37.40^{ab}
Ma-4	0.00^{d}	48.8^{a}	40.0^{ab}	0.0^{c}	70.00^{a}	44.43^{a}
Ma-35	48.8^{a}	28.0^{c}	48.0^{a}	27.2^{a}	76.67^{a}	54.80^{a}
Control	0.00^{d}	0.00^{d}	0.00^{d}	0.00^{c}	23.33^{c}	3.33^{c}

Field trials

A field trial was conducted to evaluate the endophytic isolates of *Beauveria bassiana* (NBAIR-Bb-5a and 45) and *Metarhizium anisopliae* (NBAIR Ma-4 and Ma-35) through foliar applications of oil formulations against *Plutella xylostella* in cabbage at ICAR-NBAIR, Farm Campus, Bengaluru during kharif 2019. One foliar spray of the oil formulation of each isolate of *B. bassiana* and *M. anisopliae* (1 x 10^8 conidia/ml) was given at 15 days after transplanting. All the 4 isolates tested could cause 56.1-93.5% pest reduction over control. Among these, Ma-35 isolate recorded 93.5% of pest reduction over control. No significant differences were observed in the yield between treated and untreated control (Table 7).

Table 7. Field evaluation of endophytic entomopathogenic fungi against *Plutella xylostella* in Cabbage

Isolate	Pre count	Post count	% reduction over control	Average yield/5 plants (kg)	Average yield/ hectares (kg)
Bb-5a	2.40	0.20^{a}	81.30	5.49	87840
Bb-45	2.80	0.47^{a}	56.07	5.61	89760

Ma-4	2.60	0.40[a]	62.61	5.59	89440
Ma-35	3.60	0.07[a]	93.46	5.46	87360
Control	3.20	1.07[b]	-	5.28	84480
CD @ 0.05	NS	0.255	-	NS	NS

Evaluation of entomopathogenic fungi against mites

Metarhizium anisopliae isolates IF(Gm)90 and IF(Soil)91 were evaluated against four phytophagous mite species, including the green and red forms of *Tetranychus urticae*. Both caused more than 90% mortality within 7 days of application as dust or spray.

For the first time, *Hirsutella thompsonii* was effectively used against the broad mite on mulberry. Five field trials on mulberry and one on rose were conducted.

Surveillance of whiteflies

Eleven field surveys covering five different states were undertaken across India to collect whiteflies from different crop plants for morphological and molecular based identification. Two highly invasive palm infesting whitefly, *Aleurotrachelus atratus* infesting coconut and Woolly whitefly, *Aleurothrixus floccosus* infesting guava were reported for the first time in India as well as Oriental region. Rugose spiraling whitefly, *A. rugioperculatus* and nesting whitefly, *Paraleyrodes minei* were the dominant species causing damage in coconut in Karnataka whereas *P. bondari* and *A. rugioperculatus* were recorded to be the dominant species in Kerala and Tamil Nadu. Our study revealed that the most dominant genetic group of *Bemisia tabaci* is Asia-I and Asia-II-1. Asia –II 5 was also found to occur in Chhattisgarh. New host plants of rugose spiralling whitefly were recorded *viz.*, ginger, turmeric, colocasia, betelvine, ficus and lipstick tree. Custard apple, ficus, Indian almond, capsicum, banana, jamun, oil palm, cassava, mango, sapota, citrus, china rose and duranta were recorded as hosts for nesting whiteflies. Solanum whitefly was recorded infesting new host plants like day blooming jasmine, wild jasmine and pagoda tree.

Biological control of rugose spiralling whitefly

Explorations were carried out to document the natural enemies of rugose spiraling whitefly. Among natural enemies encountered, two aphelinid parasitoids, *Encarsia guadeloupae* and *E. dispersa* were found to have colonized the RSW and naturally suppressed the pest. The dominant parasitoid was found to be *E. guadeloupae* with a natural parasitism of 56-82% while *E. dispersa* recorded 5-10%. Apart from these parasitoids, predators like *Dichochrysa astur, Jauravia pallidula*, *Cheilomenes sexmaculata* and *Cybocephalus* sp. were also observed to be feeding on RSW.

Entomopathogenic fungus, *Isaria fumosorosea* (ICAR-NBAIR pfu-5) a promising bioagent against rugose spiraling whitefly infesting coconut

ICAR-NBAIR has identified a promising entomopathogenic fungus, *Isaria fumosorosea* (ICAR-NBAIR pfu-5) based on laboratory bioassays (Fig. 57) and also on multi-locational field trials in Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. The fungus was effective against all the life stages of the pest. The egg and early instar nymphal mortality was up to 91% and the late nymphal instars and pupal mortality was up to 80%. Mass production technology for this fungus has been standardized using solid state fermentation (rice grains) and liquid state fermentation technology (Saboroud dextrose yeast broth, potato dextrose broth). Talc, rice grain and oil formulations have been developed with long shelf life (Fig. 58). Due to its high field efficacy, there is a huge demand for this biocontrol agent from the coconut farming community. Farmers in Andhra Pradesh are regularly trained on farm level production of *I. fumosorosea* using rice grains as substrate for their use in the coconut gardens.

Fig. 57. *Isaria fumosorosea* (NBAIR-Pfu5) growth on RSW nymphs

ICAR-NBAIR conducted extensive research on biological control of this pest on a priority basis under its core programme as well as under a project funded by the Coconut Development Board, Kochi. Biocontrol strategies using parasitoids and the entomofungal pathogen, *I. fumosorosea* were adopted for the efficient management of the RSW. Economic analysis of the impact of conservation and augmentation of *E. guadeloupae* and foliar application of *I. fumosorosea* for management of RSW revealed a savings of Rs 9500/ha towards the crop protection cost and 900 ml of pesticides/ha is being saved.

Fig. 58. Talc and rice-based formulations of *Isaria fumosorosea*

Semiochemicals for the management of rose flower thrips

A field experiment was conducted at Krishnagiri in polyhouse conditions to assess the attraction of flower thrips to the attractants developed using plant volatiles. The volatiles were impregnated in rubber septa and placed in the yellow sticky traps. Several sets of experiments were conducted and one combination was found to attract a large number of thrips (Fig. 59). The experiments were repeated at different places in Dharmapuri, Thali and Hosur. The thrips population were effectively reduced in the rose gardens.

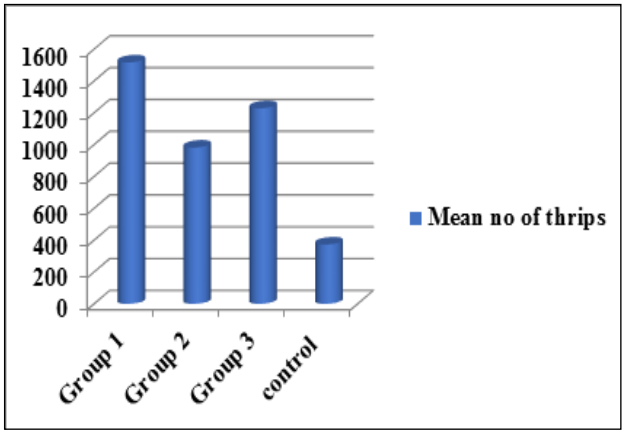


Fig. 59. Mean catches of thrips in different combination of volatiles

Management of melon flies in cucurbit vegetables

Field experiment (covering 5 acres) was conducted to demonstrate the efficacy of combination of cuelure formulation and bisexual attractant developed by NBAIR. The results indicated that the number of flies in the demonstration plots was around 38 per trap while no flies were trapped in the control traps. The fruit damage was 1.36% in the treated plots while the damage was 8.17% in the untreated control.

Studies on gall insects and their management

Leaf galls of Jamun trees were collected, reared and the adults were sent for identification (Fig. 60). The time taken from initiation of gall till the gall cracking was four months. Stem galls were also collected and kept for adult emergence (Fig. 61).

Fig. 60. Leaf galls symptom in Jamun

Fig. 61. Stem galls symptom in Jamun

Effect of non-crop plant, *Ocimum basilicum* on the diversity of bee pollinators in bell pepper

A field experiment was undertaken to study the role of intercropping *Ocimum basilicum* in Bell pepper (*Capsicum annuum)* in the conservation and their role as pollinators (Fig. 62). Seven different species of bees viz., *Apis florea*, *Amegilla confusa*, *Hoplonomia westwoodi*, *Nomia* sp, *Ceratina hieroglyphica* and *C. binghami* were recorded from the plots of *O. basilicum* intercropped with *C. annuum*. In the bell pepper sole crop plots, only two species of bees viz., *Apis cerana* and *C. hieroglyphica* were observed to forage on the flowers of *C. annuum.* The diversity and richness of bee pollinators were significantly higher in intercropped plots compared to sole cropped plots of *C. annuum*.

Fig. 62. Experimental plot of non-crop plants to attract pollinators in Capsicum

Conservation of Solitary leaf cutter bee, *Megachile laticeps*

Leaf cutting bee, *Megachile laticeps* constructed its nest inside the hollow pruned petioles of papaya plant. The nest occupancy and adult emergence rate were 64.70% and 89.07% respectively, with an average of 12.7 ± 2.11 cells per nest. Scopal pollen loads from foraging adult female bees were removed and identified to the lowest taxonomic level possible. Pigeon pea, sunnhemp, and field bean pollen (Fabaceae) made up on an average of 54% of total pollen grains carried in the scopae of adult female bees. Nest pollen analysis indicated that Fabaceae pollen was the most prevalent in the brood provision.

Role of buzz pollinating bee, *Amegilla violacea* in pollination and fruit set of brinjal

Buzz pollinating bee, *A. violacea* was the major flower visitor in brinjal. The presence of bruises on the anther cone were considered as the successful flower visit made by the bee, *A. violacea* apart from visual sighting of the bees visiting the target flowers. Pollinator exclusion studies showed that the percent fruit set, mean fruit weight and number of seeds per fruit was significantly higher in the bee pollinated flowers compared to the self-pollinated flowers.

Studies on diversity of Pollinators

The diversity of pollinators has been studied in *Rosmarinus officinalis* (Rosemary), *Mentha longifolia* (Mint), *Ocimum gratissimum*, *Ocimum basillicum* (Tulasi), *Nepeta cataria* (Catmint), *Leucas aspera* (Thumbai). A total of 35 species of flower visitors belonging to three families viz., Apidae, Halictidae and Megachilidae were recorded on Lamiaceae medicinal and aromatic plants. Overall, the abundance of *Apis* bees was slightly higher (51 %) than that of non-*Apis* bees (49 %).

Black soldier fly (BSF) feeding trials in fish

A feeding trial was conducted to evaluate the potential of black soldier fly (*Hermetia illucens*) meal (BSFM) incorporated feed for Pangas, *Pangasianodon hypophthalmus*. Black soldier fly based pellet meal recorded significantly higher gain in weight, lowest feed efficiency ratio (FCR) and specific growth rate (SGR) compared to commercial fish meal diet.

Ovipositional substrate preference of Black soldier fly

Different structures were evaluated to study the ovipositional preference of black soldier fly and it was observed that gravid adult females prefer natural substrates like unpolished wood stacks followed by corrugated carton stacks, whereas, polished wood stacks, laminate sheet stacks and plastic sheet stacks had no preference and zero oviposition.

Influence of lighting on the oviposition of black solider fly

The influence of light on oviposition of black soldier fly was evaluated by installing 400W incandescent bulbs in the mass rearing structure. The lights were controlled with a timer with day and night cycle of 12h:12h. The introduction of artificial illumination recorded good oviposition by black soldier fly larvae even in non-congenial weather conditions especially during winter seasons (September to January) when night temperature drops below 27°C.

Microflora associated with black solider fly

Four microflora were isolated from black soldier fly larvae and identified (based on molecular tools by sequencing of 16S rDNA) as *Bacillus oleronius*, *B. licheniformis*, *Pseudomonas aeruginosa* and *Serratia marcescens*.

Shelf life studies on black soldier fly compost

Black soldier fly compost evaluation for shelf-life with respect to physicochemical analysis, nutrients like N, P, K, C:N ratio and micronutrient status was recorded on monthly basis from December 2018 to November 2019. The results of twelve months shelf-life studies indicated no significant changes in nutrient composition and compost-maintained shelf life under room temperature. The C:N ratio recorded from compost varied between 17.8- 22.0:1, electrical conductivity of 1.1 to 1.9 dSm^{-1} and pH 6.0 to 7.1 (Table 8). The analysis of mature black soldier fly compost revealed a humic substance content of 11.70% (w/w), moisture 26.05 % (w/w), organic matter 19.43% (w/w), pH of 7.19 and bulk density of 0.57 gmL^{-1}.

Table 8. Shelf life studies of BSF compost at different time intervals

Parameter	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19
pH (1:10)	6.0	6.4	6.5	7.0	6.6	7.1	6.9	7.1	6.9	6.7	6.8	7.1
EC (1:10) dSm^{-1}	1.6	1.5	1.1	2.0	1.6	1.6	1.8	1.6	1.6	1.6	1.9	1.9
Particle size (4-mm sieve size)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Carbon %	36.0	39.7	36.3	38.5	36.5	39.5	38.2	39.5	36.2	35.1	36.5	34.5
Nitrogen %	1.9	1.8	1.8	1.9	1.9	1.9	1.9	1.9	1.8	1.8	1.8	1.9
Phosphorus %	0.9	0.8	1.0	1.2	1.2	1.2	1.1	1.0	1.1	1.0	1.1	1.2
Potassium %	1.3	1.2	1.2	1.2	1.2	1.2	1.1	1.2	1.2	1.1	1.1	1.2
Calcium %	0.9	0.9	1.0	1.0	1.1	1.0	1.1	1.1	1.0	1.1	1.1	1.1
Magnesium %	0.8	0.8	0.8	0.6	0.7	0.7	0.7	0.8	0.7	0.7	0.7	0.8
Sulphur %	0.7	1.6	1.1	1.3	1.6	1.3	1.3	1.4	1.6	1.2	1.4	1.5
Zinc (ppm)	130.5	125.5	110.0	126.0	134.0	124.0	136.0	127.0	126.0	114.0	130.0	137.0
Copper (ppm)	45.0	50.0	55.0	49.0	48.0	51.0	52.0	53.0	54.0	49.0	48.0	51.0
Manganese (ppm)	630.0	580.0	370.1	690.0	596.0	623.0	658.0	584.0	674.0	680.0	586.0	691.0
Iron (ppm)	145.0	165.0	500.0	513.0	180.0	160.5	421.0	416.0	265.0	315.0	518.0	345.0
C:N Ratio	18.8:1	22.0:1	20.2:1	20.1:1	19.3:1	20.4:1	20.5:1	20.3:1	19.6:1	19.7:1	19.8:1	17.8:1

All-India Coordinated Research Project on Biological Control of Crop Pests

Biodiversity of biocontrol agents from various agro ecological zones

A total of 876 trichogrammatids were collected from the states viz., Karnataka, Maharashtra, Tamil Nadu, Gujarat and Meghalaya. Eight genera of trichogrammatids, *Chaetostricha, Lathromeroidea, Megaphragma, Oligosita, Paracentrobia, Trichogramma, Trichogrammatoidea* and *Tumidiclava* were collected. The genera *Megaphragma* Timberlake was collected for the first time from Maharashtra. Parasitism of *Trichogramma chilonis* was recorded on *Spodoptera frugiperda* for the first time on eggs of fall armyworm infesting maize. *Trichogramma achaeae*, *T. chilonis* and *Trichogrammatoidea bactrae* were recorded on the eggs of *T. absoluta* infesting tomato in Karnataka. More than 530 spider specimens were collected from 7 states (15 locations) in different agroecosystems. One hundred and fifty-two species identified up to the genus level and 53 upto species level. Eighty-one spider species from families (Salticidae, Thomisidae, Tetragnathidae, Araneidae and Gnaphosidae) were newly added into the collection. *Peucetia yogeshi* (Oxyopidae: Araneae) the green lynx spider was redescribed. It has new distribution record to Karnataka (Gangavathi).

Surveillance for alien invasive pests/pest outbreaks

CPCRI: The population of rugose spiralling whitefly (RSW) *(Aleurodicus rugioperculatus)* was found to be very low (1.5 colonies /leaflet) during July-December 2019 and thereafter shot up as high as 4.5 colonies by February 2020. The population of Bondar's nesting whitefly (BNW) *(Paraleyrodes bondari)* was found to be higher, recording as high as 4.0 colonies per leaflet in the month of September 2019, which reduced subsequently reaching as low as 0.5 colonies during March 2020. The non-native nesting whitefly *(Paraleyrodes minei)* that co-existed with BNW and RSW during 2018 was not observed and was completely displaced by the other exotic whitefly species. Percentage parasitism by *Encarsia guadeloupae* on RSW colonies decreased from 48% in July 2019 to 22% in February 2020 which encouraged the build up of RSW colonies in 2020 favoured by weather factors.

KAU-T: Incidence of rugose whitefly on coconut was widespread in Thrissur and Palghat districts during 2019-20. The buildup of pest started in November, possibly due to the delayed withdrawal of the South West monsoon. The whitefly infestation broadly followed the pattern observed in 2018-19 though the severity of infestation was high well into March, unlike in previous years when it had declined by January. Mean parasitism by *Encarsia guadeloupae* remained throughout the study period, ranging from 28.64 to 80.18 per cent at Palakkad and from 35.72 to 62.10 per cent at Thrissur and never reached 90 per cent at either of the locations.

RARS Kumarakom: In Kumarakom, rugose spiralling whitefly infestation was noticed to be in a medium range from April to June 2019, followed by a slight decline in July with an average of 9.60 live colonies per leaflet. Thereafter, gradual increase was noticed in the colony count with a maximum of 24.85 colonies per leaflet recorded in February. Highest per cent intensity was noticed in March (80.32%) and the least in August (29.41%) which might be due to the heavy rain and flood, which occurred then. Per cent infestation was observed to follow an increasing trend from September 2019 onwards.

Surveillance for pest outbreak and alien invasive pests including Fall armyworm

TNAU: In guava, woolly whitefly *(Aleurothrixus floccosus)* (Maskell) was observed during October 2019 at Coimbatore. Predators viz., *Cryptolaemus montrouzieri* and *Mallada desjardinsi* were found feeding on the woolly whitefly. Bondar's Nesting Whitefly *Paraleyrodes bondari* was observed in coconut gardens in Coimbatore, Erode and Tirupur Districts since October 2019. *Mallada boniensis* was found feeding on Bondar's Nesting Whitefly. Fall armyworm damage was observed in the surveyed areas.

UAS-R: Roving survey conducted in six districts of North Eastern Karnataka indicated that FAW incidence was negligible in rabi Jowar (M35-1). In maize, the number of egg patches per plant and number of larvae were highest compared to rabi jowar. In Koppal district the natural epizootics of *Metarhizium rileyi* was noticed.

MPKV: Amongst the targeted invasive pests, the mealybug species, *Pseudococcus jackbeardsleyi* and *Paracoccus marginatus* were recorded on custard apple and papaya respectively, in Pune, Nadurbar, Dhule and Jalgaon districts. *Tuta absoluta* was not observed on tomato crop in Western Maharashtra. The Fall Army Worm (FAW) was recorded in all

maize growing areas of Maharashtra. The pest extended its host range on sorghum and bajra crops in Pune, Solapur, Satara and Sangli districts. FAW was reported for the first time on Cotton crop at Susare Village of Pathardi Tahasil in Ahmednagar district.

MPUAT: Incidence of fall armyworm was noticed to be moderate to severe in Udaipur, Chittorgarh, Banswara and Dungarpur districts of Southern Rajasthan with an average incidence range of 30-40 per cent. The swarm of Locust was first spotted in month of December, 2019 in Udaipur region, mainly Kotra block. It has damaged several hectares of mustard and wheat crops and plants in the large forest area. It has so far stationed at Dedhmariya, Phulwariya, Maldar, Mahudi and Khajuria villages. Earlier, locust swarms were spotted in Jaisalmer, Barmer, Jodhpur, Jalore, Sirohi, Pali, Bikaner and Ganganagar districts of Rajasthan. Among these districts, in Jalore, Barmer, Jaisalmer district, this pest caused significant damage to cumin, castor and isabgol crops.

