All India Co-ordinated Research Project on Biological Control of Crop Pests

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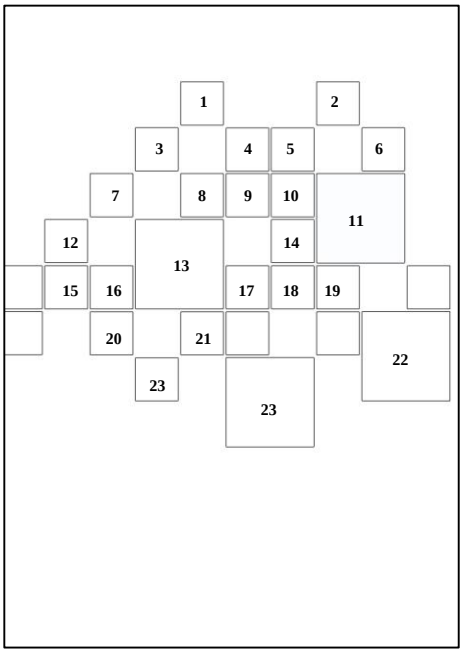
ANNUAL PROGRESS REPORT 2017-18

ICAR - National Bureau of Agricultural Insect Resources
Bengaluru 560 024



Cover page

1. Trapping of *Tuta absoluta* (Meyrick) in delta traps
2. *Heterorhabditis pakistanensis* Shahina *et al*. emerged from *Pieris brassicae* (Linnaeus)
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5. EPN infected larvae of the codling moth
6. *Cydia pomonella* (Linnaeus) adults on apple fruit
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9. Trichocard released in maize crop for large scale evaluation in farmers field
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21. Evaluation of *Nomuraea rileyi* against *Spodoptera litura* (Fabricius)
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23. Distribution of PBAT-3 at Kotabagh, Nainital
24. On farm demonstration of bioagents in farmer's field at Chikaballapur

Photo credits: Photographs 1, 7, 8, 10, 13, 16 & 17 – AAU; 2, 4, 5, 6 & 8 – SKUAST; 3, 14, 22 & 23 – GBPUAT; 9 – MPUAT; 11 & 20 – IGKV; 12 – TNAU; 15 & 24 – NBAIR; 19 – PAU; 21 – MPKV

Cover design: Sunil Joshi

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Technical Programme for 2017-18

I. Basic Research

I. Biodiversity of biocontrol agents from various agro-ecological zones

I.1 National Bureau of Agricultural Insect Resources

I.1.1 Taxonomic and biodiversity studies on parasitic Ichneumonidae wasps

I.1.2 Taxonomic and biodiversity studies on parasitic Platygastroidea

I.1.3 Molecular Characterization and DNA barcoding of agriculturally important parasitoids, predators and other insects

I.1.4 Endophytic establishment of *Beauveria bassiana* and *Metarhizium anisopliae* in cabbage for management of diamond back moth, *Plutella xylostella* (L.)

I.1.5 Diversity of Trichogrammatids

I.1.6 Diversity and predator-prey interactions in predatory mirids, geocorids, anthocorids and mites

I.1.7 Taxonomy and biocontrol potential of entomopathogenic nematodes in Deccan Plateau of India

I.1.8 Taxonomy of Pseudococcidae, Coccidae and Diaspididae (Hemiptera: Coccoidea)

I.1.9 Diversity of *Bacillus thuringiensis*

I.2 Biodiversity of biocontrol agents from various agro ecological zones (AAU, Anand; AAU, Jorhat; ANGRAU, Anakapalle; KAU, Thrissur; MPKV, Pune; PAU, Ludhiana; PJTSAU, Hyderabad; SKUAST, Srinagar; TNAU, Coimbatore; YSPUHF, Solan; OUAT, Bhubaneswar; UAS, Raichur; IGKV, Raipur; IIVR, Varanasi)

II. Surveillance for pest outbreak and alien invasive pests

II.1 Surveillance for invasive pests (All centres)

II.2 Pest outbreak (All centres)

III. Biological control of plant disease using antagonistic organisms

III.1 List of *Trichoderma/ Pseudomonas* isolates used in various experiments

III.2 Large scale demonstration of biocontrol technology in Chickpea and Lentil

III.3 Development of consortium using promising *Trichoderma* and *Pseudomonas* isolates

III.4 Evaluation of consortium in glasshouse for the germination and plant growth

III.5 Molecular signatures of promising *Trichoderma* isolates validated under AICRP biological control at Pantnagar

Biological Control of Crop Pests

CEREALS

1. Biological Control of Rice Pests

1.1 Management of rice stem borer and leaf folder using entomopathogenic nematodes and entomopathogenic fungi (KAU, ANGRAU)

1.2 Evaluation of *Beauveria bassiana* and *Lecanicillium lecanii* against brown plant hopper *Nilaparvata lugens* Stål (KAU)

1.3 Management of plant hoppers through BIPM approach in Organic basmati rice (PAU) / rice (ANGRAU)

1.4 Large scale bio-intensive pest management on rice [ANGRAU (5 ha); PAU (50 ha));

KAU (100 ha); AAU-A (2 ha); AAU-J (10 ha); CAU (2 ha); OUAT (2 ha); NBAIR & GBPUAT (25 ha)]

1.5 Evaluation of fungal and bacterial isolates for disease management in Rice (GBPUAT, PAU)

2. Biological Control of Maize Pests

2.1 Evaluation of entomopathogenic fungi and Bt against maize stem borer (rabi 2017-18 or as per season) (PJTSAU, PAU)

2.2 Biological control of maize stem borer, *Chilo partellus* using *Trichogramma chilonis* [ANGRAU (5 ha); PAU (120 ha); MPUAT (0.4 ha)]

PULSES

3. Biological Control of Pigeon Pea Pests

3.1 Evaluation of NBAIR Bt formulation on pigeon pea against pod borer complex [PAU (2 ha); MPKV (2 ha); ANGRAU (2 ha); TNAU (0.4 ha as intercrop in groundnut ecosystem); UAS-R (2 ha)]

4. Biological Control of Mungbean Pests

4.1 Integration of botanical/microbials and insecticide spray schedule for the management of pod borer complex in mungbean (PAU)

5. Biological Control of Cowpea Pests

5.1 Evaluation of entomopathogenic fungi against pod bug *Riptortus pedestris* on cowpea *Vigna unguiculata* (KAU, Thrissur)

5.2 Screening of promising fungal and bacterial isolates for management of anthracnose disease in cowpea (KAU, Thrissur)

5.3 Evaluation of potential isolates of *Pseudomonas, Trichoderma, Bacillus* and microbial consortia against major diseases of cowpea (KAU, Kumarakom)

6. Biological Control of Chickpea Pests

6.1 Integration of botanicals/microbials and insecticide spray schedule for the management of Helicoverpa armigera on chickpea (PAU, Ludhiana)

6.2 Management of *Helicoverpa armigera* by Hear NPV in chickpea ecosystem (NBAIR) in collaboration with UAS-R)

6.3 Biological suppression of pod borer Helicoverpa armigera infesting chickpea (MPUAT, Udaipur)

6.4 Evaluation of fungal and bacterial isolates for chickpea disease management (GBPUAT)

7. Biological Control of soybean Pests

7.1 Demonstration on biological suppression of *Spodoptera litura* with *Nomuraea rileyi* in soybean (MPKV-100 acres trial)

COMMERCIAL CROPS

8. Biological Control of Cotton Pests

8.1 Management of Pink bollworm by using *Trichogrammatoidea bactrae* in *Bt* cotton

(UAS-R with NBAIR; PJTSAU)

8.2 Evaluation of entomofungal agents and botanicals for the management of sucking pests in cotton [PAU – 2nd year (whitefly); PJTSAU & MPKV (for all sucking pests)]