YSPUH&F: Different vegetable and fruit ecosystems in district Solan, Sirmour, Mandi, Kullu, Bilaspur, Shimla, Kangra, Kinnaur and Lahaul & Spiti were surveyed for the collection of pests like, *Aleyrodicus* digessi, *Phenacoccus manihoti, Paracoccus marginatus, Phenacoccus madeirensis* and *Tuta absoluta* but only *T. absoluta* was recorded.

PJTSAU: Fall armyworm (FAW) incidence was noticed from low to moderate during Kharif 2019-20, in many maize growing districts of Telangana viz., Karimnnagar, Siddipet, Sangareddy & Mahbubnagar. It was found to be medium to high in Nagarkurnool and Khammam districts as compared to other districts of the state.

IIMR: Surveys for incidence of *Spodoptera frugiperda* showed 3 – 10 % foliar damage on Sorghum. During Rabi season 15 – 40 % foliar damage was observed at Hyderabad, Warangal.

Biological suppression of sugarcane pests

Application of ICAR- NBAIR *Heterorhabditis indica* WP formulation recorded the lowest plant damage by white grub (8.50 %) and it was at par with *Metarhizium anisopliae* (ICAR-NBAIR Ma 4) and Chlorantraniliprole 18.5 SC which recorded 9.25 and 6.50 per cent plant damage. Highest plant damage of 61.25 per cent was noticed in untreated control. *H. indica* WP (ICAR- NBAIR) recorded 121.85t/ha cane yield which was at par with *M. anisopliae* (ICAR-NBAIR Ma 4) and Chlorantraniliprole 18.5 SC which recorded 118.50 and 123.50t/ha, respectively. Untreated control recorded 95.25 t/ha cane yield (UAS-R).

Highest white grub reduction (75.85 %) was recorded in chemical treatment with Fipronil. Amongst EPN strains, highest white grub reduction (72.78 %) was recorded in *H. indica* @ 3.0 x10^5 / m^2 (NBAIR WP formulation). Amongst EPN, *H. indica* @ 1.0x10^5 / m^2 (NBAIR WP formulation) treatment recorded 54.72 % and become next promising treatment after chemical treatment (Fipronil) for suppressing white grub in sugarcane (ANGRAU).

Biological suppression of cotton pests

Pink boll worm damage was 22.50 per cent in BIPM plots which was 28.57 per cent lesser than the damage in the control plot. There was 36.13 per cent reduction in pink boll worm damage in the insecticide sprayed plots. The yield was maximum in insecticide sprayed plots (1654 Kg/ha) followed by 1562 Kg/ha and 1344 Kg/ha in BIPM and control plots, respectively. The CB ratios were 1:2.41 and 1:2.57 for BIPM and insecticide treatments, respectively (TNAU).

The biointensive pest management module with pheromone traps (Funnel type) @ 10/ plot + releases of *Trichogrammatoidea bactrae* 100,000/ha/release, 6-8 releases starting from 55 days after germination + application of 5% Neem Seed Kernel Extract (NSKE) fared better in terms of reduced percent green boll damage (19.20) and percent locule damage (6.12) in comparison to insecticide treatment (24.67 % green boll and 7.13 percent locule damage) (PJTSAU).

Biological suppression of rice pests

Percent reduction in leaf folder damage over untreated control was high in Flubendiamide (81.52 %) followed by *Bacillus thuringiensis* (73.62%), *Heterorhabditis indica* (65.72%) and *Steinernema carpocapsae* (63.19 %). Percent reduction in stem borer damage over untreated control was high in flubendiamide (78.28%) and *Bacillus thuringiensis* (56.49 %) (ANGRAU). The population of plant hoppers in BIPM and control plots was 1.93 and 3.00 per hill, respectively resulting in a reduction of 35.8 per cent over control. The population of spiders was comparatively higher in BIPM plot. Basmati yield was 32.00 q/ha in BIPM as compared to 30.50 q/ha in untreated control with an increase of 4.92 per cent (PAU). *Lecanicillium saksenae* @ 10^7 spores

ml-1, was the best treatment to manage *Leptocorisa acuta* population, when sprayed twice at the panicle initiation and milky stage of the crop (COA-Vellyani).

Biological suppression of cereal pests

Release of *Trichogramma pretiosum* recorded lowest damage by fall armyworm (23.82 – 35.1 %) with egg parasitisation (5.84 - 9.01 parasitised eggs/20 plants) upto 20 days after sowing. Total damaged plants per plot recorded high in untreated control (169.33) followed by pheromones @ 15 traps/acre (155.33). Total number of dead larvae per plot was high in insecticidal check (50.38) followed by *T. pretiosum* release+ *M. anisopliae* sprays (42.9) and *T. pretiosum* release + NBAIR Bt (41.9) (ANGRAU).

Biological suppression of pests of pulses

In pigeon pea, NBAII-BTG4 formulation recorded minimum damage of 13.13% followed by insecticidal spray recording 14.13 % pod damage and both the treatments were significantly superior to untreated control (24.25 % damage). Maximum yield (16.59 q/ha) was observed in NBAII-BTG4 treatment. followed by insecticidal spray (15.74 q/ha) and both treatments were at par with each other and significantly superior over untreated control (PDKV).

The per cent pod damage in NBAIR BT G4 was 10.16 per cent while in farmers practice it was 7.38 per cent. In NBAIR BT G4 the grain yield was 10.68q/ha in farmers practice 13.04 q/ha (UAS-R).

Biological suppression of pests of tropical fruit crops

Among the bio pesticides, low incidence of hoppers was recorded in treatment with NBAIR strain *Beauveria bassiana* which recorded 6.23 hoppers/panicle at 7 days after spraying. Efficacy of *B. bassiana* (CISH formulation) and *M. anisopliae* (NBAIR formulation) was in parity with each other (CISH). *Metarhizium anisopliae* and *Beauveri bassiana* recorded a low hopper population of 0.25 and 0.75 hoppers / tree after second spray (DRYSRHU). Significantly highest percent reduction in population of mealy bugs and scales were recorded in *B. bassiana* (NBAIR isolates) spray (45.88 and 44.56% reduction in mealy bug and scale population, respectively) which was at par with that of azadirachtin spray (44.86 and 41.83% reduction in mealy bug and scale population, respectively) at 7 DAS in guava (SKUAST-Jammu).

Biological suppression of pests of temperate fruit crops

Metarhizium anisopliae (10^8 conidia/g) treatment @ 30g/ tree basin mixed in well rotten farm yard manure (FYM) during July-August - applied at the time of egg hatching and emergence of new/young grubs of apple root borer resulted in 62.1 to 73.4 per cent mortality in different orchards, while in chlorpyriphos (0.06%) treated plants the grub mortality was 77.3 to 84.5% (YSPUHF).

Biological suppression of pests in plantation crops

Palms treated with neem oil (5%) and water spray could reduce the population of rugose spiralling whitefly significantly followed by *Isaria fumosorosea* treated palms (56.7%). Under natural suppression about 36.3% reduction could be obtained in a period of two months (CPCRI).

Per cent reduction in whitefly intensity was observed to be high (71.01 % & 75.51%) after two sprays of *Isaria fumosorosea* (NBAIR- Pfu 5) than one spray (36.74% & 58.22 %) (ANGRAU).

Lowest number of egg spirals were recorded in neem oil and *I. fumosorosea* treated palms (8.63 and 9.65 egg spirals/leaflet) 15 days after second spray. A high number of egg spirals were observed in natural conservation of *E. guadeloupae* and water spray treatment. However, the nymphal and adult population was observed to be low in Neem oil treatment as compared to other treatments. The numbers of parasitized nymphs (live & blackened) & nymphs with parasitoid emergence holes/leaflet and aborted nymph/pupae were found to be very low in all treatments including natural conservation of *E. guadeloupae* treatment without any significant difference (DRYSRHU).

In a field trial, on 60th day after 2nd spraying, RSW nymphal population was drastically reduced in *Encarsia guadeloupae* (natural conservation) (20.0 numbers per leaflet) when compared with foliar application of *Isaria fumosorosea* (pfu-5) @ $1x10^8$ cfu/ml (36.0 numbers per leaflet), foliar water spray (39.0 numbers per leaflet.) and foliar application of neem oil 0.5% (44.0 numbers per leaflet). Parasitised nymphs in *E. guadeloupae* (natural conservation)

and foliar application of neem oil were same (14.00 numbers per leaflet) and higher than in *I. fumosorosea* (10.0 numbers per leaflet) and foliar water spray (13.0 numbers per leaflet) (TNAU).

After 60 days of treatment, percentage reduction in number of RSW spirals was maximum in water spray (37.01%) followed by natural conservation (27.18%). Palms treated with *Isaria fumosorosea* (pfu-5) recorded 27.18 % reduction in live spirals. Neem oil 0.5 % was least effective with 20% reduction in the live spirals. *Isaria fumosorosea* (pfu-5) treatment was effective in reducing the number of pupae (42.18%) followed by neem oil (0.5%) (34.21 %). However, parasitisation was found to be greatly reduced when treated with *I. fumosorosea* treatment (68.8 %). Water spray and neem oil 0.5% did not affect the parasitisation efficacy of *Encarsia* (COA-V).

Biological suppression of pests in vegetables

Tomato: The pooled per cent fruit damage in BIPM (13.24%) was significantly lower than untreated control (17.93%). However, chemical control recorded minimum per cent fruit damage (10.86%). The per cent reduction in fruit damage over control was 49.47 and 26.15 per cent in chemical control and BIPM plot, respectively. The fruit yield in BIPM (27.16 q/ha) was at par with chemical control (30.94 q/ha) (PAU). In BIPM treatment, percent fruit damage on number basis (15.75%) and on weight basis (14.05 %) was at par with chemical treatment (20.58 %) and (17.15 %), respectively. Regarding sucking pest population, the BIPM treatment recorded minimum number of thrips (3.42 thrips/plant) and whiteflies (2.04 flies/plant) (MPKV). Nine releases of *T. achaeae* were made to control the *Tuta absoluta* infesting tomato field in Karnataka. The field parasitism of *T. achaeae* ranged from 17.97 to 47.5% and reduced the population of larvae, pupae and number of leaf mines of *T. absoluta*.

Brinjal: The fruit damage in brinjal due to *Leucinodes orbonalis* was significantly low (17.82%) in plots sprayed with pesticides followed by 21.80 per cent fruit damage in BIPM plots (Azadirachtin 1500 ppm @2ml/lit (one spray) + *Lecanicillium lecanii* (one spray) + *Trichogramma pretiosum* (8 releases) + Pheromone traps @20/ha + Cowpea as bund crop). In the control plot fruit damage was 32.55 per cent (TNAU). BIPM module (Spray of Azadirachtin 1500 ppm @ 2ml/lt, spray of *Lecanicillium lecanii* (NBAIR strain) 1x 10^8 spores/ml @ 5g/lt, Ten releases of *Trichogramma chilonis* multiple insecticide tolerant strain @100,000/ha, at weekly interval from initiation of flowering, Use of pheromone traps @ 20 nos/ha, Mechanical collection and destruction of infested shoot and fruits) was the next best treatment with 10.94 % shoot and 12.11% fruit infestation (AAU-J).

Okra: Application of *Bacillus thuringiensis* (1% WP - $2x10^8$ cfu/g) (NBAIR strain) @ 50g/10 liter water thrice at fortnightly interval or six releases of *Trichogramma chilonis* @ 50000/ha at weekly interval were effective for the management of fruit borer on okra (AAU-A).

Cabbage: Among the NBAIR biopesticide isolates tested, *Metarhizium anisopliae* (Ma-4 strain) was most promising with 57.13 per cent reduction over control against diamond back moth (*Plutella xylostella*) followed by *Lecanicillium lecanii* (Vl-8 strain). In case of aphid (*Myzus persicae*), maximum reduction (36.99%) was recorded with *Lecanicillium lecanii* (Vl-8 strain) which is statistically superior over the other biopesticides followed by *Beauveria bassiana* (Bb-45 strain) with 24.43 percent reduction (IIVR).

Biological suppression of pests of oilseed crops

Application of *Lecanicillium lecanii* (NBAIR strain) @ 5g/litre and *Beauveria bassiana* (AAU-J culture) was successfull in reducing the mustard aphid population (10.0 and 11.19 /10 cm twig) with a yield of 7.35 q/ha and 7.10 q/ha, respectively (AAU-J).

Biological suppression of pests of polyhouse pests

Two releases of *Blaptostethus pallescens* @ 400 /plant resulted in 34.11 and 68.51 per cent reduction in population of European red mite and two spotted spider mite, respectively over control in apple at Srinagar.

Beauveria bassiana (NBAIR Bb5a) @ 5g/L followed by *Lecanicilium lecanii* (NBAIR Vl8) @ 5g/L were effective against aphids on capsicum under polyhouse conditions (IIHR). Among biocontrol agents, *Chrysoperla zastrowi sillemi* (4 larvae / plant) resulted in the highest (80.6%) reduction in the aphid population which was on par with imidacloprid (0.5ml/L) (90.3%) at 10 days of second spray. *Lecanicillium lecanii* (5g/l of 10^8 conidia/ g) (73%) and azadirachtin (2ml/L of 1500ppm) (68%) were

also on par with *Chrysoperla zastrowi sillemi* (4 larvae / plant), but could not match with imidacloprid (0.5ml/L) treatment in their efficacy against the pest (YSPUHF).

Biological suppression of plant diseases

In citrus, the microbial antagonists against foot rot of citrus showed highest per cent recovery in final lesion size in chemical control (45.5%) over untreated control followed by NBAII- Pf DWD *Pseudomonas fluorescens* and *Trichoderma harzianum* with 24.59 and 21.94 percent recovery, respectively (PAU).

In chickpea, minimum number of mature plant wilt at 120 DAS was observed with consortium Th17+Psf173 (3.24), while maximum in control (6.10) after 120 days of sowing (GBPUAT).

Tribal Sub-Plan programme (TSP)

AAU-A: The beneficiaries were one hundred tribal farmers from Dediyapada, Sagbara and Tilakwada tehsils of Narmada district covering ~1acre area/farmer. Biopesticides and pheromone traps were distributed among farmers. Field visits were conducted to record the use of bio-inputs by the farmers and bio-efficacy of inputs. Significant reduction (35-40%) in use of chemical pesticides was recorded.

AAU-J: Two hundred tribal farmers were selected from Baksa district dominated by tribal community. Four villages (Amarabati, Barama, Tamulpur and Baganpara) were selected under the programme. Biopesticides and neem pesticides were supplied to the farmers.

ANGRAU: Front line Demonstrations and trainings were conducted on organic farming of paddy, ginger, turmeric and vegetables at eleven villages in 165 acres benefitting 280 tribal farmers of Araku valley and Chinthapalli divisions in Visakhapatnam district at Andhra Pradesh. TSP farmers benefited with organic farming technology in obtaining good yields in rice, ginger and turmeric and expressed willingness to adopt organic farming for achieving higher yields.

YSPUHF: Two hundred farmers of Powari, Kangosh, Rangrik and Hurling villages of districts Kinnaur and Lauhal and Spiti of Himachal Pradesh covering 35 ha area of apple, almond, apricot, cabbage and pea were benefited from the trainings/demonstrations. These farmers were exposed to the use of bio-pesticides for pest management for the first time. In pea, cauliflower and cabbage there was a reduction of 2 sprays of chemical pesticides. In case of apple, farmers saved about Rs 15000/- per hectare by avoiding chemical treatment for the control of apple root borer.

IGKV: One hundred and fifty farmers were selected and three trainings were organised. Application method of Trichocards was demonstrated on a model plant. Low cost candle based light traps were also displayed.

UBKV: One hundred and ninety-five farmers were trained and inputs were supplied to them for management of insect pests of vegetables, rice, and pulses.

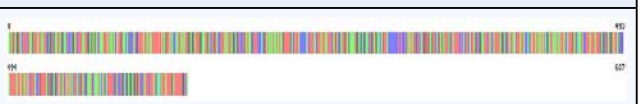
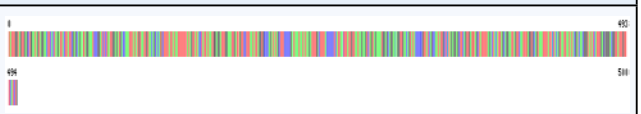
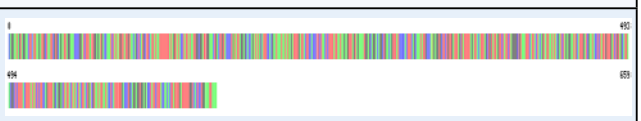
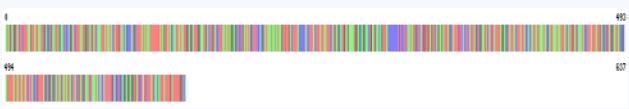
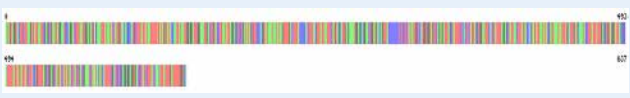
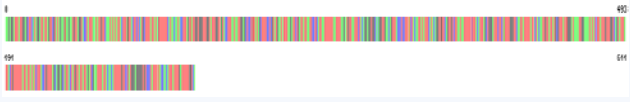
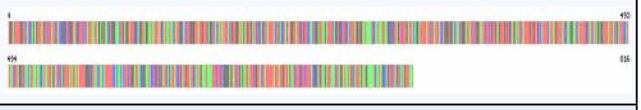
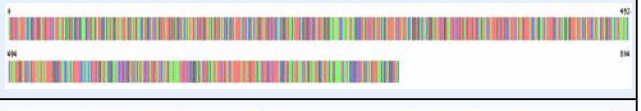
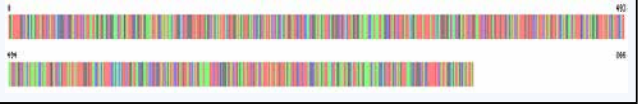
SKUAST: The agricultural inputs were supplied to seventy-seven farmers, in a total of forty villages of subdivision Kargil and Leh. Interactions with farmer groups were conducted to provide know-hows in each village on the use of distributed inputs. Beneficiaries from different villages of Kargil reported 20- 90.0 per cent increase in marketable yield.