8.3 Biointensive Pest Management in *Bt* cotton ecosystem (AAU-A; UAS-R)

8.4 Habitat manipulation for the management of *Bemisia tabaci* (Gennadius) on cotton (PAU, Ludhiana)

9. Biological Control of Sugarcane Pests

9.1 Efficacy of entomopathogenic nematodes and entomofungus for the management of white grub in sugarcane ecosystem [ANGRAU (5 ha); UAS-R (2 ha)]

9.2 Large Scale Demonstration of *Trichogramma chilonis* against sugarcane borers [PAU (4000 ha); OUAT (5 ha); ANGRAU (5 ha); MPKV (5 ha); UAS-R (5 ha); PJTSAU (5 ha)]

OILSEEDS

10. Biological Control of Mustard Pests

10.1 Bio-efficacy of entomopathogenic fungus against mustard aphid (AAU-J; OUAT; AAU-A; PAU)

FRUIT CROPS

11. Biological Control of Banana Pests

11.1 Bio-efficacy of entomopathogens against banana fruit and leaf scaring beetles, *Nodostoma subcostatum* (AAU-J)

11.2 Field evaluation of entomopathogenic fungi against banana pseudo-stem borer *Odoiporus longicollis* (KAU)

12. Biological Control of Papaya Pests

12.1 Biological control of Papaya/mulberry mealybug/ complex with *Acerophagus papayae* and *Cryptolaemus montrouzieri* (TNAU, NBAIR, AAU-A)

13. **Biological Control of Pomegranate Pests**

13.1 Biological control of pomegranate fruit borer with *Trichogramma* sp. (TNAU – Laboratory experiment)

14. **Biological Control of Apple Pests**

14.1 Integrated Pest Management of apple Codling moth, *Cydia pomonella* (SKUAST)

14.2 Evaluation of predatory bug, *Blaptostethus pallescens* against European Red mite *Panonychus ulmi* and two spotted spider mite *Tetranychus urticae* on apple (SKUAST)

14.3 Evaluation of *Trichogramma* spp. against apple fruit moth, *Argyresthia conjugella* under laboratory conditions (YSPUHF)

14.4 Management of apple root borer using *Metarhizium anisopliae* (YSPUHF)

15. Biological Control of Mango Pests

15.1 Effect of biopesticides for the management of Mango hopper, *Idioscopus* spp. in field condition (KAU, Vellayani; DRYSRHU, Ambajipeta)

15.2 Effect of biopesticides for the management of mango webber, *Orthaga* spp. in field

condition (KAU, Vellayani)

16. Biological Control of Plum Pests

16.1 Feeding potential of *Chilocorus infernalis* against *Parthenolecanium corni* scale of plum in laboratory (SKUAST)

17. Biological Control of Cocoa Pests

17.1 Evaluation of microbial insecticides against bag worm, *Pteroma plagiophelps* in cocoa

PLANTATION CROPS

18. **Biological Control of Coconut Pests**

18.1 Surveillance of Rugose whitefly in coconut and assessing the population of natural biocontrol agents (NBAIR, TNAU, KAU, DRYSRHU)

18.2 Management of coconut black headed caterpillar using *Goniozus nephantidis* and *Bracon brevicornis* in endemic areas of Tamil Nadu / Karnataka (NBAIR)

18.3 Screening of coleopteran specific Bt formulation (NBAIR strains) against red palm weevil (*Rhynchophorus ferrugineus*) at CPCRI, Kayangulam

18.4 Screening of coleopteran specific Bt formulation (NBAIR strains) against rhinoceros beetle (*Oryctes rhinoceros*) at CPCRI, Kayangulam

VEGETABLE CROPS

19. Biological Control of Tomato Pests

19.1 Bio-intensive management of *Helicoverpa armigera*, *Tuta absoluta* and sucking pests of tomato (YSPUHF, MPKV, PJTSAU, TNAU, PAU, AAU-A, IIVR)

19.2 Large scale field trials for the management of *Helicoverpa armigera* infesting tomato (MPUAT – 2 ha)

20. Biological Control of Brinjal Pests

20.1 Role of habitat manipulation for insect pests, nematodes and natural enemies in brinjal (AAU-J; TNAU)

20.2 Bio-intensive insect pest management in brinjal (MPKV, TNAU, AAU-J, OUAT, KAU, SKUAST, NBAIR)

21. Biological Control of Okra Pests

21.1 Efficacy of biocontrol agents for management of fruit borer *Earias vittella* on bhendi (MPKV, TNAU, AAU-A)

21.2 Effect of biopesticides for the management of shoot and fruit borers *Earias vittella* in bhindi (KAU, Vellayani)

22. Biological Control of Cabbage Pests

22.1 Evaluation of *Steinernema carpocapsae* and *Heterorhabditis indica* (NBAIR strain) against lepidopteran pest complex (SKUAST)

22.2 Biological control of lepidopteran pest complex and aphid on cabbage [NBAIR (0.4 ha); TNAU (0.4 ha); CAU (0.1 ha)]

23. POLYHOUSE INSECT PESTS

CONTENTS

EXPERIMENTAL RESULTS

I. BIODIVERSITY OF BIOCONTROL AGENTS FROM VARIOUS AGRO-ECOLOGICAL ZONES

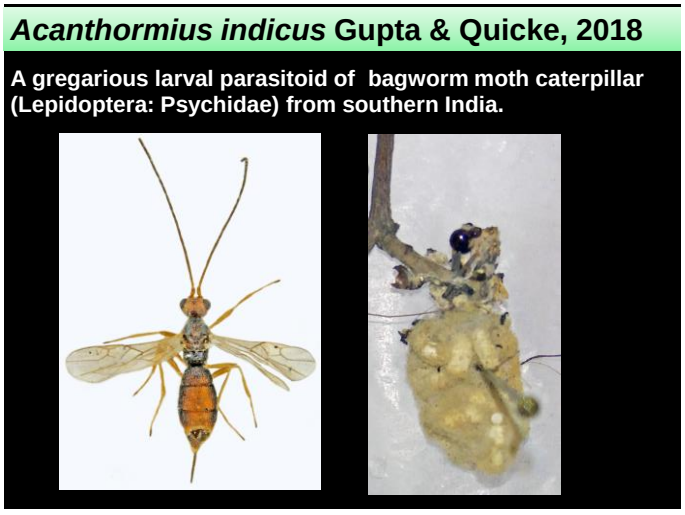
I.1 ICAR-National Bureau of Agricultural Insect Resources, Bengaluru

I.1.1 Taxonomic and biodiversity studies on parasitic Ichneumonid and chalcid wasps