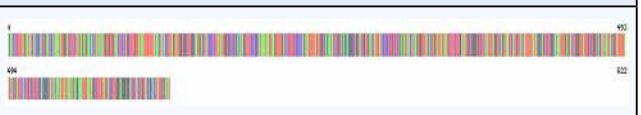
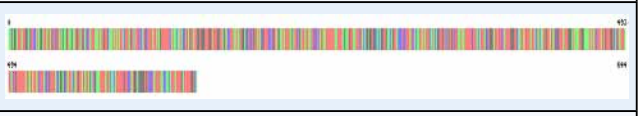
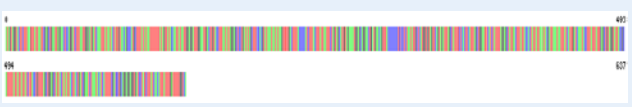
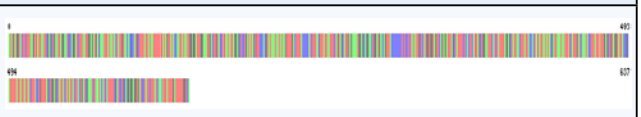
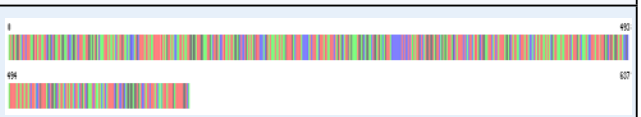
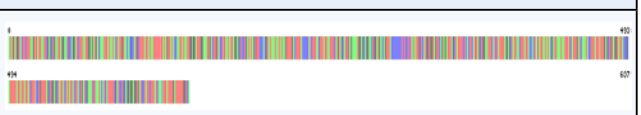
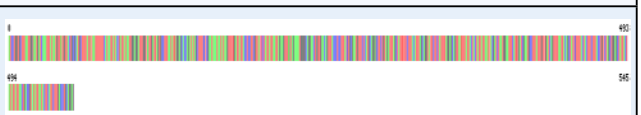
4. GENBANK / BOLD ACCESSIONS

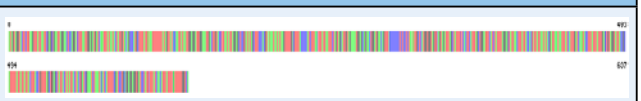
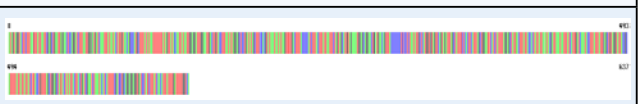
S. No.	ORGANISM	ACCESSION NUMBER
	BLATTODEA	
1.	*Hypotermes makhamensis*	KX444138
2.	*Hypotermes makhamensis*	KY614388
3.	*Odontotermes escherichi*	KY495155
4.	*Odontotermes feae*	KY676779
5.	*Odontotermes formosanus*	KY552744
6.	*Odontotermes longignathus*	KY563711
7.	*Odontotermes longignathus*	KY593992
8.	*Odontotermes mathuri*	KY676778
9.	*Trinervitermes togoensis*	KY569522
	COLEOPTERA	
10.	*Anomala bengalensis*	KY640304
11.	*Anomala ruficapilla*	KU517668
12.	*Calcinemis obese*	KU517665
13.	*Onthophagus nuchicornis*	KU517667
14.	*Protaetia alboguttata*	KM657486
	HEMIPTERA	
15.	*Aleurocanthus* sp.	MK482338
16.	*Aleuroclava* sp.	MK568466
17.	*Aleurodicus dispersus*	MK472717
18.	*Aleurodicus rugioperculatus*	MK569693
19.	*Aleurodicus rugioperculatus*	MK569692
20.	*Aleurodicus rugioperculatus*	MK482685
21.	*Aleurothrixsus floccosus*	MN027508
22.	*Bemisia tabaci*	MK568468
23.	*Bemisia tabaci*	MK568467
24.	*Bemisia tabaci*	MK497172
25.	*Bemisia tabaci*	MK482340
26.	*Bemisia tabaci*	MK185020
27.	*Bemisia tabaci*	MK185019
28.	*Bemisia tabaci*	MK123948
29.	*Bemisia tabaci*	MK165656
30.	*Bemisia tabaci*	MH891617
31.	*Bemisia tabaci*	MH823740
32.	*Formicococcus mangiferacola*	KX164289
33.	*Maconellicoccus hirsutus*	KU296035
34.	*Nipaecoccus viridis*	KU296041
35.	*Paracoccus marginatus*	KU296038
36.	*Pealius nagerkoilensis*	MK569691

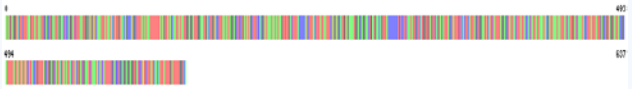
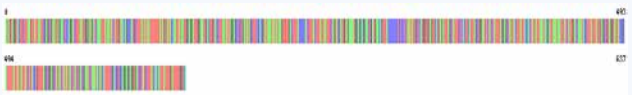
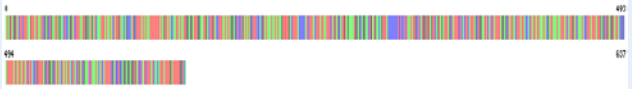
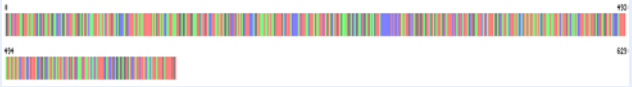
S. No.	ORGANISM	ACCESSION NUMBER
37.	*Phenacoccus solani*	KU296033
38.	*Phenacoccus solenopsis*	KU296037
39.	*Planococcus citri*	KU296034
40.	*Planococcus lilacinus*	KU296040
41.	*Pseudococcus longispinus*	KU296036
42.	*Rastrococcus iceryoides*	KX164290
43.	*Rastrococcus invadens*	KU296042
44.	*Rastrococcus mangiferae*	KU296039
45.	Wolbachia endosymbiont of *Aleurocanthus* sp.	MK482127
	HYMENOPTERA	
46.	*Ammophila clavus*	MK898952
47.	*Ammophila clavus*	MK898951
48.	*Ampulex compressa*	MK898945
49.	*Bombus* sp.1	MN856203
50.	*Bombus* sp.2	MN856204
51.	*Chalybion bengalense*	MK898946
52.	*Diarrhegma modestum*	MK559395
53.	*Halyomorpha picus*	MK559394
54.	*Liris* sp.1	MK898947
55.	*Liris* sp.2	MK898948
56.	*Liris subfasciatus*	MK898949
57.	*Megachile* sp.	MN856202
58.	*Plautia crossota*	MK559393
59.	*Sceliphron coromandelicum*	MK922295
60.	*Sceliphron madraspatanum*	MK934129
61.	*Sphex argentatus*	MK940485
62.	*Tachysphex* sp. PS-2019	MK898950
63.	*Trypoxylon* sp.	MK947367
	ENTOMOPATHOGENIC FUNGI	
64.	*Isaria fumosorosea* NBAIR Pfu-5	KC147664
65.	*Metarhizium anisopliae* strain NBAIR-MaCB	MN727141.1
66.	*Beauveria bassiana* strain NBAIR-BbEP	MN733077.1
67.	*Lecanicillium fusisporum* NBAIR Vl-41	MN876835
68.	*Metarhizium rileyi* NBAIR (Nr Sf5)	MN602591
69.	*Beauveria bassiana* strain NBAIR-BbTV	MN727364.1
70.	*Metarhizium anisopliae* NBAIR Ma-35	JQ518481
71.	*Beauveria felina* NBAIR Bf-1	MN833071
72.	*Trichoderma asperellum* strain NBAIR-TATP	MN727373.1
73.	*Beauveria bassiana* NBAIR Bb-45	JF837094

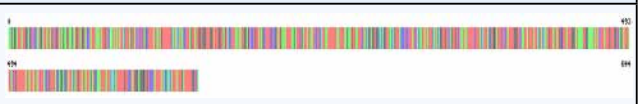
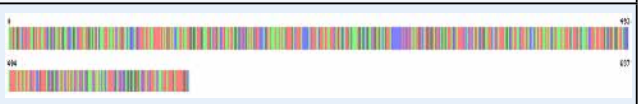
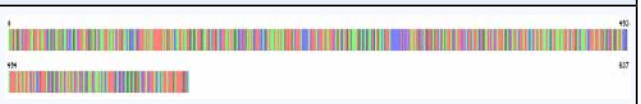
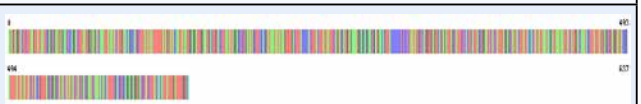
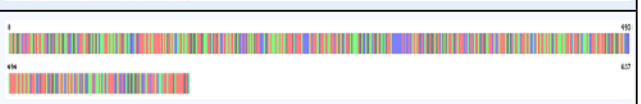
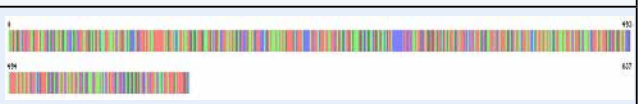
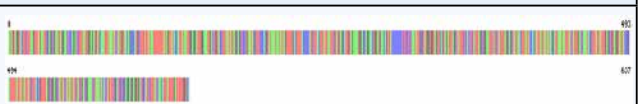
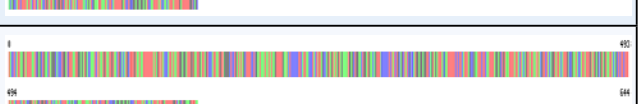
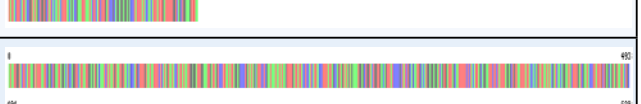
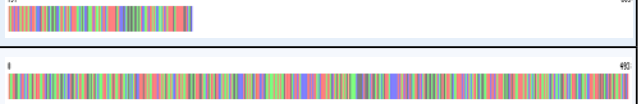
DNA barcodes

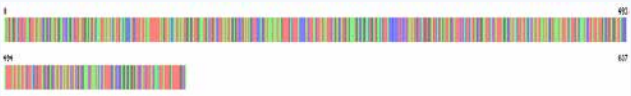
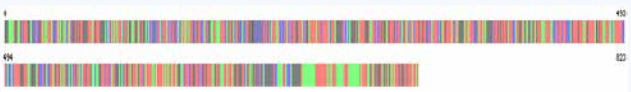
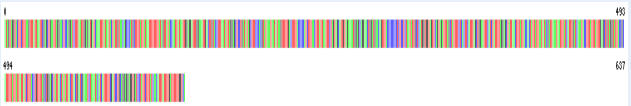
S. No.	Species	GenBank Accession number	Barcode
1.	*Aleurodicus dispersus*	MK491179	
2.	*Aleurodicus dispersus* strain (Jorhat)	MH899612	
3.	*Anomala communis*	MN656972	
4.	*Anomala communis*	MN877382	
5.	*Anomala elata*	MN966660	
6.	*Anomala ruficapilla*	MN624131	
7.	*Apis mellifera* (Tamil Nadu)	MN563104	
8.	*Apis mellifera* strain AM2-(Mart-TN)	MN563103	
9.	*Apis mellifera* strain AM3-(Mart-TN)	MN563102	
10.	*Bemisia tabaci*	MH807440	
11.	*Bemisia tabaci* (Nadupalli)	MN840828	
12.	*Bemisia tabaci* (Kolar)	MN864047	
13.	*Bemisia tabaci* (Kadur)	MN864048	
14.	*Bemisia tabaci* (Agartala)	MN787203	

S. No.	Species	GenBank Accession number	Barcode
15.	*Bemisia tabaci* (Agartala)	MN787204	
16.	*Bemisia tabaci* (Gujarat)	MK497172	
17.	*Bemisia tabaci* isolate WF_52	MH823740	
18.	*Bemisia tabaci* isolate WF_54	MH891617	
19.	*Brahmina mysorensis*	MN704860	
20.	*Ceratopogonidae* sp.	MK948082	
21.	*Chauliops fallax* (Kashmir)	MN584895	
22.	*Chelonus* sp.	MN584896	
23.	*Chelonus* strain TRI188	MN913334	
24.	*Chilo partellus* (Vijayawada)	MH916766	
25.	*Culicoides oxystoma*	MK801125	
26.	*Culicoides peregrinus*	MK756032	
27.	*Dacus ciliatus*	MH74866	
28.	*Diadegma fenestrale*	MN317033	

S. No.	Species	GenBank Accession number	Barcode
29.	*Distatrix papilionis*	MN264673	
30.	*Eocanthecona furcellata*	MH795079	
31.	*Euplectrus* sp.	MN317032	
32.	*Haemaphysalis* sp.	MH937512	
33.	*Holotrichia fissa*	MN850439	
34.	*Holotrichia rufoflava*	MN704859	
35.	*Hyalomma excavatum*	MK005261	
36.	*Hyalomma* sp.	MH923577	
37.	*Ichneumonidae* sp.	MN913336	
38.	*Mythimna separata* (West Bengal)	MH252215	
39.	*Mythimna separata* strain (Pundibari)	MN126575	
40.	*Platensina acrostacta*	MH748566	
41.	*Podagrion* sp.	MN317031	
42.	*Rhipicephalus microplus*	MH918000	
43.	*Scirpophaga fusciflua* (Cuttack)	MN496150	

S. No.	Species	GenBank Accession number	Barcode
44.	*Scirpophaga fusciflua* (Kerala)	MN519201	
45.	*Scirpophaga fusciflua* (Trivendrum)	MN514177	
46.	*Scirpophaga fusciflua* (West Bengal)	MN583331	
47.	*Spathulina acroleuca*	MH748567	
48.	*Spilarctia obliqua*	MK491177	
49.	*Spodoptera frugiperda* (Maharashtra)	MN584897	
50.	*Spodoptera frugiperda* (Pedabathevalasa)	MH822833	
51.	*Spodoptera frugiperda* (Andhra Pradesh)	MN126574	
52.	*Spodoptera frugiperda* (Anakapalle)	MH822831	
53.	*Spodoptera frugiperda* (Chinthapalle)	MH822832	
54.	*Spodoptera frugiperda* (Nelivada)	MH822834	
55.	*Spodoptera frugiperda* (West Bengal)	MN218588	
56.	*Spodoptera frugiperda* (West Bengal)	MN218589	
57.	*Spodoptera frugiperda* (West Bengal)	MN233305	
58.	*Spodoptera frugiperda* isolate tapi-1	MK279399	

S. No.	Species	GenBank Accession number	Barcode
59.	*Spodoptera frugiperda* (Nepal)	MN584898	
60.	*Spodoptera frugiperda* strain (Malada)	MN117908	
61.	*Spodoptera frugiperda* strain (Nagarkurnool)	MH881528	
62.	*Spodoptera frugiperda* strain (Nepal-Khumaltar)	MN584899	
63.	*Spodoptera frugiperda* strain (Nepal-Nawalpur)	MN584900	
64.	*Spodoptera frugiperda* strain (Pune)	MH899609	
65.	*Spodoptera frugiperda* strain (Tirupati)	MN264674	
66.	*Spodoptera frugiperda* strain2 (Pune)	MK285364	
67.	*Tabanus biannularis* (Maan)	MN969969	
68.	*Tabanus gertrudae* (Kapoli)	MN969971	
69.	*Tabanus indianus* (Kankumbi)	MN909749	
70.	*Tabanus triceps* (Chikale)	MN969970	
71.	*Telenomus remus*	MN879314	
72.	*Telenomus remus*	MN814077	
73.	*Telenomus remus* TEL_R6	MN913332	

S. No.	Species	GenBank Accession number	Barcode
74.	*Telenomus remus* TEL_R3	MN879315	
75.	*Telenomus remus* TEL_R5	MN879316	
76.	*Trialeurodes vaporariorum* (Kaanehosahalli)	MN840829	
77.	*Trichogramma chilonis*	MN879313	
78.	*Trichogramma chilonis* TRI184	MN913333	
79.	*Trichogramma chilonis* (Anakapalle)	MN116707	
80.	*Trichogramma chilonis* strain TRI187	MN913335	

5. IDENTIFICATION SERVICES

Dr Sunil Joshi

S. No.	Taxon/taxa identified	Group/Family	Service provided to
1.	*Aphis craccivora*, *A. gossypii, A. nerii, Ceratovacuna lanigera*, *Ceratovacuna* sp., *Pentalonia nigronervosa*, *Pseudoregma* sp.	Aphididae	College of Horticulture, Bagalkot
	Coccus hesperidum, *C. longulus*, *C. viridis*, *Pulvinaria polygonata*, *P. psidii*	Coccidae	
	Paracoccus marginatus, *P. parvus*	Pseudococcidae	
2.	*Aphis craccivora*, *A. gossypii*, *A.nerii*, *A. fabae, Patchiella reaumuri*, *Pentalonia caladii, Phloemyzus passerinii* (2)	Aphididae	ICAR Research Complex for North Eastern Region, Meghalaya
	Pseudopulvinaria sikkimensis (2)	Coccidae	
	Coccus hesperidum, *C. longulus*, *Paracoccus marginatus*, *Phenacoccus madeirensis, Pseudococcus longispinus*, *Pulvinaria polygonata*	Pseudococcidae	
	Icerya aegyptica, *I. seychelarum*¸ *Icerya sp.*	Monophlebidae	
3.	*Aphis craccivora* (2), *A. gossypii* (2), *A. nerii* (2)	Aphididae	Institute of Wood Science and Technology, Bengaluru
	Insignorthezia insignis, *Pulvinaria psidii*	Coccidae	
	Maconellicoccus hirsutus, *Nipaecoccus viridis*, *Phenococcus parvus*, *Paracoccus marginatus* (2), *Phenacoccus divaricatus* (2), *Phenacoccus parvus*, *Phenacoccus* sp. (2), *Pseudococcus longispinus* (2)	Pseudococcidae	
4.	*Formicococcus formicariae, Formicococcus* sp., *Paracoccus marginatus, Phenacoccus divaricatus*, *P. parvus*, *P. solenopsis* (2), *Pseudococcus cryptus, Pseudococcus longispinus, Pseudococcus* sp. *Formicococcus mangiferae*	Pseudococcidae	College of Agriculture, Vijayapur, University of Agricultural Sciences, Dharwad
	Icerya sp. (2)	Monophlebidae	
5.	*Crissicoccus hirsutus, Dysmicoccus brevipes*, *D. neobrevipes*, *Dysmicoccus* sp. (2 species), *Ferrisia virgata*, *F. malvestra Pseudococcus longispinus*, *Pseudococcus* sp. *Planococcus citri*, *P. lilacinus*, *P. bendovi*	Pseudococcidae	Regional Coconut Research Station, Ratnagiri
6.	*Phenacoccus solenopsis* (2)	Pseudococcidae	Uttar Bangal Krishi Viswavidyalaya, Cooch Behar
	Aphis craccivora (2), *A. gossypii* (2), *A. nerii* (2), *Aiceona* sp. (2), *Brevicoryne brassicae*, *Cervaphis rappardi indica*, *Hayhurstia artiplicis* (2), *M. sanborni*, *Macrosiphoniella kalimpongensis* (2), *Microparsus desmodiorum* (2), *Myzus persicae*, *Pseudomegoura ?nipponica* (2), *Sitobion aevnae*, *Sitobion* sp., *Toxoptera aurantia* (2), *T. odinae*	Aphididae	
7.	*Aphis craccivora*, *A. gossypii*, *A. nerii*, *Aphis* (*Toxoptera*) *citricidus*, *Aphis* (*Toxoptera*) *odinae*, *Aphis* sp. (nymphs), *Astegopteryx bambusae*, *A. bambusicola*, *Myzus persicae*, *M. persicae nicotianae*, *Pentalonia nigronervosa*, *Pseudoregma bambusicola*, *Sitobion avenae, Sitobion* sp.	Aphididae	Assam Agriculture University, Jorhat

S. No.	Taxon/taxa identified	Group/Family	Service provided to
8.	*Macrosiphoniella sanborni* (2)	Aphididae	University of Agricultural and Horticultural Sciences, Shivamogga
	Prococcus acutissimus, *Ceroplastes* sp.	Coccidae	
	Chrysomphalus aonidum	Diaspididae	
	Crissicoccus hirsutus, *Dactylopius* sp., *Dysmicoccus brevipes*, *D, neobrevipes*, *Ferrisia malvestra*, *F. virgate*, *Phenacoccus parvus*, *P. solenopsis*, *P. lilacinus*, *Planococcus* sp., *Pseudococcus cryptus*	Pseudococcidae	
	Icerya sp.	Monophlebidae	
9.	*Aphis craccivora*, *A. fabae*, *A. gossypii*, *A. nerii*, *Astegopteryx* sp., *Hysteroneura setarae*, *Macrosiphoniella sanbornii*, *Macrosiphum rosae*, *Melanaphis bambusae*, *M. donacis*, *M. sacchari*, *Sitobion rosaeformis*	Aphididae	Navsari Agriculture University, Navsari
10.	*Abgrallaspis* sp. and *Pseudaulacaspis* sp.	Diaspididae	Punjab Agricultural University, Ludhiana
11.	*Paracoccus marginatus*, *Phenacoccus divaricatus*, *P. madeirensis*, *P. parvus*, *Pseudococcus longispinus* (2)	Pseudococcidae	Shivaji University, Kolhapur
	A. craccivora, *A. gossypii* (2), *A. nerii*, *Hysteroneura setarae*, *Macrosiphoniella sanbornii, Melanaphis bambusae*, *Melanaphis donacis, Myzus persicae*, *Myzus persicae* sp. *nicotianae*	Aphididae	
	Aspidiotus destructor	Diaspididae	
12.	*Parlatoria* ? *ziziphi*	Diaspididae	Andaman & Nicobar Regional Centre Zoological Survey of India, Port Blair
13.	*Maconellicoccus hirsutus*	Pseudococcidae	ICAR–Indian Institute of Horticultural Research, Bengaluru
14.	*Saissetia coffeae*	Coccidae	College of Horticulture & Forestry, Auranachal Pradesh
15.	*Antonina* sp., *Dysmicoccus* sp.	Pseudococcidae	Institute of Forest Genetics and Tree Breeding, Coimbatore
16.	*Pentalonia nigronervosa*	Aphididae	College of Agriculture, Vellayani
17.	*Fiorinia* ? *fiorinae*, *Pseudaulacaspis cockerelli*	Diaspididae	Regional Plant Quarantine Station, Chennai
18.	*Aphis gossypii*, *A. nerii*	Aphididae	Indira Gandhi Krishi Vishwavidyala, Raipur
19.	*Icerya purchasi*	Monophlebidae	Punjab Agricultural University, Ludhiana
20.	*Formicoccus polysperes*	Pseudococcidae	Kerala Agricultural University, Padannakkad
21.	*Hysteroneura setarae*, *Paracoccus marginatus*, *Phenacoccus divaricatus*, *P. parvus*, *Pseudococcus longispinus*, *Rhopalosiphum maidis*	Aphididae	CSK HP Krishi Vishwavidyalaya, College of Agriculture, Palampur