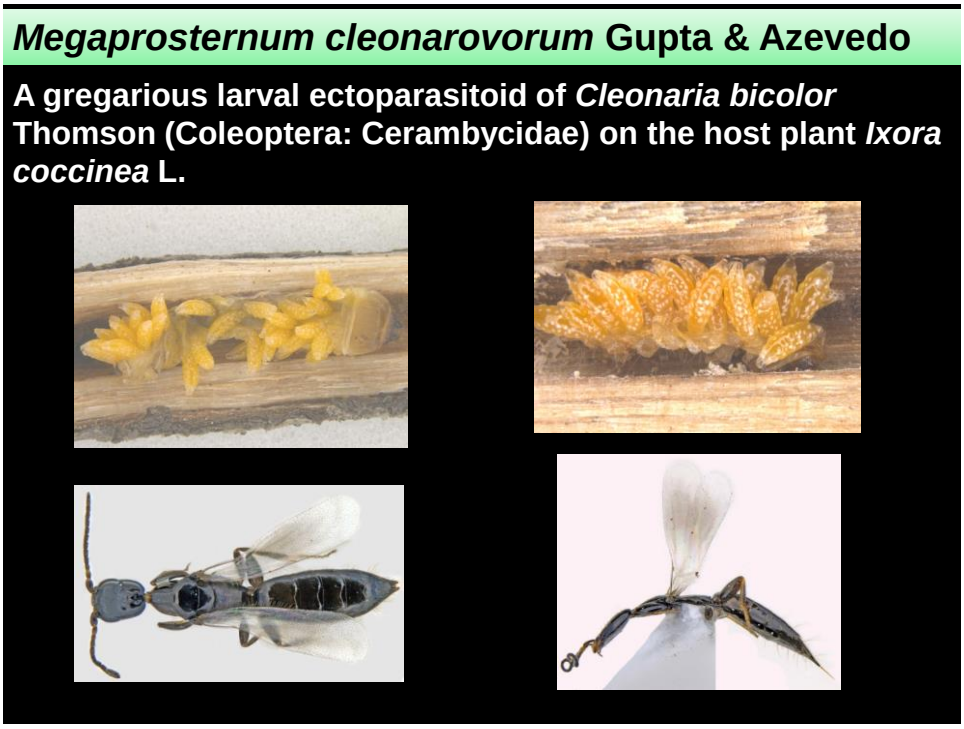
Collection of parasitized hosts followed by laboratory rearing, sweep net collection, yellow pan trap and malaise trap was done from different crops and different regions of India. Nearly **3000** specimens were collected, bred, curated, identified and preserved. Collection includes- >100 species and >100 collection/survey trips were undertaken. Collection made from following localities was studied: Himachal Pradesh (Palampur, Baijaura, Katrain Kullu, and Manali), Goa, Karnataka and Arunachal Pradesh.

Three new species were described/published in 2017-2018: *Acanthormius indicus* Gupta & Quicke, 2018 (Hymenoptera: Braconidae); *Uniclypea similis* Gupta, 2018 (Hymenoptera: Pteromalidae) and *Megaprosternum cleonarovorum* Gupta & Azevedo, 2017 (Hymenoptera: Bethylidae).

In the present study a new species of *Acanthormius* Gupta & Quicke (Hymenoptera: Braconidae) is described and illustrated as a gregarious larval parasitoid of undetermined bagworm moth caterpillar (Lepidoptera: Psychidae) from southern India. Notes on biology and host associations of other members of the Lysiterminae are also provided. Key diagnostic characters: Antenna with 18-20 antennomeres, brown; scape and pedicellus and first two to three antennomeres yellowish brown. Malar space 0.68× as long as height of eye; apical width of first tergite 1.5× its length; second apically 1.4× as wide as long medially and 1.7× longer than third tergite. Apical tooth nearly straight and about 0.3× as long as median length of third tergite, rather short. Ovipositor sheath short; about 0.7× as long as combined length of second and third tergite.



Megaprosternum Azevedo (Bethylidae: Scleroderminae) is newly recorded from the Oriental region, and *M. cleonarovorum* Gupta & Azevedo is described and illustrated from Southern India as a gregarious larval ectoparasitoid of *Cleonaria bicolor* Thomson (Coleoptera: Cerambycidae) on the host plant *Ixora coccinea* L. (Rubiacae). This is the first ever documentation of the biology of *Megaprosternum* Azevedo. This paper provides some important additions to bethylid taxonomy and biology. First, description of a new species in a small genus represents a good opportunity to improve the generic diagnosis because which characters are useful at the species and genus level can be better differentiated. Second, the discovery that males and females of the new species are polymorphic in the head structure provides clues of how to interpret intra- and inter-specific variations. Third, discovering the host of the new species helps to comprehend the tritrophic interactions in insects in wild conditions. This is the third species classified in *Megaprosternum* and the first from the Oriental region. It shares several characteristics with the other two Australian species described by Azevedo (2006), such as a very flat body, pronotal disc partially overlapped by mesoscutum at posterior corners, metanotum completely fused to propodeum, wing venation reduced to subcostal vein, and prosternum very large. In the male genitalia Gupta & Azevedo (2017) point out the short basiparamere, the elongate paramere, and the large cuspis. The authors report here the first alate female. As seen from the descriptions, the female of *M. cleonarovorum* is very similar to its conspecific male. The general ground plan of both sexes is quite similar. This expands the concept of the genus and highlights how variable the morphological patterns can be in a small genus like *Megaprosternum*.