S. No.	Taxon/taxa identified	Group/Family	Service provided to
22.	*Pentalonia nigronervosa*	Aphididae	University of Agricultural Science, Bengaluru
23.	*Brevicoryne brassicae*	Aphididae	ICAR–Indian Agricultural Research Institute Regional station, Wellington
24.	*Hysteroneura setarae*	Aphididae	Anand Agricultural University, Anand
	Ferrisia virgata	Pseudococcidae	
25.	*Dysmicoccus neobrevipes*, *Dysmicoccus* sp.	Pseudococcidae	Bidhan Chandra Krishi Viswavidyalaya, Kalyani
26.	*Ceroplastes* sp. *Pulvinaria polygonata*	Coccidae	College of Horticulture, Vellanikkara
	Antonina graminis, *Chorizococcus* sp., *Dysmicoccus brevipes*, *Dysmicococcus neobrevipes*, *Formicococcus lingnani*, *F. mangiferacola*, *F. polysperes* (2), *Paraputo lingnani*, *Planococcus* sp., *Planococcus lialcinus*, *Pseudococcus viburni*, *Trionymus townesi*, *Xenococcus annandalei*, *Xenococcus annandalei*	Pseudococcidae	
27.	*Smynthurodes betae*	Aphididae	ICAR–Central Potato Research Institute, Regional Station, Ooty
28.	*Aphis craccivora*, *A. gossypii*, *Melanaphis sacchari, Rhopalosiphum maidis*	Aphididae	Shivaji University, Kolhapur
29.	*Aphis craccivora*, *A. gossypii*, *A. spiraecola*, *Melanaphis sacchari, Pentalonia nigronervosa, Rhopalosiphum maidis*, *Macrosiphoniella sanborni*	Aphididae	College of Agriculture, Vellayani, Thiruvananthapuram
	Icerya sp.	Monophlebidae	
	Planococcus lilacinus	Pseudococcidae	
30.	*Nipaecoccus viridis*	Pseudococcidae	ICAR–National Research Centre on Pomegranate, Solapur
	Icerya purchasi	Monophlebidae	
	Aphis punicae	Aphididae	
31.	*Aonidiella aurantia, Parlatoria pergandii*	Diaspididae	Directorate of Plant Protection, Quarantine & Storage, Mumbai
32.	*Icerya aegyptica*	Monophlebidae	Zoological Survey of India, Western Ghats Research Centre, Kerala
33.	*Aphis craccivora*, *A. gossypii*, *A. spiraecola*, *Macrosiphoniella sanborni*, *Melanaphis sacchari*, *Rhopalosiphum maidis*	Aphididae	ICAR–Indian Institute of Natural Resins and Gums, Ranchi
	Planococcus lilacinus	Pseudococcidae	
34.	*Brevicoryne brassicae*	Aphididae	Dr Y. S. Parmar University of Horticulture & Forestry, Solan
	Pseudococcus cryptus	Pseudococcidae	
35.	*Aphis gossypii*	Aphididae	Jaipur National University, Jaipur

S. No.	Taxon/taxa identified	Group/Family	Service provided to
36.	*Cheilomenes sexmaculata*, *Coccinella transversalis*, *Micraspis* sp.	Coccinellidae	Dr Rajendra Prasad Central Agricultural University

Dr K. Sreedevi

1.	*Adoretus* sp. (4 species), *Anomala* ?*rugosa*, *Anomala biharensis, Anomala dimidiata*, *Anomala dorsalis*, *Anomala polita*, *Anomala ruficapilla*, *Anomala* sp. (6 species), *Anomala varicolor*, *Brahmina* sp., *Catharsius molossus, Chiloloba acuta*, *Holotrichia consanguinea*, *Holotrichia serrata*, *Holotrichia* sp. (2 speceis), *Hybosorus* sp., *Maladera ferruginea*, *Maladera sinaeivi*, *Maladera* sp. (3 speceis), *Maladera* sp.(5 species), *Maladera thomsoni*, *Melolontha cuprescens*, *Melolontha furcicauda Melolontha* sp.(2 species), *Melolonthine* sp.(2 species), *Onitis* sp., *Onthophagus* sp. (7 species), *Scarabaeine* sp., *Schizonycha ruficollis*, *Schizonycha* sp., *Sophrops* sp.	Scarabaeideae	CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur
2.	*Altica* sp?, *Aulocophora* sp.	Chrysomelidae	Dr Rajendra Prasad Central Agricultural University, Samastipur
	Lycidae, Chrysomelidae, Carabidae (2), Elateridae		
3.	*Phyllognathus dionysius*, *Schizonycha* sp.	Scarabaeideae	College of Agriculture, Nandurbar
4.	*Carpophilus?* sp.	Nitidulidae	AICRP on Vegetables Rajendranagar, Hyderabad
5.	*Anomalochela bicolor*, *Anomala communis*, *Holotrichia* sp., *Adoretus* sp., *Maladera* sp.	Scarabaeideae	ICAR–Indian Agricultural Research Institute Regional Station, Wellington
6.	*Anomala communis*, *Holotrichia* sp., *Maladera indica*, *Maladera* sp., Melolonthine beetle	Scarabaeideae	ICAR–Central Potato Research Institute, Ooty
7.	*Adoretus* sp., *Apogonia* sp., *Holotrichia consanguinea*	Scarabaeideae	Punjab Agricultural University, Ludhiana
8.	*Holotrichia fissa*, *Holotrichia serrata*, *Sophrops karschi*, *Phyllognathus dionysius*	Scarabaeideae	College of Agriculture, Karad, Satara
9.	*Adoretus* sp., *Anomala bengalensis*, *Anomala dimidiata*, *Holotrichia nagpurensis*, *Holotrichia serrata*, *Oryctes rhinoceros*, *Pentodon* sp., *Phyllognathus dionysius, Scarabaeine beetle*, *Schizonycha ruficollis*	Scarabaeideae	Farmer, Ghaziabad.
10.	*Adoretus* sp., *Anomala bengalensis*, *Anomala dorsalis*, *Anomala dorsalis*, *Holotrichia reynaudi/akolana*, *Holotrichia serrata*, *Hybosorine* beetle, *Oxycetonia versicolor*	Scarabaeideae	Rajasthan Agricultural Research Institute, Durgapura, Jaipur
11.	*Adoretus* sp., *Apagonia* sp., *Holotrichia rufoflava*, *Holotrichia* sp.*?*, *Holotrichia/ Brahmina* sp., *Sophrops* sp.	Scarabaeideae	ICAR–Indian Institute of Natural Resins and Gums, Ranchi

12.	*Anomala bengalensis*, *Anomala dimidiata*, *Anomala dorsalis*, *Catharsius molossus*, *Holotrichia consanguinea*, *Holotrichia nagpurensis*, *Holotrichia serrata*, *Hybosorus* sp., *Maladera insanabilis*, *Onitis* sp. (2 speceis), *Onthophagus* sp., *Pentodon* sp. (2 species), *Schizonycha ruficollis*	Scarabaeideae	Farmer, Ghaziabad
13.	*Amadotrogus* sp., *Anomala* sp. (2 species), *Miridiba herteli*	Scarabaeideae	Department of Zoology, Nehu, Shillong
14.	*Protaetia* sp.	Scarabaeidae	Agricultural Research Station, Agriculture University, Jodhpur
15.	*Popillia* sp.	Scarabaeidae	Institute of Wood Science and Technology, Bengaluru
16.	*Sagra femorata*, *Anomala? chorochelys*	Scarabaeideae	ICAR Research Complex for North Eastern Region, Manipur Centre, Imphal
17.	*Polyphylla fullo*	Scarabaeideae	CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur
18.	*Adoretus* sp.	Scarabaeideae	Vasantdada Sugar Institute Manjari, Pune
19.	*Adoretus* sp., *Phyllognathus dionysius*	Scarabaeidae	Dr K.K. Saini Haryana
20.	*Apogonia* sp., *Holotrichia* sp., *Leucopholis coneophora*, *Maladera caifensis*, *Maladera rufocuprea*, *Maladera seriatoguttata*, *Maladera sujitrae*	Scarabaeidae	ICAR–Central Plantation Crops Research Institute, Kasaragod
21.	*Anomala communis*, *Holotrichia fissa*, *Leucopholis coneophora*, *Mimela xanthorrhina*	Scarabaeidae	Kerala Agricultural University, Vellanikara, Thrissur
22.	*Scolytid* sp.	Scolytidae	ICAR–Indian Institute of Horticultural Research, Bengaluru
23.	*Callosobruchus chinensis*, *Callosobruchus maculatus*, *Callosobruchus* sp.	Chrysomelidae	Uttar Banga Krishi Vishwa Vidyalaya, West Bengal
24.	*Araecerus fasciculatus*	Anthribidae	ICAR–Central Plantation Crops Research Institute, Kasaragod

25.	*Coccotrypes dactyliperda*	Curculionidae	Date Palm Research Station, S.D. Agricultural University, Mundra
26.	*Coptosoma* sp.	Plataspidae	ICAR–Indian Institute of Horticultural Research, Bengaluru
27.	*Achatina fulica,* Round snail	Achatinidae	Indira Gandhi Krishi Vishwavidyalaya, Raipur

Dr S. Salini

1.	*Eocanthecona furcellata, Nezara viridula, Plautia crossota*	Pentatomidae	BASF India Pvt. Ltd
2.	*Glaucias dorsalis*, *Halys shaista*, *Nezara viridula var torquata*, *Placosternum* sp., *Priassus exemptus*	Pentatomidae	Geetha Iyer, Suchindrum
	Coridius chinensis	Coreidae	
	Scutellera sp.	Scutelleridae	
3.	*Glaucias nigromarginatus*	Pentatomidae	Institute of Wood Science and Technology, Bengaluru
4.	*Eysarcoris ventralis*, *Menida versicolor*	Pentatomidae	Dr Rajendra Prasad Central Agricultural University, Pusa
5.	*Megymenum brevicorne*	Dinidoridae	Institute of Wood Science and Technology, Bengaluru
6.	*Coridius* sp.	Dinidoridae	Kerala Agricultural University
7.	*Tessaratoma quadrata*	Tessaratomidae	ICAR–North Eastern Region, Manipur
8.	*Clavigralla* sp.	Coreidae	Dr Rajendra Prasad Central Agricultural University, Pusa
9.	*Scutellera nubilis*	Scutelleridae	S.D. Agricultural University, Jagudan

Dr K.J. David

1.	*Bactrocera latifrons*, *Bactrocera zonata*, *Diarrhegma modestum*, *Zeugodacus tau, Zeugodacus cucurbitae*	Tephritidae	Magadh University, Bodh Gaya
	Rhinia sp.	Calliphoridae	
	Stratiomyidae	Stratiomyidae	

2.	*Atherigona* sp, *Haematobia irritans*, *Musca* sp. (5 species), *Stomoxys calcitrans*	Muscidae	St. Joseph's College, Devagiri, Calicut
	Tabanus triceps	Tabanidae	
3.	*Epistrophe* sp., *Episyrphus balteatus*, *Episyrphus viridaureus*	Syrphidae	Punjab Agricultural University, Ludhiana
4.	*Drosophila melanogaster*	Drosophilidae	ICAR–National Research Centre for Grapes, Pune
5.	*Stomorhina* sp.	Calliphoridae	S.V. Agricultural College, Tirupati
6.	*B. zonata*, *Bactrocera correcta*, *Bactrocera dorsalis*, *Dacus discophorus*, *Dacus ramanii*, *Zeugodacus cucurbitae*	Tephritidae	University of Agricultural Sciences, Raichur
	Sciomyzidae	Sciomyzidae	

Dr G. Mahendiran

1.	*Rhynchaenus mangiferae*	Curculionidae	Punjab Agricultural University, Ludhiana
2.	*Cyphicerus* sp., *Mecobaris* sp., *Crinorrhinus* sp.	Curculionidae	ICAR Research Complex for North East Region, Umiam
3.	*Sternuchopsis collaris*	Curculionidae	Krishi Vigyan Kendra, Khedbrahma
4.	*Myllocerus dentifer*	Curculionidae	Kerala Agricultural University, Vellanikkara
5.	*Conapion* sp.	Apionidae	Dr Rajendra Prasad Central Agricultural University, Pusa
6.	*Sitophilus oryzae*	Dryophthoridae	ICAR–Central Institute of Post Harvest Engineering &Technology, Ludhiana

Dr Ankita Gupta

1.	*Telenomus* sp.	Platygastridae	Tamil Nadu Agricultural University, Coimbatore
2.	*Eurytoma* sp.	Eurytomidae	Agricultural College, Bapatla
3.	Indetermined genus	Encyrtidae	
4.	*Brachymeria* sp.	Chalcididae	University of Agricultural Sciences, Bengaluru
	Phanerotoma sp., Indet Cheloninae	Braconidae	
	? *Xanthopimpla* sp.	Ichneumonidae	
5.	*Brachymeria* sp.	Chalcididae	Tirhut College of Agriculture, Dholi, Muzaffarpur
6.	Indetermined genus	Agathidinae (Braconidae)	Tirhut College of Agriculture, Dholi, Muzaffarpur
7.	*Oomyzus scaposus*	Eulophidae	Rani Lakshmi Bai Central Agricultural University, Jhansi

8.	*Campoletis chlorideae* (2)	Ichneumonidae	ICAR-Indian Grassland and Fodder Research Institute, Jhansi
	Cotesia ruficrus	Braconidae	
9.	*Cotesia ruficrus*, *Cotesia glomerata*, *Chelonus* sp.	Braconidae	Punjab Agricultural University, Ludhiana
10.	*Apanteles galleriae*	Braconidae	TamilNadu Agricultural University, Madurai
11.	*Coccygidum transcaspicum*	Braconidae	ICAR–Indian Institute of Maize Research, Winter nursery centre, Hyderabad
12.	*Cotesia ruficrus*	Braconidae	Central Agricultural University, Umiam, Meghalaya
13.	*Cotesia ruficrus*	Braconidae	Agriculture Research Station, Banswara
14.	*Spodoptera frugiperda*	Noctuidae	College of Agriculture, Hassan
15.	*Campoletis chlorideae*	Ichneumonidae	College of Agriculture, Hassan

Ms R.R. Rachana

1	*Thrips florum*, *Thrips hawaiiensis*	Thripidae	Shre-e-Kashmir University of Agricultural Sciences and Technology, Srinagar
2	*Frankliniella schultzei*, *Scirtothrips dorsalis*, *Thrips palmi*, *Thrips tabaci*	Thripidae	BASF Pvt. Ltd
3	*Rhipiphorothrips cruentatus*, *Rhipiphorothrips pulchellus*, *Thrips palmi*	Thripidae	Punjab Agricultural University, Ludhiana
4	*Ayyaria chaetophora*, *Scirtothrips dorsalis*, *Thrips palmi*, *Thrips tabaci*	Thripidae	ICAR-Cental Institute of Cotton Research, Coimbatore
	Dolichothrips sp.	Phlaeothripidae	
5	*Thrips florum*, *Thrips hawaiiensis*	Thripidae	University of Agricultural Sciences, Raichur
6	*Byctothrips* sp., *Haplothrips* sp.	Phlaeothripidae	Institute of Wood Science and Technology, Bengaluru
7	*Frankliniella schultzei* (2), *Megalurothrips peculiaris*¸ *Megalurothrips usitatus*, *Microcephalothrips abdominalis*, *Rhipiphorothrips cruentatus*, *Thrips apicatus*, *Thrips florum*, *Thrips hawaiiensis*, *Thrips palmi*	Thripidae	University of Agricultural Sciences, Bengaluru
	Haplothrips sp.	Phlaeothripidae	
8	*Caliothrips indicus*, *Caliothrips luckmanni*, *Scirtothrips dorsalis*, *Thrips palmi*	Thripidae	Mr Nayan (Farmer, Raipur)
9	*Megalurothrips peculiaris*, *Megalurothrips usitatus*	Thripidae	University of Agricultural and Horticultural Sciences, Shivamogga
	Haplothrips sp. (2 species)	Phlaeothripidae	
10	*Gynaikothrips* sp. *Haplothrips* sp.(2), *Xylaplothrips* sp.	Phlaeothripidae	College of Agricultural, Vellayani
	Scirtothrips dorsalis	Thripidae	University of Agricultural and Horticultural Sciences, Shivamogga
11	*Thrips palmi*, *Scirtothrips dorsalis*	Thripidae	University of Agricultural and Horticultural Sciences, Shivamogga

12	*Pseudodendrothrips mori*	Thripidae	College of Agriculture, Vijayapur
	Franklinothrips vespiformis	Aeolothripidae	
13	*Frankliniella occidentalis*, *Frankliniella schultzei*, *Scirtothrips dorsalis*	Thripidae	Plant Quarantine Station, Hebbal

Dr Omprakash Navik

1	*Chaetostricha* sp., *Lathromeroidea* sp., *Oligosita* sp. *Trichogramma achaeae*, *Trichogramma chilonis*, *Trichogramma hebbalensis*, *Trichogramma* sp., *Trichogrammatoidea bactrae*, *Trichogrammatoidea* sp., *Tumidiclava* sp.	Trichogrammatidae	University of Calicut, Kerala
2	*Trichogramma chilonis*	Trichogrammatidae	ICAR–National Institute of Biotic Stress Management, Raipur
3	*Trichogramma* sp. (20)	Trichogrammatidae	University of Agricultural Sciences, Raichur
4	*Trichogramma* sp. (26)	Trichogrammatidae	Indira Gandhi Krishi Vishwavidyalaya, Raipur

Dr M. Sampath Kumar

1.	*Gasteracantha* sp.	Araneidae	Regional coconut station, Ratnagiri (M.S)
	Oxyopes sp.	Oxyopidae	
2.	*Telamonia dimidiata, Hyllus semicupreus*	Salticidae	College of Agriculture, Bapatla
	Neoscona theisi, *Cyclosa* sp.	Araneidae	
3.	*Neoscona* sp., *Argiope* sp., *Araneus* sp.	Araneidae	University of Agricultural Sciences, Raichur
	Stegodyphus sarasinorum	Eresidae	
	Cheiracanthium spp.	Cheiracanthiidae	
	Thomisus spectabilis	Thomisidae	
	Menemerus sp., *Harmochirus brachiatus*	Salticidae	
	Pardosa pseudoannulata	Lycosidae	
4.	*Pardosa pseudoannulata*, *Pardosa* sp.	Lycosidae	Punjab Agricultural University, Ludhiana
	Araneus sp., *Argiope* sp., *Neoscona* sp.	Araneidae	
	Harmochirus brachiatus, *Rudakius ludhianaensis*, *Icius* sp., *Marpissa* sp., *Hyllus* sp., *?Chrysilla* sp.	Salticidae	
	Cambalida sp.	Corinnidae	
	Runcinia sp., *Thomisus* sp.	Thomisidae	
	Oxyopes sp.	Oxyopidae	

5.	*Argiope* sp.	Araneidae	Anand Agricultural University, Anand
	Tetragnatha sp.	Tetragnathidae	
	Argiope pulchella, *Neoscona theisi*, *Araneus ellipticus*, *Cyclosa* sp.	Araneidae	
	Thomisus spectabilis	Thomisidae	
6.	*Araneous ellipticus*, *Argiope* sp., *Neoscona theisi*	Araneidae	Agricultural Research Station, Gangavathi
	Peucetia yogeshi	Oxyopidae	
	Tetragnatha sp., *Tetragnatha javana*	Tetragnathidae	
	Plexippus paykulli	Salticidae	
	Pardosa sp., *Pardosa ?irriensis*, *Pardosa pseudoannulata*	Lycosidae	
7.	*Pardosa* sp.	Lycosidae	Kerala Agricultural University, Thrissur
	Araneus sp., *Argiope* sp., *Neoscona theisi*	Araneidae	
	Hyllus sp.	Salticidae	
	Tetragnatha javana	Tetragnathidae	
8.	*Clubiona* sp., *Clubiona ?altissimoides*	Clubionidae	University of Agricultural Sciences, Dharwad
	Oxyopes javanus	Oxyopidae	
	Araneus sp.	Araneidae	
	Heteropoda sp.	Sparassidae	
	Thomisus sp.	Thomisidae	
9.	*Peucetia ?viridana*	Oxyopidae	ICAR–Central Tobacco Research Institute, Rajamahendravaram
10.	*Oxyopes pankaji*, *Oxyopes shweta*, *Peucetia viridana*, *Oxyopes javanus*	Oxyopidae	University of Horticultural Sciences, Bagalkot
	Pardosa sp.	Lycosidae	
	Stegodyphus sarasinorum	Eresidae	
	Araneus mitificus	Araneidae	
	Cheiracanthium sp.	Cheiracanthiidae	
11.	*Neoscona theisi*	Araneidae	Dr Rajendra Prasad Central Agricultural University, Pusa
	Lycosa mackenziei, *Pardosa pseudoannulata*, *Pardosa* sp.	Lycosidae	
	Thomisus sp.	Thomisidae	
	Cheiracanthium inornatum	Cheiracanthiidae	
	Oxyopes sp.	Oxyopidae	
12.	*Rhene flavigera*, *Telamonia dimidiata*	Salticidae	Mango Research Station, Nuzvid
	Cheiracanthium sp.	Cheiracanthiidae	
	Thomisus pugilis	Thomisidae	
	Pardosa sp.	Lycosidae	
	Oxyopes sp.	Oxyopidae	

Dr Jagadeesh Patil

1.	*Steinernema pakistanense* (5 speceis)	Steinernematidae	Anand Agricultural University, Anand
2.	*Steinernema cholashanense* (1 species)	Steinernematidae	ICAR–Central Potato Research Insitute, Ooty
3.	*Steinernema abbasi, Steinenema siamkayi, Heterorhabditis indica* (4 species)	Steinernematidae Heterorhabditidae	ICAR–Indian Institute of Vegetable Research, Varanasi

Dr B. Ramanujam

1.	*Cladosporium* spp.	Entomopathogenic fungi	Punjab Agricultural University, Ludhiana
2.	*Metarhizium rileyi*	Entomopathogenic fungi	Regional Agricultural Research Station, Anakapelle

Note: Figures given in parenthesis denote the number of times identified and communicated.