One new species of parasitic wasp, *Uniclypea similis* Gupta (Hymenoptera: Pteromalidae), reared from the leaf knots constructed by *Apoderus tranquebaricus* Fabricius (Coleoptera: Attelabidae) on the host plant *Grewia abutilifolia* Vent. ex Juss. is described and

illustrated. The characteristic features of the new species are: post-marginal vein 2.39 stigmal vein, metasoma length 4.39 its width and costal cell 1.479 marginal vein. The male of a species of *Uniclypea* is described and illustrated for the first time. *Uniclypea similis* closely resembles the Indian species *U. elongata* but differs in (i) larger body size 4.61 mm (*vs* 3.5 mm); (ii) propodeum width 4.39 length; median carina not distinct in basal one third and median area raised (*vs* width 3.39 length; median carina distinct throughout and median area depressed). *Uniclypea similis* is unique and different from the remaining species of the genus (based on comparison with original descriptions) in the following combination of characters: (i) gaster black with metallic green shine (*vs* bicoloured, with yellow transverse regions alternating with brown/black in U. conica); (ii) post-marginal vein 2.39 stigmal vein (*vs* 1.99 in *U. conica*); (iii) metasoma length 4.39 its width (*vs* 2.89 width in *U. kumarani*); (iv) costal cell 1.479 marginal vein (*vs* 1.99 in *U. deporai*).

Uniclypea similis Gupta, 2018

Reared from the leaf knots constructed by _Apoderus tranquebaricus_ Fabricius (Coleoptera: Attelabidae) on the host plant _Grewia abutilifolia_ Vent. ex Juss.

Severe outbreak of rice green semilooper *Naranga aenescens* Moore (Lepidoptera: Noctuidae: Eustrotiinae) in West Bengal, India is documented along with the first record of its primary parasitoid *Cotesia ruficrus* (Haliday) (Hymenoptera: Braconidae: Microgastrinae). Simultaneously two hyperparasitoids, *viz.*, *Trichomalopsis apanteloctena* (Crawford) (Pteromalidae) and indet. Ichneumonidae were also recorded. The population of rice green semilooper varied from 3.20 to 5.45 larvae per hill with the peak in the first fortnight of August, 2015. Percent parasitism of the larvae was as high as 94.00% recorded in the first fortnight of August with 77.50% as the mean.

The species *Polistes* (*Polistella*) *dawnae* Dover & Rao (Hymenoptera: Vespidae: Polistinae) is recorded for the first time from Arunachal Pradesh, India. This discovery extends the distribution of the species to India, previously known from Dawna Hills (Myanmar), Northeastern Laos and Northern Vietnam.

Two species of parasitic wasps were identified for the new invasive rugose spiraling whitefly (RSW) *Aleurodicus rugioperculatus* Martin *viz*., *Encarsia guadeloupae* Viggiani and *Encarsia dispersa* Polaszek, which was found infesting coconut, banana and several ornamental plants in Tamil, Nadu, Andhra Pradesh and Kerala in India. During the survey, several natural enemies were also recorded and maximum parasitism was recorded by *Encarsia guadeloupae* Viggiani.

First ever record of family Xenasteiidae (Diptera: Brachycera: Cyclorrhapha) from mainland India is provided (Gupta et al. 2017). Most of the previous records of this family are from coastal sites, as they have usually been found on islands in the Indian and Pacific Oceans. For the first time biology and life stages of *Xenasteia* are illustrated. *Xenasteia* members were found associated with an exotic rugose spiraling whitefly (RSW) colony of *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) in the coastal areas of Karnataka in southern India, however no direct obligate association could be diagnosed. Also for the first time *Ooencyrtus* sp. (Hymenoptera: Encyrtidae) was recorded from the genus *Xenasteia* as its solitary parasitoid. Worldwide, this is the first ever report of parasitism associated with any member of this little-known family Xenasteiidae (Fig. 1).

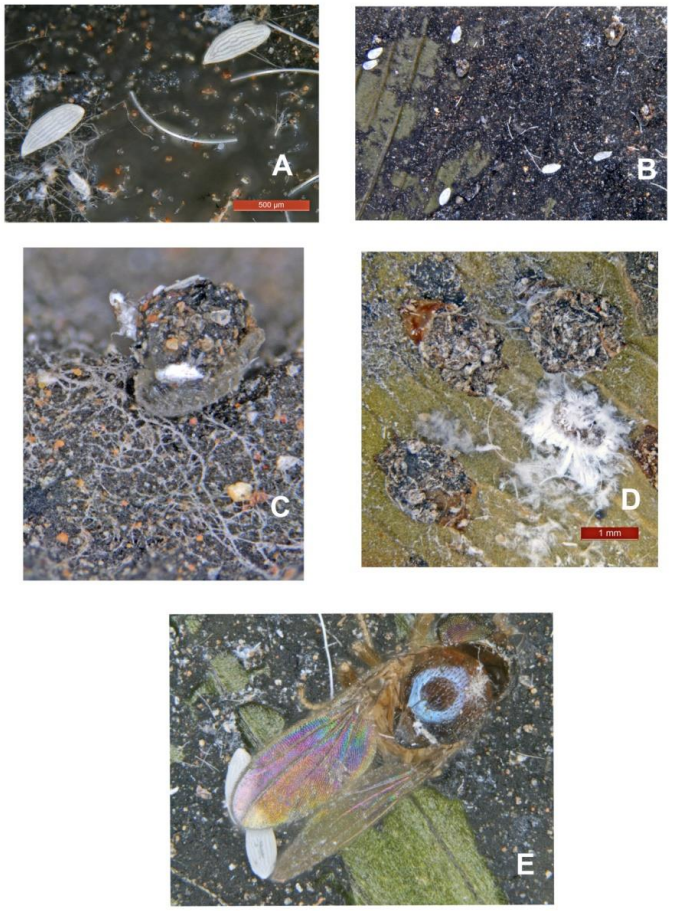
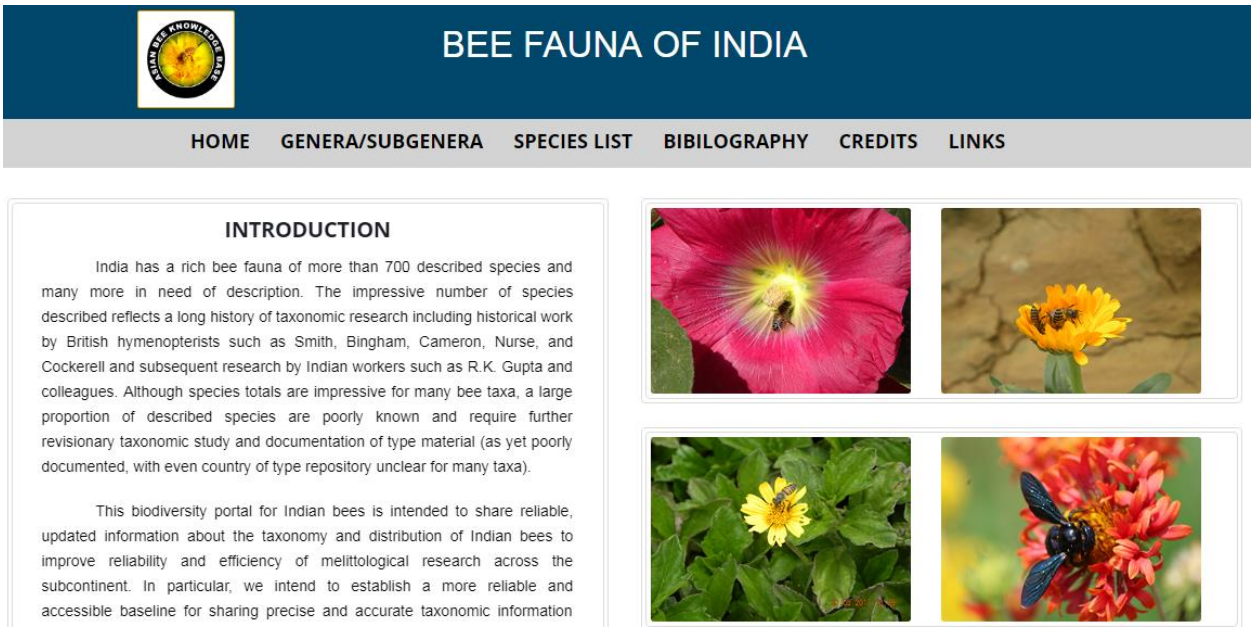