6. EXTENSION ACTIVITIES

NBAIR in collaboration with ICAR–National Centre for Integrated Pest Management, New Delhi, and Krishi Vigyan Kendra, Jalna, organised an "On-farm demonstration of egg parasitoid *Trichogrammatoidea bactrae* for the management of pink bollworm" at Wakhari in Maharashtra in an area of 75 acres of *Bt* cotton. An interactive meeting was also held with *Bt* cotton growers. The method of field use of Tricho-cards under the IPM module was explained to the farmers. Tricho-cards were supplied for large-scale demonstrations to other farmers.

NBAIR organised "An on-farm demonstration on installation and use of pheromone traps for monitoring and mass trapping FAW" at Aizawl, Mizoram for Agriculture Department officials, researchers and farmers on 15 May 2019.

Demonstration on installation and use of pheromone trap

An on-farm demonstration cum farmers-scientists interactive meet on the management of fall army worm, *Spodoptera frugiperda* in maize was organized for the benefit of maize growing farmers at the Research farm at Yelahanka on 03 August 2019. Farmers from Hosahalli, Tekalahalli and Mallasandra of Doddaballapura taluk participated in the programme. On-farm trials with the Bureau's ecologically-safe technologies viz., formulations of entomopathogenic nematodes, formulations of plant growth promoting rhizobacterium, *Pseudomonas fluoresens* for the management of FAW in maize were showcased. Technologies for the management of FAW viz., trichogrammatid egg parasitoids, *Bacillus thuringiensis* strain and entomopathogenic fungi specific to FAW, use of pheromone traps and nano gel formulations were exhibited for the benefit of the farmers.

NBAIR scientists demonstrated the efficacy of *M. anisopliae* (Ma-35) against maize FAW to farmers in Chilamatur and Srikakulam, Andhra Pradesh, Chikkaballapur and Gauribidanur district in Karnataka.

Demonstrations on biological control agents, particularly *Isaria fumosorosea* for the management of rugose spiralling whitefly *Aleurodicus rugioperculatus* on coconut were conducted at Ranastalam, Andhra Pradesh, Purva Midnapur, West Bengal and Channarayapatna, Karnataka.

Demonstration on field efficacy of *Isaria fumosorosea* in coconut

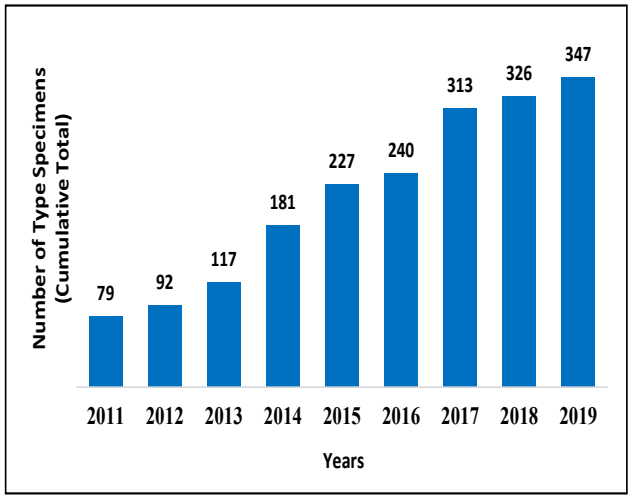
Large scale field demonstration on the technology "WP formulation of *Heterorhabditis indica* and *Steinernema abbasi"* was taken up for the management of white grubs in sugarcane, and ground nut in various AICRP-BC centers. The wettable powder formulation of *Heterorhabditis indica* for the management of fall army worm in maize at Andhra Pradesh, Telangana and Karnataka was demonstrated.

Demonstrated management of fall armyworm in the farmers field using various biocontrol technologies and non-pesticidal approaches including pheromone traps developed by NBAIR at Krishi Vigyan Kendra, Sepahijala, Tripura on 15 October 2019.

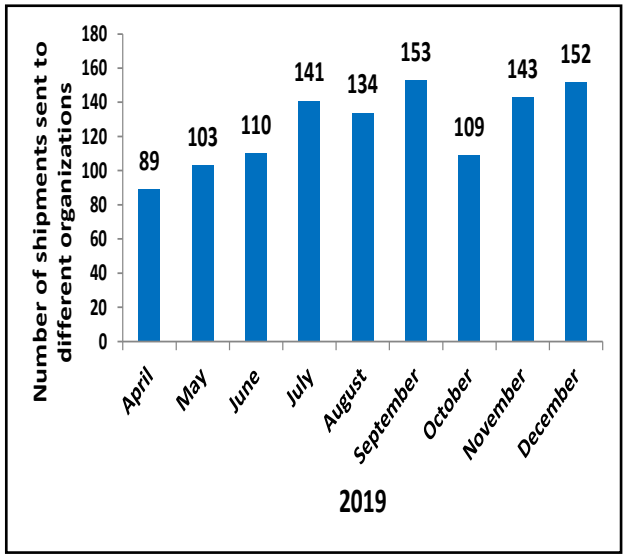
Demonstration of biocontrol technologies at KVK, Sepahijala, Tripura

Awareness cum training programme conducted on biological control of rugose spiralling whitefly in coconut at Ramanagara, Karnataka and BCKV, West Bengal to the departmental officials, students and farmers.

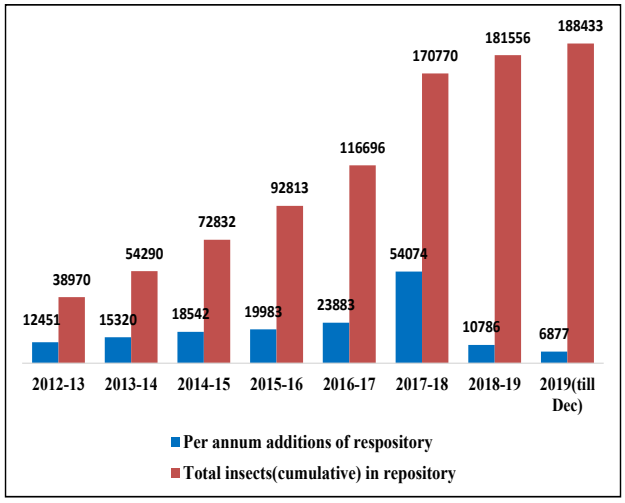
Pheromone lures, namely fall army worm pheromone lure (2000 lures), rice yellow stem borer (600 lures), red palm weevil (20 lures) and rhinoceros beetle (20 lures) were supplied to research institutes and farmers from Karnataka, Kerala, Tamil Nadu, West Bengal, Central Integrated Pest Management Centre (Trichy Centre), National Institute for Plant Health Management, Hyderabad, AICRP centers under ICAR – IIMR and AICRP on biocontrol. Similarly, *Bacillus thuringiensis* (NBAIR-BT) formulation for management of FAW were distributed among the farmers from Doddaballapur, Karnataka, Hindupur and Pusapatirega, Andhra Pradesh.



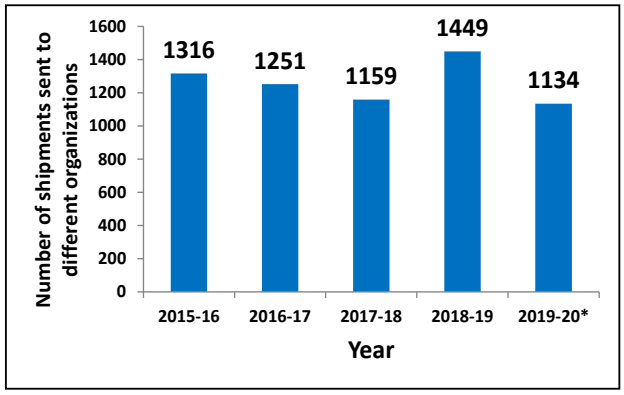
Number of type specimens of insects in the ICAR-NBAIR museum



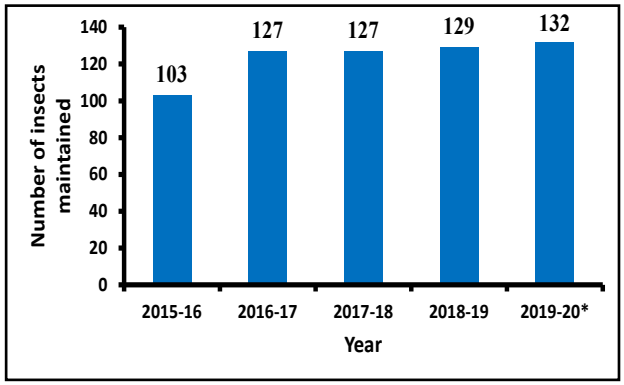
Number of insect shipments supplied during 2019



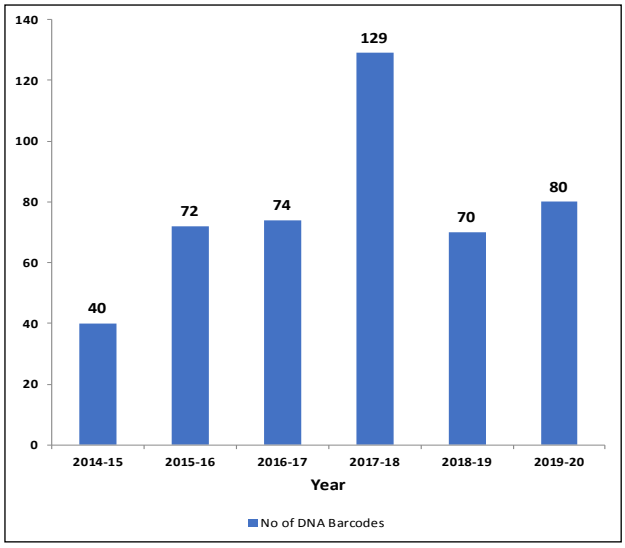
Number of preserved insects in the ICAR-NBAIR museum: Annual additions and cumulative figures



Number of shipments (Host insects and natural enemies) supplied to different organisations



Number of live insect cultures maintained at NBAIR (*till December 2019)



Number DNA barcodes developed

7. AWARDS AND RECOGNITIONS

Dr Chandish R. Ballal

Served as DBT Nominee for the Institutional Biosafety Committee to be constituted at the Department of Microbiology and Biotechnology, Bengaluru University.

Member, Research Council of University of Horticultural Sciences, Bagalkot.

Member, RCGM Expert Committee constituted by DBT for site visit for transgenic silkworm trials and rearing places at farmers premises.

Host scientist of the 'Research Training Fellowship for Developing Countries Scientist (RTF-DCS) programme' by Department of Science and Technology.

Member, National Advisory Committee for Agricultural Scientist and Farmers' Congress on 'Postharvest Technology and Management for empowering the rural society and employment generation', 22–23 February 2020.

Member of expert committee to standardize the test protocols and helping in review of proposals by National Innovation Foundation, India.

Delivered a talk on 'Challenges of Indian Agro biodiversity including pests and non pest resources' during the Symposium on "Biodiversity Future Challenges in the Indian Context" held at Indian National Science Academy, New Delhi, 16–18 December 2019.

Member, National Advisory Committee, International Conference on Plant Protection in Horticulture Advances and Challenges, ICAR–IIHR, Bengaluru, 24–27 July 2019.

Delivered a talk on 'Feasible biocontrol strategies for pests of horticultural crops' during the International Conference on Plant Protection in Horticulture Advances and Challenges, ICAR–IIHR, Bengaluru, 24–27 July 2019.

Served as Co-chair for Technical Session II - Biological Control: Approaches and Success Stories during the International Conference on Plant Protection in Horticulture Advances and Challenges, ICAR–Indian Institute of Horticultural Research, Bengaluru, 24–27 July 2019.

Reviewer of Journal of Biological Diversity.

Member, National Advisory Committee, National Conference on Human-Wild life conflict and Animal Behaviours, 28–30 January 2020.

Nominated by DBT as Member of Review Committee on Genetic Manipulation (RCGM).

Chairperson of RAC of CSGRC, Hosur.

RCC Member of Central Silk Board, Bengaluru.

Member of National Advisory Board for the National Swadeshi Science Congress held at Pune, 23–24 December 2019.

Received Travel Grant and invitation to participate in the Workshop on Fall Armyworm- Preparedness and Management from CIMMYT at Plant Quarantine & Pesticide Management Centre, Nepal, 29–31 July 2019.

Received "Lifetime Achievement Award 2019" from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Member of Committee for judging best researcher, Best farm Superintendent and Certificate of Merit for externally funded project at UAHS, Shivamogga.

Reviewer for Annals of Entomological Society of America.

Delivered a lead talk on 'Biological Control in Organic Farming' during the Global Organic Convention 2019 - National Resource Management for Sustainable Agriculture, Soil Health & Quality food, Lucknow, 16 September 2019.

Delivered a guest lecture on 'Biocontrol in Pest Management' for Post Graduate students at Karnataka Science & Technology Academy, Yelahanka, Bengaluru, 24 October 2019.

Member, Award Committee to evaluate & scrutinize the application for Kalayya Krishnamurthy National Award constituted by University of Agricultural Sciences, Bengaluru.

Guest of Honour at Hindi Diwas and Swatchatha Abhayan Program at ICAR-National Research Centre for Banana, Tiruchirappalli, 27 September 2019.

Served as Chairperson of the Symposium on 'Management of *Tuta absoluta*' at XIX International Plant Protection Congress 2019 held at Hyderabad, Telangana, 12 November 2019.

Delivered Keynote address on 'Biological Control–expect the unexpected' at XIX International Plant Protection Congress 2019 held at Hyderabad, Telangana, 12 November 2019.

Invited speaker for the Indian National Science Academy Anniversary meeting at National Institute of Oceanography Goa, 17 November 2019.

Dr N. Bakthavatsalam

Delivered an invited lecture on 'Can the plant volatiles play a role in insect pest management?' at Institute of Forest Genetics and Tree Breeding, Coimbatore, 30 September 2019.

Delivered an invited lecture on 'Semiochemicals: Eco-friendly chemicals for the insect pest management' at Indira Gandhi Krishi Viswavidyayala, Raipur 13 September 2019.

Dr B. Ramanujam

Served as Research Advisory Committee member of Institute of Wood Science and Technology (IWST), Bengaluru.

Dr M Nagesh

Best oral presentation for the paper entitled 'Relevance and opportunity of ecological services of entomopathogenic nematodes in pest management in horticultural ecosystems' at the "International conference on Plant Protection in Horticulture: Advances and Challenges" held at ICAR – Indian Institute of Horticultural Research, Bengaluru, 24–27 July, 2019.

Received 'Excellence in Innovation and Industry Product Research & Development related to Pesticides and biopesticides development, manufacture and marketing Award' from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Dr T. Venkatesan

Received Research Excellence Award-2019 at BioScon 2019 Conference at Sona College of Technology, Salem organised by Society of Biotic and Environmental Research, Tripura, 26–27 July 2019.

Received Sithanantham Award-2019 for the Outstanding contribution to Biological control of Horticultural pests by Association for Advancement in Pest management in Horticultural Ecosystems at "International conference on Plant Protection in Horticulture: Advances and Challenges" held at ICAR – IIHR Bengaluru, 24–27 July 2019.

Received 'Outstanding contribution to Science Award' from Dr B. Vasantharaj David Foundation at National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Served as Vice-President, Society for Biocontrol Advancement, Bengaluru.

Acted as Special Editor for the Journal of Environmental Biology, Lucknow, India

Served as Chairman for evaluating poster session on theme 'Innovation in plant health management' at National Conference on Challenges and Innovative approaches in agriculture & allied sciences Research, Salem, Tamil Nadu, 26–27 July 2019.

Served as Co-Chairman for evaluating best oral presentation on 'Innovation in plant health management' at National Conference on Challenges and Innovative approaches in agriculture & allied sciences Research', Salem, Tamil Nadu, 26–27 July 2019.

Guided M.Sc (Agri Entomology) Ms. Ashwini, Dept. of Entomology, University of Agricultural Sciences, Bengaluru.

Guided as Co-Supervisor for M.Sc (Agri. Entomology), Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur.

Acted as External Expert for the selection of Assistant Director (Plant protection) at NIPHM, Hyderabad, 30–31 August 2019.

Dr P. Sreerama Kumar

Received "International Travel Support" from the Society for Invertebrate Pathology, USA, to participate in the 2019 International Congress on Invertebrate Pathology and Microbial Control & 52nd Annual Meeting of the Society for Invertebrate Pathology & 17th Meeting of the IOBC-WPRS Working Group on Microbial and Nematode Control of Invertebrate Pests (SIP/IOBC 2019), Palacio de Congresos de València, Valencia, Spain, 28 July–01 August 2019.

Received "Registration Fee Reimbursement" from the Department of Biotechnology, Government of India, for attendance at the SIP/IOBC 2019, Palacio de Congresos de València, Valencia, Spain, 28 July–01 August 2019.

Editor of the Society for Invertebrate Pathology (SIP) Newsletter, USA.

Ambassador for The Association of Applied Biologists, Warwick, UK.

Member of the Publications Committee, Society for Invertebrate Pathology, USA.

Recognised as Expert/Subject Specialist by the Institute of Wood Science and Technology, Indian Council of Forestry Research and Education, Bengaluru.

Dr K. Subaharan

Delivered an invited lecture on 'Olfactory basis of host selection in insects' in Monthly Seminar on Plant Volatiles in Forest Pest Management Monday held at Institute of Forest Genetics and Tree Breeding Coimbatore, 30 September 2019.

Invited to present the work on 'Controlled Release dispenser for delivery of semiochemicals' at National Advisory Committee members of Department of Science and Technology Research Centre, Jawaharlal Nehru Centre for Advanced Scientific Research chaired by Prof. Goverdhan Mehta, Former Director, Indian Institute of Sciences, Bengaluru.

Served as member for screening the beneficiaries for recruitment under compassionate grounds at ICAR – NBAIR, Bengaluru.

Served as expert for Screening the DST SERB project proposal on Development of Models for management of Fall Armyworm.

External examiner for M.Sc (Agri) thesis of Department of Entomology, Faculty of Agriculture, Annamalai University.

Served as member for pre thesis colloquium of Mrs. Vibina Venugopal at Department of Applied Zoology, Mangalore University.

Served as member for pre thesis colloquium of Mr P. Raveendran at Department of Applied Zoology, Mangalore University.

Served as DPC member for position of Assistant Administrative Officer at ICAR– NBAIR, Bengaluru.

Served as verification officer for Division of Genomic Resources, ICAR–NBAIR Bengaluru.

Served as external examiner for Post Graduate Research work at Faculty of Agriculture, Annamalai University.

Served as external examiner for Post Graduate thesis evaluation from Department of Agricultural Entomology, Agricultural College and Research Institute, Madurai.

Served as Selection committee member for recruiting the Senior Research Fellow under the ITMU project at ICAR–NBAIR Bengaluru.

Served as Selection committee member for recruiting the Senior Research Fellow under the DST funded collaborative project on teak defoliator at ICAR–NBAIR Bengaluru.

Invited for an interaction with Shri Pu C Lalrinsanga, Agriculture Dept. Irrigation & Water Resources Co-operation Department, Mizoram and Agricultural Department officials to prepared a roadmap for the non-chemical methods for management of fall armyworm, 16 May 2019.

Facilitated the visit of Officials from Mizoram to ICAR–NBAIR, Bengaluru for mass production of bioagents.

Served as Co chairman for thesis advisory committee member for S.V. Agricultural College, Tirupati.

Delivered a lecture on 'Chemical Ecology methods' at "ICAR-sponsored training on Molecular Identification and DNA Barcoding of Insect Pests

and Natural Enemies including Invasive species", ICAR–NBAIR, Bengaluru, 19 November 2019.

Received Best Scientific worker award of ICAR–National Bureau of Agricultural Insect Resources, Bengaluru for the year 2019-2020 during the NBAIR Foundation day celebration, Karnataka Veterinary Council Hall, Bengaluru, 19 October 2019.

Received 'Excellence and Innovation Award 2019' from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Best oral presentation for the paper entitled 'Developing a matrix for controlled release of diamondback moth *Plutella xylostella* (L.) (Plutellidae: Lepidoptera) pheromone' at the "International conference on Plant Protection in Horticulture: Advances and Challenges" held at ICAR – IIHR Bengaluru, 24–27 July 2019.

Best poster award for the paper entitled 'Electrophysiological and behavioral response of food baits to coconut red weevil *Rhynchophorus ferrugineus* (Oliver) (Coleoptera: Curculionidae)' at the "International conference on Plant Protection in Horticulture: Advances and Challenges" held at ICAR – IIHR Bengaluru, 24–27 July 2019.

Dr G. Sivakumar

Served as expert for Action Plan workshop of KVKs in the Karnataka 2019-20 held at University of Agricultural Sciences, Dharwad, 25–27 April 2019.

Served as External Examiner for Ph.D. Thesis evaluation Jawaharlal Nehru Technology University, Hyderabad.

Chaired the technical session on 'Innovations in Plant Health Management' held at Biotic Science Congress 2019 at Sona College of Technology, Salem organised by Society of Biotic and Environmental Research, Tripura, 26–27 July 2019.

Received 'Outstanding Scientist Award' at Biotic Science Congress 2019 at Sona College of Technology, Salem organised by Society of Biotic and Environmental Research, Tripura, 26–27 July 2019.

Organizing Committee member in International Congress of Biological Control, Davos, Switzerland April 26–30, 2021.

Served as External Examiner for MSc. Qualifying Examination at Tamil Nadu Agricultural University, Coimbatore.

Served as External Examiner for Ph.D. Thesis evaluation of Kuvempu University, Karnataka, Bengaluru.

Served as expert for reviewing the project proposal of UIC-TNAU cluster funded by Biotechnology Industrial Research and Assistance Council (BIRAC), Department of Biotechnology, New Delhi.

Served as Expert committee member for assessing the cases of Scientist under Career Advancement Scheme in the discipline of Microbiology.

Dr M. Mohan

Received 'Outstanding contribution to Science' from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Dr Mahesh Yandigeri

Recognised as Post Graduate teacher for Veterinary Microbiology at Karnataka Veterinary Animal & Fisheries Sciences University, Bidar, Karnataka.

Dr Deepa Bhagat

Served as Reviewer for Seven Biotechnology Industrial Research and Assistance Council (BIRAC) projects, Department of Biotechnology, New Delhi.

Dr K. Sreedevi

Received Fellow award of Entomological Society of India, New Delhi.

Received 'Outstanding contribution to Science Award 2019' from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Received Fellow award of National Academy of Biological Sciences (NABS), Chennai.

Received 'Woman Scientist Award' at Biotic Science Congress 2019 at Sona College of Technology, Salem organised by Society of Biotic and Environmental Research, Tripura, 26–27 July 2019.

Received Best Oral Presentation award for the paper entitled 'Taxonomic diversity and distribution of

white grub fauna (Coleoptera: Scarabaeidae) in India' at International Conference on Plant Protection in Horticulture ICPPH-2019 held at ICAR-Indian Institute of Horticultural Research, Bengaluru, 24–26 July 2019.

Received Best Oral Presentation award for the paper entitled 'Distribution of *Anomala communis* (Burmeister, 1844) (Coleoptera: Scarabaeidae: Rutelinae) in South India: A note on its century long existence' at BioScon 2019 Conference held at Sona College of Technology, Salem during 26–27 July 2019.

Dr Ankita Gupta

Received Best Oral Presentation award in the International Conference on Plant Protection in Horticulture organized by the Association for advancement of pest management in horticulture ecosystems and ICAR- Indian Institute of Horticulture Research, Hessarghatta, 24–27 July 2019.

Received 'Young Women Scientist Award-2019' from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Delivered an invited talk on "Role of NBAIR in integrated pest management" at CABI UK- Egham, 30 May 2019.

Visiting scientist at the Natural History Museum, London from 5 May to 8 June 2019 to study and digitize Indian Braconidae wasps.

Delivered an invited talk on 'Dire need of biodiversity studies in the midst of "sixth mass extinction' at XIX International Plant Protection Congress 2019, Hyderabad, Telangana, 13 November 2019.

Dr R. Gandhi Gracy

Received "International Travel Support" from Department of Biotechnology, Government of India to participate in "Eighth International Symposium in Molecular Insect Science" held at Sitges, Spain, 7–10 July 2019.

Received Dr R.J. Rabindra Team Award -2019 by ICAR-NBAIR, Bengaluru for the research on molecular entomology, insect genomics and database.

Received Women Scientist Award 2019 from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Dr G. Mahendiran

Received 'Young Scientist Award 2019' for Commendable Contribution to Taxonomy and IPM modules from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Dr Jagadeesh Patil

Received 'Young Scientist Award' for significant contribution to Agricultural Entomology, Nematology, Biological control and Biopesticides development from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Best Oral Award for paper entitled "Biocontrol potential of entomopathogenic *Heterorhabditis* and *Steinernema* nematodes against *Phyllognathus dionysius* Fabricius (Coleoptera: Scarabaeidae)" at International Conference on Plant Protection in Horticulture held at ICAR-Indian Institute of Horticultural Research, Bengaluru, 24–27 July 2019.

Dr M. Sampath Kumar

Received 'Young scientist award-2019' for Commendable contribution to taxonomy of spiders and semiochemicals in pest management from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Guided V. Nandha Kumar 2016012022, IV B.Tech (Biotechnology), TNAU, Coimbatore, student for completing his three months Biotechnology Work Experience Programme entitled "Documentation of tea ecosystem spiders from Nilgiris, Tamil Nadu and an attempt on gut content analysis of *Cheiracanthium* sp. (Cheiracanthidae : Araneae)" at ICAR–NBAIR, Bengaluru, 4 September 2019 to 2 December 2019.

Served as Treasurer, Society for Biocontrol advancement, Bengaluru.

Organised Five training programmes (as a programme coordinator), three trainings to NEH officials on FAW management and two trainings to agri- entrepreneurs on mass production of macrobials and microbials.

Dr K. Selvaraj

Recognized as Life fellow of the Entomological Society of India, New Delhi.

Received 'Young Scientist Award' from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Dr S. Salini

Received 'Young Woman Scientist Award' from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Dr K.J. David

Received Young Scientist award from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Dr U. Amala

Received Best Oral presentation award for the paper entitled "Influence of native bee, *Amegilla violacea* (Anthophorini: Apidae) on pollination and fruit set of brinjal, *Solanum melongena*" during International Conference on Plant Protection in Horticulture, ICAR-Indian Institute of Horticultural Research, Bengaluru during 24–27 July 2019.

Received 'Young Women Scientist Award' for significant contributions in the area of Native Bee Ecology from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Dr Richa Varshney

Delivered a lead talk on 'Prospects for predatory mirids in biological control' in the Symposium on Biological control – prospects and associated challenges at XIX International Plant Protection Congress 2019, Hyderabad, Telangana, 10–14 November 2019.

Received 'Young Woman Scientist Award' for significant contribution in biological control from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

Ms R. R. Rachana

Received 'Young Woman Scientist Award-2019' for significant contribution to Biosystematics and Taxonomy of Thysanoptera from Dr B. Vasantharaj David Foundation at the National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology", Chennai, 17 November 2019.

NBAIR team of scientists at the Dr B. Vasantharaj David Foundation awards ceremony

Dr T. Venkatesan receiving Sithanantham Award-2019 instituted by AAPMHE

8. AICRP COORDINATION UNIT AND CENTRES

The biocontrol technologies developed at NBAIR are field–tested, validated and demonstrated on a large scale under the All-India Coordinated Research Project on Biological Control of Crops Pests by selected ICAR institutes and State Agricultural Universities.

Coordination Unit

• ICAR–National Bureau of Agricultural Insect Resources, Bengaluru	Basic research

State Agricultural University-based centres

• Acharya N.G.Ranga Agricultural University, Hyderabad	Sugarcane, maize
• Anand Agricultural University, Anand	Cotton, pulses, oilseeds, vegetables, weeds
• Assam Agricultural University, Jorhat	Sugarcane, pulses, rice, weeds
• Central Agricultural University, Pasighat	Rice, vegetables
• Dr Y.S. Parmer University of Horticulture and Forestry, Solan	Fruits, vegetables, weeds
• Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar	Plant disease antagonists
• Kerala Agricultural University, Thrissur	Rice, coconut, weeds, fruits
• Maharana Pratap University of Agriculture and Technology, Udaipur	Maize, vegetables
• Mahatma Phule Krishi Vidyapeeth, Pune	Sugarcane, cotton, soybean, guava
• Orissa University of Agriculture and Technology, Bhubaneswar	Rice, vegetables
• Professor Jayashankar Telangana State Agricultural University, Hyderabad	Cotton, pulses, oilseeds, sugarcane
• Punjab Agricultural University, Ludhiana	Sugarcane, cotton, oilseeds, rice, tomato, weeds
• Sher-e-Kashmir University of Agriculture Science and Technology, Srinagar	Temperate fruits, vegetables
• Tamil Nadu Agricultural University, Coimbatore	Sugarcane, cotton, pulses, tomato, papaya, cassava
• University of Agricultural Sciences, Raichur	Oilseeds, pulses, millets, cotton
• Indira Gandhi Krishi Viswavidhyalaya, Raipur	Rice, pulses, vegetables
• KAU–Regional Agricultural Research Station, Kumarakom	Rice, plantation crops, vegetables
• Kerala Agricultural University, Vellayani	Rice, papaya, cassava
• Uttar Banga Krishi Vishwavidyalaya, Pundibari	Rice, maize, vegetables, pulses

ICAR Institute-based centres

• ICAR–Central Plantation Crops Research Institute, Kayangulam	Coconut, arecanut
• ICAR–Indian Institute of Horticultural Research, Bengaluru	Fruits, vegetables
• ICAR–Indian Institute of Rice Research, Hyderabad	Rice
• ICAR–Indian Institute of Vegetable Research, Varanasi	Vegetables
• ICAR–National Centre for Integrated Pest Management, New Delhi	Biocontrol in IPM
• ICAR–Central Institute for Subtropical Horticulture, Lucknow	Tropical fruits

• ICAR–Central Tobacco Research Institute, Rajahmundry	Tobacco
• ICAR–Indian Institute of Millet Research, Hyderabad	Maize, sorghum and other millets

Voluntary centres

- Dr Y.S.R. Horticultural University, Ambajipeta
- Sun Agro Biotech, Chennai
- Panjabrao Deshmukh Krishi Vidyapeeth, Akola
- SKUAST–Jammu, Rakh Dhiansar
- Nagaland University, Medziphema
- National Institute of Plant Health Management, Hyderabad

9. ONGOING RESEARCH PROJECTS

A. Institute Projects for 2019

DIVISION OF GERMPLASM COLLECTION AND CHARACTERISATION

I. Biosystematics of agriculturally important insects and associated fauna

1. Taxonomy of Pseudococcidae, Coccidae and Diaspididae (Hemiptera Coccoidea) (01.04.2017 to 31.03.2022) – Dr Sunil Joshi

2. Biosystematics studies on Scarabaeidae of Coleoptera (22.06.2017 to 31.03.2022) – Dr. K. Sreedevi

3. Taxonomic studies on Indian Curculionidae (Coleoptera) with emphasis on Entiminae (01.07.2016 to 31.03.2021) – Dr G. Mahendiran

4. Taxonomy and biocontrol potential of entomopathogenic nematodes in Deccan Plateau of India (01.04.2017 to 31.03.2022) – Dr Jagadeesh Patil

5. Taxonomic Studies on Fruit Flies (Diptera: Tephritidae) of India (01.04.2012 to 31.03.2020) – Dr K.J. David

6. Taxonomic studies on Pentatomidae (Hemiptera: Pentatomoidea) of India with special reference to Pentatominae (14.03.2012 to 31.03.2020) – Dr S. Salini

7. Taxonomy, diversity and host-parasitoid association of Ichneumonoidea: Braconidae with special reference to Braconinae, Doryctinae & Microgastrinae (09.05.2016 to 31.03.2021) – Dr Ankita Gupta

8. Digitization of type specimens and cataloguing of voucher specimens in ICAR-NBAIR reference collections. (01.04.2018 to 31.03.2023) – Dr Ankita Gupta

9. Taxonomy of Indian spiders (Araneae) with reference to agro ecosystem (01.07.2016 to 31.03.2021) – Dr M. Sampath Kumar

10. Taxonomy and diversity of Indian Thysanoptera with special reference to Terebrantia (01.10.2015 to 31.03.2021) – Ms R. R. Rachana

11. Taxonomy of Indian Trichogrammatidae (Chalcidoidea: Hymenoptera) and evaluation of potential species (01.09.2016 to 31.03.2022) – Dr Navik Om Prakash Samodhi

DIVISION OF GENOMIC RESOURCES

II. Molecular characterization, genomics and bioinformatics of agriculturally important insects, entomopathogenic nematodes and associated microorganisms

12. Studies on molecular and functional diversity of EPN-EPB-insect tritrophism and their utilization against soil pests (08.07.2016 to 31.03.2021) – Dr M. Nagesh

13. Molecular characterization and DNA barcoding of agriculturally important parasitoids and predators (01.06.2013 to 31.05.2020) – Dr T. Venkatesan

14. Molecular characterization and DNA barcoding of subterranean insects (01.04.2014 to 31.03.2020) – Dr K. Srinivasa Murthy

15. *Bacillus thuringiensis* – Fermentation and formulation strategies for enhanced toxicity against insect pests (01.04.2017 to 31.03.2020) – Dr R. Rangeshwaran

16. Population genetic diversity in selected insect borer of economic importance (01.04.2018 to 31.03.2022) – Dr M. Mohan

17. Development of Interactive Mobile Apps for Non-chemical methods in insect pest management (01.04.2017 to 31.03.2020) – Dr M. Pratheepa

18. Molecular docking studies of insecticide resistance gene of storage pests: *Tribolium castaneum* (Herbs) and *Callosobruchus maculatus* (Fabricius) (01.04.2017 to 31.03.2020) – Dr M. Pratheepa

19. Studies of detritivorous insects and associated microorganisms for their scope in farm waste management (01.10.2016 to 31.03.2020) – Dr Mahesh S. Yandigeri

20. Taxonomy and diversity of Sphecidae (01.09.2014 to 31.03.2020) – Dr R. Gandhi Gracy

21. Exploration of induced Hormesis for the possible role in enhanced efficacy of biocontrol agent (01.09.2017 to 31.03.2019) – Dr R. Gandhi Gracy

22. Studies on insecticide and *Bt* resistance in pink bollworm, *Pectinophora gossypiella* (Saunders) (01.09.2016 to 31.03.2020) – Dr R.S. Ramya

23. Identification and Molecular characterisation of Indian Tachinids associated with Lepidoptera (01.04.2019 to 30.06.2023) – Dr R.S. Ramya

24. Molecular Characterization and diversity of Megachilidae (31.04.2019 to 31.03.2023) – Dr. Veeresh Kumar

DIVISION OF GERMPLASM CONSERVATION AND UTILISATION

III. Biodiversity conservation, behavioural studies and maintenance and utilisation of arthropod germplasm

25. Behavioural manipulation techniques for the management of some important insect pests using olfactory and visual cues (01.07.2017 to 31.07.2021) – Dr N. Bakthavatsalam

26. Climate change effect on the diversity and bioecology of some important sucking pests (01.04.2014 to 31.03.2021) – Dr N. Bakthavatsalam

27. Endophytic establishment of *Beauveria bassiana* and *Metarhizium anisopliae* in cabbage for management of diamond backmoth (*Plutella xylostella* (L.)) (01.04.2017 to 31.03.2020) – Dr B. Ramanujam

28. Gall formers of important crops and their management (01.04.2017 to 31.03.2021) – Dr A.N. Shylesha

29. Effect of pollinator friendly crop plants in enhancing pollination and yield in selected crops (01.04.2017 to 31.03.2020) – Dr T.M. Shivalingaswamy

30. Documenting agriculturally important mites and establishing an authentic collection (01.04.2014 to 31.03.2021) – Dr P. Sreerama Kumar

31. Exploiting the olfactory cues for management of key stored product pests (01.04.2019 to 31.03.2024) – Dr Kesavan Subaharan

32. Characterization of viruses with special reference to Lepidoptera & Coleoptera (24.11.2015 to 31.03.2021) – Dr G. Sivakumar

33. Developing controlled release formulations for major pests (03.10.2018 to 02.10. 2021) – Dr. Deepa Bhagat

34. Studies on tospovirus-thrips interactions and ecofriendly management of the vector (01.08.2017 to 31.03.2020) – Dr A. Kandan

35. Studies on whiteflies and associated natural enemies for their management (19.09.2016 to 31.03.2021) – Dr K. Selvaraj

36. Habitat manipulation as a tool to conserve beneficial insects (15.07.2016 to 31.03.2021) – Dr U. Amala

37. Studies on exploitation of insects as food and feed (01.01.2017 to 31.03.2019) – Dr U. Amala

38. Diversity and predator-prey interactions in predatory mirids and geocorids (01.10.2015 to 31.03.2019) – Dr Richa Varshney

B. List of Externally Funded Projects for 2019

DIVISION OF GERMPLASM COLLECTION AND CHARACTERISATION

1. DBT: Multifaceted exploration of edible molluscs of North East India (18.07.2018 to 17.07.2021) – Dr K. Sreedevi

2. DST: Biogeography, systematics and molecular characterization of white grub fauna (Coleoptera: Scarabaeidae) of South India (19.11.2018 to 18.11.2021) – Dr K. Sreedevi

3. CABI: Insect Biodiversity documentation in Sikkim region including research into the potential for biological control of *Hedychium* species using Indian natural enemies (2018 to 2020) – Dr Ankita Gupta

4. Bioversity International: Biodiversity of insect pests and natural enemies in organically grown land races of rice at Chengalpattu, Tamil Nadu (01.03.2019 to 01.03.2022) – Dr M. Sampath Kumar

5. DST: Systematic studies on fruit flies of subfamily Tephritinae (Diptera: Tephritidae) from south India with special reference to Western Ghats (30.03.2019 to 29.03.2022) – Dr K.J. David.

6. Systematics studies on Pentatominae (Hemiptera: Heteroptera: Pentatomidae) from North East India – Dr S. Salini (03.01.2020 to 03.01.2023)

DIVISION OF GENOMIC RESOURCES

7. NICRA: Development of IPM strategies to combat whitefly and other emerging pests in cotton (2016-2020) – Dr T. Venkatesan

8. AMAAS: Exploitation of endosymbionts of insect pests for pest management (01.04.2017 to 31.03.2020) – Dr Mahesh S. Yandigeri

9. ICAR-CRP on Genomic platforms (01.04.2015 to 31.03.2020) – Dr M. Mohan

10. DST: Studies on pollination dynamics, pod yield and oil content in *Pongamia pinnata* (26.02.2018 to 31.02.2021) – Dr Veeresh Kumar

11. Network project on Agricultural bioinformatics and computational biology (31.03.2014 to 31.03.2020) – Dr T. Venkatesan

12. Tropical Nanosciences Pvt Ltd: Evaluation of bio-efficacy of TagNOK, a microbial formulation against fall armyworm *Spodoptera frugiperda* in maize (*Zea mays*) (10.11.18 to 09.11.19) – Dr M. Mohan

DIVISION OF GERMPLASM CONSERVATION AND UTILISATION

13. DST: Signalling mechanism in the tri-trophic interaction between Brassicacious plants and their insect pest and parasitoid of the pest (14.11.2018 to 31.03.2021) – Dr N. Bakthavatsalam.

14. Development of sustainable management tools for the invasive pest FAW, *Spodoptera frugiperda* (J. E. Smith) in maize – Dr N. Bakthavatasalam (November 2019 to October 2020)

15. AMAAS: Exploitation of endophytism of entomopathogenic fungi for insect pest management in groundnut, soybean, pigeonpea and chickpea (01.04.2014 to 31.03.2020) – Dr B. Ramanujam

16. DBT: Wide use of the Foldscope as a research tool: Attesting the utility of the Foldscope in agriculture and demonstrating its value to farmers in crop protection (20.03.2018 to 19.09.2019) – Dr P. Sreerama Kumar

17. CDB: Biological control of invasive rugose spiralling whitefly *Aleurodicus rugioperculatus* using *Encarsia guadeloupae* in coconut (04.08.2017 to 31.03.2020) – Dr K. Selvaraj

18. KCPM: Characterisation and application of virulent strains of nucleopolyhedrosis viruses (NPV) *Bacillus thuringiensis* (*Bt*) and entomopathogenic nematodes (EPN) for the management of rice armyworm *Spodoptera mauritia* (10.10.2017 to 9.10.2019) – Dr G. Sivakumar

19. NTRF: Feasibility of suppression of tea shot hole borer *Euwallacea fornicates* through its mutualistic *Fusarium* sp. (01.01.2016 to 31.03.2019) – Dr G. Sivakumar

20. DBT: Developing a nanomatrix for delivery of pheromone synergists of house fly, *Musca domestica* L. (01.03.2018 to 01.03.2021) – Dr K. Subaharan

21. DST JNCASR TRC: Controlled release dispenser for delivery of rice stem borer, *Scirpophaga incertulus* and citrus leaf miner, *Phyllocnistis citrella* pheromone (04.02.2018 to 04.04.2020) – Dr K. Subaharan

22. CABI: Emergency response to address Fall Armyworm, (*Spodoptera frugiperda*) in India through deployment of proven IPM technologies for its management (2018-2020) – Dr A. N. Shylesha

10. ACTIVITIES OF ITMU

Technologies developed

1. Multiple insecticide tolerant strain of egg parasitoid, *Trichogramma chilonis.*
2. High temperature tolerant strain of egg parasitoid, *Trichogramma chilonis.*
3. Pesticide tolerant strain of aphid lion, *Chrysoperla zastrowi sillemi*, an important predator of sucking pests.
4. Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs and other soil insect pests.
5. Novel WP formulation of *Pochonia chlamydosporia* as bio-nematicide against plant parasitic nematodes.
6. Liquid formulation of *Bacillus thuringiensis.*
7. Powder-based formulation of *Pseudomonas fluorescens*, a DAPG producing abiotic stress tolerant isolate for rain fed and stressed agricultural soil.
8. Closed system for mass production of predatory mites.
9. A dispenser for the monitoring of eucalyptus gall wasp.
10. Bioformulation of salinity tolerant *Trichoderma harzianum* with biocontrol potential.
11. Bioformulation of carbendazim tolerant *Trichoderma harzianum* with biocontrol potential.
12. Powder–based formulation of *Bacillus megaterium* as growth promoter.
13. A plant volatile based attractant for enhanced attraction of fruit fly.
14. A simple technique of rearing brinjal shoot and fruit borer, *Leucinodes orbonalis.*
15. Protocol for designing lure for impregnating parapheromone 4[4-acetoxy) phenyl-butanone to attract male flies of *Bactrocera* spp. attacking cucurbit crops for mass trapping and monitoring its population thereof.
16. Control release dispensers for semiochemicals.
17. Mass production of *Trichogramma chilonis* and *T. embryophagum* using Eri silkworm eggs
18. A herbal based repellent for termites on woody trees-REPTER
19. A herbal swabber for the management of white stem borer *Xylotrechus quadripes* in coffee (organic and non-pesticidal). B. Booster for boosting plant health in coffee (not for certified organic coffee)
20. Adsorption and delivery of molecules using nanoporous materials.
21. Shatpada Dorsa-Delta an efficient trap for Mango fruit fly
22. A technique for rearing of Housefly parasitoid *Spalangia*.
23. A technique for rearing of Housefly parasitoid *Nasonia vitripennis* (Pteromalidae)
24. Waste to wealth: Technology on black soldier fly mediated bioconversion of farm and kitchen wastes
25. Insect repellent formulation and methods thereof
26. Novel device for field release of Parasitoids
27. *Metarhizium anisopliae* ICAR–NBAIR Ma 4 for management of white grubs in sugarcane.
28. Long-term storage of *Trichogramma chilonis* (Ishii)

Technologies commercialised

1. Closed system for mass production of predatory mites
2. Waste to wealth: Technology on black soldier fly mediated bioconversion of farm and kitchen wastes

Achievements of ITMU under National Agriculture Innovation Fund Project

- Total technologies ready for commercialisation: 28

- Number of technologies commercialised: 2
- Number of licensees that purchased technologies from NBAIR: 3
- Industry Interface meet conducted**:** 1

Patents filed

- Nanogels, methods and devices thereof for managing *Holotrichia consanguinea,* (Application No. EP17827142, dated 15 March 2019) (Primary innovator: Dr Deepa Bhagat).
- Surface functionalization for sensing of volatile organic carbonyl compounds, patent (Application No. 3696/CHE/2015 FER, dated 21 February 2019) (Primary innovator: Dr Deepa Bhagat).
- A reusable charge transfer based agrogel (Application No. 201741016464, dated 11 November 2019 (Primary innovator: Dr Deepa Bhagat).
- Nanoemulsion composition for pest management (Application No. 201911051051 dated on 10 December 2019) (Primary innovator: Dr K. Subaharan).

Revenue generated during 2019 (April to December 2019)

The total revenue generated was ₹21,32,976/- through following activities.

Details	Revenue generated (₹)
Commercialisation of technologies	2,00,000
Sale of macrobials	7,24,656
Sale of microbials	3,21,580
Contract research	8,00,000
Training	84,370
Sale of publications	2,370
Total	**21,32,976**

MOU being exchanged between NBAIR and BioTherm Flavour and Fragrance, Bengaluru

MOU being exchanged between NBAIR and Dhanwantari Pvt. Ltd., Satara

MOU being exchanged between NBAIR and Vijay Ganesan, Komarapalayam

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11. PUBLICATIONS

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13. MEETINGS AND DECISIONS

XXIII Research Advisory Committee Meeting

The XXIII meeting of the Research Advisory Committee (RAC) of the National Bureau of Agricultural Insect Resources was held on 4 May 2019, in the conference hall of NBAIR.

The following members of the RAC attended the meeting:

Dr S.N. Puri	Chairman
Dr P.K. Chakrabarty	Member
Dr S.Rajan	Member
Dr Chandish R. Ballal	Member
Dr V.V. Ramamurthy	Member
Dr Joseph Bhagyaraj	Member
Dr Suresh Nair	Member
Dr S. Lingappa	Member
Dr Suraj Singh Rajput	Member
Dr K. Srinivasa Murthy	Member-Secretary

General Comments

Dr Chandish R. Ballal, Director of ICAR–NBAIR welcomed the Chairman and members of the RAC and highlighted the achievements made by the institute including the research outputs, publications, commercialization and revenue generated.

1. ICAR–NBAIR can organize a brainstorming session for all the plant protection institutes including state Departments for FAW management.
2. Traditional practice can be integrated and validated for the management of storage grain pests.
3. ICAR–NBAIR should strengthen the quarantine lab/section to facilitate smooth import of natural enemies from other countries.
4. Biological control studies of citrus pests should be initiated in collaboration with AICRP centres.
5. Attempts could be made to adopt villages for demonstration and promotion of Biocontrol technologies on village basis through MCRP centers.
6. Economics or success stories to be quantified and impact on environment must be assessed.
7. It is important for ICAR-NBAIR scientists to network with scientists of national and international institutes.
8. Presentations during RAC must be confined to mandate of the Division and care must be taken to avoid overlapping in presentations by the Divisions.
9. Brain storming sessions with all ICAR institutes on the collaborative work may be conducted.
10. Biosecurity issues for invasive pests in the countries, from where agricultural commodities are imported may be probed in details.
11. Emphasis should be on digitalization of type specimen.
12. We will have to be cautious in informing the occurrence of recent invasive pests taking into consideration export potential of commodities from our country.

The following comments / suggestions were given by the RAC:

I. Division of Germplasm Collection and Characterization

Dr Sunil Joshi presented the report on the projects handled in the division.

Recommendations

1. ICAR–NBAIR should explore the possibilities of international exposure /training for improving level of taxonomic expertise and to stand out as experts in their respective taxonomic group, in which they are working.
2. It is important for taxonomists to come out with monographs.
3. ICAR–NBAIR should initiate collaboration with International / Indian experts in the field of taxonomy and have updated information on latest developments.
4. Database/mapping on invasive pests to be developed by ICAR-NBAIR. NBAIR may provide links on the website for databases created by other Institutes (Viz. NCIPM,

NIBSM, NBAIM) for invasive pests and diseases.

5. Attempts may be made to obtain duplicate specimens from other Museums and Institutes to strengthen the ICAR-NBAIR's museum collections.
6. Ecology of EPNs and their performance under stressed conditions must be studied.
7. Along with documenting natural enemies, information on field parasitism of FAW by natural enemies may be generated.

II. Division of Genomic Resources

Dr M. Nagesh presented the research achievements of the Division.

Recommendations

- Studies on genetic groups of whitefly biotypes as per the international classification may be taken up and morphological differentiation to be documented along with molecular characters.
- Work on Insecticide resistance of Pink bollworm may be discontinued as it is being carried out at many places under insect resistance management programme.
- Molecular characterization of local or native NPVs isolated and found effective against FAW, needs to be carried out and compared with other NPV strains.
- Develop molecular identification of ICAR-NBAIR strains of Bt including ICAR-NBAIR Bt 25 that are effective against FAW
- Molecules/ proteins/ moieties that are identified to play role in insecticide resistance in stored grain pests through in silico techniques need to be validated through in vivo lab studies, In-silico techniques would be of tremendous significance in predicting and managing insecticide resistance among stored grain pests.

III. Division of Insect Germplasm Conservation and Utilization

Dr N. Bakthavatsalam presented the research achievements of the Division.

Recommendations

- Alternate hosts such as eggs of pentatomid or mirid bugs which can be easily reared, can be explored for the multiplication of parasitoids of litchi stink bug as the present technology using eri silk worm may be uneconomical since silk worm is an important insect for silk industry.
- Studies on ecofriendly storage pest management including use of biofumigants and semiochemicals may be taken up in order to develop robust technologies to reduce the economic losses and pesticide pollution.
- Scientists from ICAR-NBAIR may collaborate with the centres of AICRP-Honey bee and pollinators.
- Synthesis of pheromone compounds of *Lepidiota mansueta* may be initiated with the collaboration of AINP on Soil arthropods and ATGC.
- Effective biocontrol methods may be developed for the 20-60 days old maize crop which is the vulnerable period for the attack of *Spodoptera frugiperda*.
- Endophytic *Beauveria bassiana* and *Metarhizium anisopliae* isolates from other research centres may be explored by ICAR-NBAIR.
- Search may be carried out for parasitoids or predators for late instars of RSW, *Aleurodicus rugioperculatus*.
- Mass production of predatory mites, especially for the management of mite pests in protected cultivation crops may be initiated.
- IPM strategies for *Spodoptera frugiperda* including need based chemical treatments may be worked out and evaluated for kharif maize.

IV. Institute Technology Management Unit

Dr T. Venkatesan, Officer i/c ITMU, presented the report.

Recommendations

- Rider to be included at the time of MoU with Licensee companies to maintain the standard and recommended dose of EPN/biopesticides.
- Institutional credit must be maintained.

XXXX Institute Research Council

Meeting

- The XXXX Institute Research Council Meeting of the ICAR-NBAIR, Bengaluru was held on 01–03 July 2019 under the Chairmanship of Dr Chandish R. Ballal, Director, ICAR–NBAIR.

General Comments

- Cover maximum area with macrobials and microbials for FAW management in selected areas (Action: M. Nagesh, J. Patil, Richa Varshney, G. Sivakumar, R. Rangeshwaran, B. Ramanujam)
- Unpublished research data if any along with copies of two publications to be given to Dr Pratheepa for uploading in the portal (Action: All Scientists)
- Research greenhouse to be proposed in the new EFC on rooftop at main campus and in the farm (Attn: Dr Nagesh)
- Maintain database on list of microbial cultures and date of supply which has to be put up on NBAIR website (Action: All Pathologists/ Microbiologists)

Note:

All Heads to ensure that ATR of previous IRC and IRC comments of 40th IRC are included by the scientists in the respective RPP II, before sending it to PME Cell. The RPP II should be submitted by 15.08.2019.

The scientists whose projects are closed should submit the copy of RPP-III and RPP IV where commercialization is involved to PME Cell. The same may be uploaded in PIMS on or before 15.08.2019.

XXIII RAC Meeting in progress

14. PARTICIPATION OF SCIENTISTS IN MEETINGS

Abroad

Dr Chandish R Ballal & Dr A.N. Shylesha	Workshop on Fall Armyworm-Preparedness and Management, Lalitpur, Nepal, 29–31 July 2019.
Dr P. Sreerama Kumar	Society for Invertebrate Pathology/IOBC 2019, Valencia, Spain, 28 July–1 August 2019.
Dr K. Sreedevi	Immature Beetles Meeting 2019, Department of Environmental Sciences at Charles University, Prague, Czech Republic, 3–4 October 2019.
Dr R. Gandhi Gracy	Eighth International Symposium on Insect Molecular Science, Sitges, Spain, 7–10 July 2019.

India

Dr Chandish R Ballal	Brainstorming Meeting on Agrobiodiversity Index and Ecosystem services, Bioversity International, New Delhi, 15 April 2019. Fall Armyworm Regional Workshop at ICRISAT, Hyderabad, 1–3 May 2019. Training on production of bioagents, BHEL Ashankura Trust, 3 April 2019. 91st ICAR Foundation Day and Award Ceremony, NASC Complex, New Delhi, 16 July 2019. ICAR-Directors' Conference, NASC Complex, New Delhi, 17 July 2019. Invited lecture at International Conference on Plant Protection in Horticulture: Advances and Challenges (ICPPH-2019), ICAR-IIHR, Bengaluru, 24 July 2019. 63rd RCC meeting of Central Silk Board, Central Silk Board, Bengaluru, 25–26 July 2019. Meeting on Mission National Biodiversity, PSA, 5 August 2019 Meeting at National Innovation Foundation, Gandhinagar, 21 August 2019. RAC Meeting of Central Sericulture Germplasm Resources Centre, Hosur, 30 August 2019. External Expert meeting, University of Agricultural and Horticultural Science, Shivamogga, 9 September 2019. Farmers interaction meeting, KVK Hassan, 12 September 2019. Global Organic Convention 2019 on National Resources Management for Sustainable Agriculture, Soil Health & Quality Food, Akola, 16 September 2019.

Dr Chandish R Ballal	176th RCGM Meeting, Department of Biotechnology, New Delhi, 11 October 2019. Third Consultation Meeting on National Mission on Biodiversity and Human Wellbeing, New Delhi, 16 October 2019. Inaugural meeting of Krishi Mela 2019, University of Agricultural Sciences, Bengaluru, 24 October 2019. Thematic Consultation Meeting on Biodiversity, Agriculture & Nutritional Security, National Mission on Biodiversity & Human Wellbeing, Bengaluru, 29 October 2019. AICRP Review Committee meeting, NASC Complex, New Delhi, 30 October 2019. Review meet at farmers *Trichogramma* production unit in Kerala, 1 December 2019. Indian National Science Academy (INSA) Anniversary meeting, Goa, 16–18 December 2019. DPC meeting for promotion of Scientist (Agri Entomology), ICAR-NCIPM, New Delhi, 23 December 2019.
Dr B. Ramanujam	Research Advisory Committee meeting, Institute of Wood Science and Technology, Bengaluru.
Dr Sunil Joshi	Selection committee meeting for promotion of ARS scientist, ICAR – Sugarcane Breeding Institute, Coimbatore, 10 December 2019.
Dr M. Nagesh	Regional Expert Consultation meeting on Gene Editing in Agriculture and Biosafety Regulation, International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, October 10–11 2019.
Dr T. Venkatesan	Review meeting on Network Project on Agricultural Bioinformatics and Computational Biology under CABin Scheme, 02 November 2019. Board of Examiner meeting of GPS Institute of Agricultural Management, Bengaluru University, 06 December 2019. National Consultation meeting on Genomics and Bioinformatics, 27 November 2019, New Delhi. CABI-FAW Review Meeting, 15 November 2019. Advisory committee Meeting of PhD (Agri. Entomology) student, Dept. of Entomology, University of Agricultural and Horticultural Science, Shivamogga, 7 September 2019. Expert meeting, Central Sericultural Germplasm Resources Centre, Hosur, 22 October 2019. ICAR Expert committee meeting, NASC Complex, New Delhi, 14 October 2019.

Dr P. Sreerama Kumar	Awareness programme on Demonstration on Integrated Pest Management in Mulberry, Mothersabaradoddi, Ramanagara district, Karnataka, 29 August 2019. XXVI Annual Review Meeting of the All-India Coordinated Research Project on Weed Management, Assam Agricultural University, Jorhat, 15–16 October 2019. Meeting to Discuss Management of Aquatic Weeds in Kuttanad, Thrissur, 12 December 2019.
Dr Deepa Bhagat	XI State Level Forestry & Wildlife Research Advisory Committee meeting, Bengaluru, 05 January 2019. Curtain raiser meeting of Bengaluru India Nano, Hotel Ashoka, Bengaluru, 17 January 2020. XX Group Meeting of All India Network project on Soil Arthropod Pests at University of Agricultural Sciences, Bengaluru, 01–02 March 2019. Biotechnology Industrial Research and Assistance Council (BIRAC) Regional Techno- Entrepreneurship Promotion Centre meeting in partnership with KIIT-Technology Business Incubator, Bhubaneswar established by BIRAC (Biotechnology Industrial Research Assistance Council), Govt. of India. Webinar on DBT's Competitive Grant System, 25 October 2019.
Dr K. Sreedevi	Consultation meeting on Digital Sequence Information at Ministry of Environment, Forest and Climate Change (MoEF & CC), New Delhi, 30 July 2019. Review meeting of All India Network Project on Soil Arthropod pests, University of Agricultural Sciences, Bengaluru, 1–2 March 2019. Advance workshop on the National and International Framework for the Conservation of Biodiversity, National Law School of India, Bengaluru, 18–22 February 2019.
Dr Mahesh Yandigeri	Farmers Scientists Interactive Meet on FAW management, Doddaballapura, 3 August 2019.
Dr Ankita Gupta	ICAR–CABI meeting, 17 July 2019 & 18 August 2019. FAO meeting, ICAR–NBAIR, Bengaluru, 22 July 2019.
Dr M. Sampath Kumar	Meeting on Management of Aquatic Weeds in Kuttanad, Thrissur, 12 December 2019.
Dr K. Selvaraj	Seventh Annual Review Workshop on NICRA, New Delhi, 17–18 December 2019.
Dr Navik Omprakash Samodhi	Training Programme on Organic Farming, Organic Farming Research and Training Centre, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, 02–04 December 2019.
Dr T. Venkatesan Dr G. Sivakumar Dr K. Sreedevi	Biotic Science Congress 2019, Sona School of Management, Salem, 26–27 July 2019.

Multiple scientists	National Conference on "Trends in Higher Education, Taxonomy, Agriculture, Biotechnology & Toxicology, Chennai, 17 November 2019. XXVIII Annual Group meeting of All–India Coordinated Research Project on Biological Control of Crop Pests, Anand Agriculture University, Anand, 6–8 June 2019. NBAIR–Industry Interface Meet, ICAR–NBAIR Bengaluru, 26 June 2019. International Conference on Plant Protection in Horticulture: Advances and Challenges, ICAR–IIHR, Bengaluru, 24–27 July 2019. Farmers-Scientists Interactive Meet on FAW management, ICAR-NBAIR, Bengaluru, Yelahanka, 03 August 2019. XIX International Plant Protection Congress 2019, Hyderabad, Telangana, 10–14 November 2019.

15. TRAININGS CONDUCTED

S. No.	Trainee(s)	Particulars of the training programme	Date(s)	Coordinator(s)** / Resource person(s)*	No of participants
1.	Ms. N. Lavanya Scientific officer NIPHM, Hyderabad	Isolation, identification, mass production, formulation of entomofungal pathogens	15–14 April 2019	Dr B. Ramanujam*	1
2.	Differentially abled persons, BELASJT, Bengaluru	Tricho card making, handling of Chrysopids larvae and seed treatment techniques using *Trichoderma*	03 April 2019	Dr Y. Lalitha*	13
3.	Agripreneurs: Mr. R. Rajesh, Bengaluru; Mr. R. Palaneeswar, Jeypee biotech, TN; Mr. Kamal Sandeep, Kakinada, AP; Mr. Rajeev Ojha, Maharashtra: Dr. Y. Sreevalli, Hyderabad	Mass production of macrobials and microbials including EPN	06–09 May 2019	Dr M. Sampath Kumar** Dr B. Ramanujam* Dr R. Rangeshwaran* Dr G. Sivakumar* Dr Jagadeesh Patil* Dr Richa Varshney* Dr Y. Lalitha*	5
4.	ICAR Scientist Probationer, Mr. Venkatesh, Y., ICAR-CAFRI, Jhansi, UP.	Professional Attachment Training	15 May–15 August 2019	Dr Veeresh Kumar*	1
5.	State department officials of Karnataka	Mass production of *Trichogramma pretiosum* and *Metarhizium anisopliae* for management of FAW	27 May 2019	Dr B. Ramanujam* Dr Y. Lalitha*	6
6.	Mr. Agney Gautam Raj, Std. X, St. Theresa's School, Bendur, Mangalore	Practicals related to Molecular Biology	21–22 May 2019 & 25 May 2019	Dr K. Subaharan* Dr R. Gandhi Gracy*	1
7.	Agricultural Extension officers, Govt. of Mizoram	Mass production of macrobials and microbials including EPN for FAW management	17–21 June 2019	Dr M. Sampath Kumar** Dr B. Ramanujam* Dr R. Rangeshwaran* Dr G. Sivakumar* Dr Jagadeesh Patil* Dr Richa Varshney* Dr Y. Lalitha*	3
8.	Ph.D. (Entomology) student, BCKV, Mohanpur, West Bengal	Fruit fly identification and taxonomy	04–07 July 2019	Dr K.J. David*	1
9.	M.Sc. (Zoology) students, REVA University, Bengaluru	Mass production of Diamond Back Moth	01 August 2019	Dr Richa Varshney* Dr Y. Lalitha*	4

S. No.	Trainee(s)	Particulars of the training programme	Date(s)	Coordinator(s)** / Resource person(s)*	No of participants
10.	Farmers from Karnataka	Technology awareness for FAW management	03 August 2019	Dr M. Nagesh** Dr A. Kandan** Dr B.K. Choubey** Ms L. Lakshmi**	37
11.	KVK technical officer/scientists of NEH region	Biological control and compatible pest management modules for management of major pests in NEH region with emphasis on FAW-batch I	19–24 August 2019	Dr M. Sampath Kumar** Dr K. Selvaraj** Dr Richa Varshney** Dr Veeresh Kumar** Dr B. Ramanujam**	12
12.	Senior field officer and technical staff, CDB, DSP farm, Mandya	Mass production of *Isaria* fungus and mass rearing technique for *Encarsia guadeloupe* for the management of Coconut RSW	23 August 2019	Dr B. Ramanujam* Dr K. Selvaraj*	2
13.	KVK technical officer/scientists of NEH region	Biological control and compatible pest management modules for management of major pests in NEH region with emphasis on FAW-batch II	16–20 September 2019	Dr M. Sampath Kumar** Dr S. Salini** Dr G. Mahendiran** Dr U. Amala** Dr B. Ramanujam**	9
14.	M.Sc. (Entomology) student, UAS, Raichur, Karnataka	Handling of *Telenomus* culture and its maintenance	22–23 October 2019	Dr Richa Varshney* Dr Y. Lalitha*	1
15.	Ph.D./ M.Sc. (Entomology) students, KAU	Taxonomy of mealybugs	05–15 & 18–24 October 2019	Dr Sunil Joshi*	2
16.	KVK technical officer/scientists of NEH region & Technical staff of VIB, Nimpith, West Bengal	Biological control and compatible pest management modules for management of major pests in NEH region with emphasis on FAW-batch III	14–18 October 2019	Dr M. Sampath Kumar** Dr K.J. David** Dr Jagadeesh Patil ** Dr Omprakash Navik** Dr B. Ramanujam**	8
17.	Asst. Professor, Govt. Science college, Chitradurga	Mass rearing of *Corcyra* and *Trichogramma chilonis*	28 September 2019	Dr Y. Lalitha*	1
18.	Ph.D. Student, University of Calicut, Calicut	Trichogrammatidae identification	18–29 September, 2019	Dr Omprakash Navik*	1
19.	Staffs of KCPM, Alleppey, Kerala	Mass production of macrobials and microbials for rice pest management	28–30 November 2019	Dr G. Sivakumar** Dr B. Ramanujam* Dr R. Rangeshwaran* Dr Jagadeesh Patil * Dr Richa Varshney* Dr Y. Lalitha*	5

S. No.	Trainee(s)	Particulars of the training programme	Date(s)	Coordinator(s)** / Resource person(s)*	No of participants
20.	Scientist/ Assistant Professor of ICAR/ State & Central Agricultural Universities	ICAR sponsored training on "Molecular identification and DNA barcoding of insect pests and natural enemies including invasive species"	18–27 November 2019	Dr T. Venkatesan** Dr Gandhi Gracy** Dr M. Mohan** Dr Veeresh Kumar**	25
21.	Agripreneurs: Mr Saroj Kaanth, Kovvur, A.P. Mr T. Nikhil, Hyderabad	Mass production of macrobials and microbials for pest management	02–04 December 2019	Dr M. Sampath Kumar** Dr B. Ramanujam* Dr R. Rangeshwaran* Dr G. Sivakumar* Dr Jagadeesh Patil* Dr Richa Varshney* Dr Y. Lalitha*	2
22.	Scientist/ Assistant Professor/ Lecturer/ Subject Matter Specialist of ICAR/ State & Central Agricultural Universities	ICAR sponsored 21 days winter school on "Novel techniques in mass culturing of smart microbials biocontrol agents for the development of biopesticides"	03–23 December 2019	Dr G. Sivakumar** Dr M. Mohan** Dr A. Kandan** Dr G. Mahendiran** Dr Jagadeesh Patil**	25
23.	Farmers	Mass production of biocontrol agents for management of fall armyworm (FAW)	27–28 December 2019	Dr Richa Varshney** Dr A. N. Shylesha** Dr N. Bakthavastsalem** Dr Y. Lalitha**	15
24.	Ph.D./M.Sc. (Entomology) students, UAHS, Shivamogga	Taxonomy of mealybugs	23–28 December 2019	Dr Sunil Joshi*	2

ICAR–sponsored 21–day winter school on "Novel techniques in mass culturing of smart microbials biocontrol agents for the development of biopesticides" (03–23 December 2019)

ICAR–sponsored training on "Molecular identification and DNA barcoding of insect pests and natural enemies including invasive species" (18–27 November 2019)

16. DISTINGUISHED VISITORS

- Dr S.N. Puri, Chairman, Research Advisory Committee, ICAR–NBAIR, Bengaluru, 4 May 2019.
- Dr V.V. Ramamurthy, Member, Research Advisory Committee, ICAR–NBAIR, Bengaluru, 4 May 2019.
- Dr S. Lingappa, Member, Research Advisory Committee, ICAR–NBAIR, Bengaluru, 4 May 2019.
- Dr Rajan, Member, Research Advisory Committee, ICAR–NBAIR, Bengaluru, 4 May 2019.
- Dr Joseph Bagyaraj, Member, Research Advisory Committee, ICAR–NBAIR, Bengaluru, 4 May 2019.
- Dr Suresh Nair, Member, Research Advisory Committee, ICAR–NBAIR, Bengaluru, 4 May 2019.
- Dr Suraj Singh Rajput, Member, Research Advisory Committee, ICAR–NBAIR, Bengaluru, 4 May 2019.
- Dr B.L. Jalali, Former Director, ICAR–National Centre for Integrated Pest Management, New Delhi, 22 June 2019.
- Mr Tomio Shichirt, FAO Country Director, India, 22 July 2019.
- Ms Anne Sophie Poisot, FAO Advisor, 22 July 2019.
- Dr S.D. Shikhamany, Former Vice Chancellor, Dr YSR Horticultural University, Andhra Pradesh, 23 September 2019.
- Dr Ashok Dalwai, IAS, CEO, National Rainfed Area Authority and Chairman, Empowered Body on Doubling Farmer's Income, Ministry of Agriculture & Farmer's Welfare, 19 October 2019.

Dr Ashok Dalwai, IAS, CEO, National Rainfed Area Authority, at NBAIR on 19 October 2019, the Foundation Day of the bureau

17. MERA GAON MERA GAURAV

Seven teams of scientists/technical officers have adopted a total of 18 villages in Karnataka and Tamil Nadu. The teams visited their respective adopted villages every month and conducted farmer centric activities including demonstrations and providing technical guidance and information to the farmers. Farmers' gosthies were also conducted on a regular basis to sensitise the farmers about the importance of non chemical modes of pest management.

Awareness creation and empowerment of farmers on fall armyworm management in maize

As part of MGMG, Dr A.N. Shylesha and his team conducted a farmer's awareness meeting on fall armyworm management at the Krishi Vigyan Kendra in Davangere, Karnataka, on 22 August 2019. Around 190 farmers and officials from the Department of Agriculture participated in the programme. NBAIR scientists delivered lectures on the biology of the pest and on its biological control methods. In the interactive session, the queries raised by the farmers were clarified by NBAIR experts.

An awareness–cum–method demonstration programme for FAW management was organized by ICAR–NBAIR along with CABI and University of Agricultural Sciences, Bengaluru at KVK, Hassan on 12 September 2019. There were 110 participants from HN Pura and Alur villages of Hassan District. The participants included 40 input dealers from Hassan District. Information related to identification, biology and management of FAW was explained to the participants. Use of pheromone traps and bioagents for the management of FAW was demonstrated. A programme of Swachh mission to create awareness of cleanliness was conducted during the demonstration.

Field visits were made to provide advisory service for fall armyworm management in sweet corn cultivated for peri-urban market at Gantiganahalli. Field demonstration of wettable powder formulation of *H. indica* for the management of fall army worm in maize was conducted at Chikkaballapur on 12 August 2019.

Field demonstrations of NBAIR technologies for the management of fall armyworm in maize was conducted at Vathamalai in Dharmapuri districts, Samanapalli, Pillekothur, Kaverinagar, Maharajakadai, Rayakottai, Elumichangiri, Earichinnampatti in Shoolagiri Block at Krishnagiri of Tamil Nadu.

Field demonstration of wettable powder formulation of entomopathogenic nematodes, *Heterorhabditis indica* and *Steinernema abbasi* was conducted for the management of brinjal ash weevil at Doddaballpur on 30 December 2019.

NBAIR organised training for the differently abled indivisuals

NBAIR Scientists organised introductory biological control awareness programme for differently abled

persons at BEL Ashankura Silver Jubilee Trust (BELASJIT), Jalahalli, Bengaluru on 3 April, 2019. Mass production protocols of biocontrol agents were explained to the participants in local language. Demonstrations on filling of pots with red soil, use of farmyard manure, vermicompost and method of application of antagonistic fungus, *Trichoderma viride* for the good vigour of the plants were conducted.

Under Mera Gaon Mera Gaurav, 405 trichocards, 3289 *Cryptolaemus montrouzieri*, 39245 numbers of Chrysopids, 4778 numbers of *Goniozus nephantidis* and 311 *Nephus* sp. were supplied to 170 farmers.

Institute's team-wise progress (summary)

Team	No. of scientists involved	No. of field activities conducted	No. of messages/ advisory sent	Farmers involved (No.)
1	5	18	285	300
2	5	32	450	700
3	5	20	550	650
4	5	32	450	500
5	5	35	500	550
6	5	25	450	550
Total	**30**	**162**	**2,190**	**3,250**

Activities organised by ICAR -NBAIR under MGMG

Name of activity	No. of activities conducted	No. of farmers participated & benefitted
Visit to village by teams	8	14,500
Interface meeting/ *Goshthies*	22	4500
Training organized	12	250
Demonstrations conducted	35	5000
Mobile based advisories (No. of messages)	15,700	15,700
Literature support provided	1,000	1,000
Awareness created (No.)	7	5,000
Total	**16,784**	**45,950**

18. EXHIBITION

NBAIR participated in the following exhibition to showcase various technologies developed at the institute:

'Krishi mela' organised at GKVK campus, UAS, Bengaluru on 24–27 October 2019.

Visitors at the NBAIR exhibition stall

19. PERSONNEL

S.No.	Name	Designation
Director		
1.	Dr Chandish R. Ballal	Director
Scientists		
Division of Germplasm Collection and Characterisation		
2.	Dr Sunil Joshi	Principal Scientist (Agricultural Entomology) & Head (In-Charge)
3.	Dr K. Sreedevi	Senior Scientist (Agricultural Entomology)
4.	Dr K.J. David	Scientist (Agricultural Entomology)
5.	Dr S. Salini	Scientist (Agricultural Entomology)
6.	Dr G. Mahendiran	Scientist (Agricultural Entomology)
7.	Dr Ankita Gupta	Scientist (Agricultural Entomology)
8.	Dr Jagadeesh Patil	Scientist (Nematology)
9.	Dr M. Sampath Kumar	Scientist (Agricultural Entomology)
10.	Ms R.R. Rachana	Scientist (Agricultural Entomology) (On study leave from 04.09.2017)
11.	Dr Navik Omprakash Samodhi	Scientist (Agricultural Entomology)
Division of Genomic Resources		
12.	Dr M. Nagesh	Principal Scientist (Nematology) & Head (In-Charge)
13.	Dr T. Venkatesan	Principal Scientist (Agricultural Entomology)
14.	Dr K. Srinivasa Murthy	Principal Scientist (Agricultural Entomology)
15.	Dr R. Rangeshwaran	Principal Scientist (Microbiology)
16.	Dr M. Mohan	Principal Scientist (Agricultural Entomology)
17.	Dr M. Pratheepa	Principal Scientist (Computer Applications)
18.	Dr Mahesh Yandigeri	Senior Scientist (Microbiology)
19.	Dr R. Gandhi Gracy	Senior Scientist (Agricultural Entomology)
20.	Dr R.S. Ramya	Scientist (Agricultural Entomology)
21.	Dr Veeresh Kumar	Scientist (Agricultural Entomology)
Division of Germplasm Conservation and Utilisation		
22.	Dr N. Bakthavatsalam	Principal Scientist (Agricultural Entomology) & Head (In-Charge)
23.	Dr B. Ramanujam	Principal Scientist (Plant Pathology)
24.	Dr A.N. Shylesha	Principal Scientist (Agricultural Entomology)

S.No.	Name	Designation
25.	Dr T.M. Shivalingaswamy	Principal Scientist (Agricultural Entomology)
26.	Dr P. Sreerama Kumar	Principal Scientist (Plant Pathology)
27.	Dr Kesavan Subaharan	Principal Scientist (Agricultural Entomology)
28.	Dr G. Sivakumar	Principal Scientist (Microbiology)
29.	Dr Deepa Bhagat	Principal Scientist (Organic Chemistry)
30.	Dr A. Kandan	Principal Scientist (Plant Pathology)
31.	Dr K. Selvaraj	Scientist (Agricultural Entomology)
32.	Dr U. Amala	Scientist (Agricultural Entomology)
33.	Dr Richa Varshney	Scientist (Agricultural Entomology)
Technical Officers/Assistants		
34.	Dr Y. Lalitha	Chief Technical Officer
35.	Dr B.K. Chaubey	Chief Technical Officer
36.	Mr Satandra Kumar	Chief Technical Officer
37.	Ms L. Lakshmi	Assistant Chief Technical Officer
38.	Mr P.K. Sonkusare	Senior Technical Officer (T6)
39.	Mr H. Jayaram	Senior Technical Officer (T6)
40.	Ms S.K. Rajeshwari	Senior Technical Officer (T6)
41.	Mr P. Raveendran	Technical Officer (T5)
42.	Dr A. Raghavendra	Senior Technical Assistant (Laboratory Technician)
43.	Mr Umesh Kumar Sanjeev	Technical Assistant (Laboratory Technician)
44.	Mr R. Maruthi Mehanth	Technical Assistant (Laboratory Technician) & Cashier
45.	Mr K.M. Venugopala	Technical Assistant (Laboratory Technician)
46.	Mr M. Chandrappa	Senior Technical Assistant (Driver)
47.	Mr R. Narayanappa	Senior Technical Assistant (Generator Operator)
48.	Mr P. Madanathan	Technical Assistant (Driver)
Administrative Staff		
49.	Mr Alok Kumar	Administrative Officer (Transferred to ICAR–CSSRI, Karnal on 24.07.2019)
50.	Mr Malay Bisht	Administrative Officer (Joined NBAIR on 17.09.2019)
51.	Ms S. Kusuma	Assistant Finance & Accounts Officer (deputation from ICAR–IVRI, Bengaluru relieved on 01.08.2019)
52.	Mr A. Vijay Kumar	Assistant Finance & Accounts Officer (deputation from ICAR–NIVEDI, Bengaluru on 29.07.2019)

S.No.	Name	Designation
53.	Mr K.N. Visveswara	Private Secretary to Director (Superannuated on 31.05.2019)
54.	Ms S. Kaveriamma	Private Secretary to Director
55.	Mr Ajit Desai	Assistant Administrative Officer (Deceased on 19.05.2019)
56.	Mr M. Eswar Reddy	Assistant (On deputation to ICAR–NBSS&LUP, Bengaluru from 25.06.2018)
57.	Ms Dipanwita Deb	Assistant Administrative Officer
58.	Ms M.S. Uma	Personal Assistant
59.	Ms Nazia Anjum	Upper Division Clerk
60.	Ms P. Anitha	Lower Division Clerk
Supporting Staff		
61.	Mr Ramakrishnaiah	Skilled Supporting Staff
62.	Mr P. Nagaiah	Skilled Supporting Staff
63.	Ms Sanjeevani Desai	Skilled Supporting Staff (Joined NBAIR on 07.11.2019)