Fig. 1. Life stages of *Xenasteia* (Diptera: Brachycera: Cyclorrhapha)

New web portal- 'Bee fauna of India' uploaded on NBAIR website: Presently this online diagnostic database comprises of genus *Xylocopa* with 34 species factsheets.



I.1.2 Taxonomic and biodiversity studies on parasitic Platygastroidea

Two new genera and 67 new species have been described and imaged in the superfamily Platygastroidea.

Two new genera *Indiscelio* Veenakumari et al with *Indiscelio aulon* Veenakumari et al as type species and *Anokha* Rajmohana and Veenakumari with *Anokha anoojii* Rajmohana and Veenakumari as type species are erected.

Cremastobaeus belonging to the monotypic tribe Cremastobaeini is represented by 24 species worldwide. Only two species, *C. indicus* Mukerjee and *C. unicolor* Rajmohana are known from India. Surveys conducted from different parts of India including the remote Andaman and Nicobar islands resulted in 22 species of *Cremastobaeus* of which 20 are new to science. These 20 species are *C. boolei*, *C. breviabdominus, C. cornutus*, *C. eila*, *C. foveatus*, *C. fuscus*, *C. longigaster*, *C. luteus*, *C.* mahaviraii, *C. nicobarensis*, *C. nigricephalus*, C. nigrifemoralis, *C. parallelogaster*, *C. robustus*, *C. suvarnadeha*, *C. tanugatra*, *C. valmikii*, *C. variegatus*, *C. varuna* and *C. yoganarasimha*.

Indian species of *Lepacis* has been revised with the description of 58 species of which 42 are new to science: *L. belli*, *L. boseii*, *L. brevicorniculata, L. corbetti*, *L. deerghakanta, L. densipilis*, *L. dhura*, *L. farmanii*, *L. ferrarii*, *L. flavicorniculata*, *L. gargiae*, *L. gaurasaktha*, *L. grossiclava*, *L. hayatii*, *L. insolita*, *L. kolhapurensis*, *L. laevifrons*, *L. lakshmiae*, *L. longicantha*, *L. mandakuta*, *L. maulikii*, *L. mechaka*, *L. naiduii*, *L. neelakesha*, *L. oculopilis, L. pithambara*, *L. ramanujanii*, *L. rayii*, *L. rekilii*, *L.rossii*, *L. salimalii*, *L. sarabhaii, L. shenbagam*, *L. spumida*, *L. stebbingii*, *L. tanvi*, *L. viralaroma*, *L. vittata*, *L. wallaceii*, *L. wheelerii*, *L. zenoi* and *L. zorbasii*. Five species: *L. ocellaris* Buhl, *L.pederseni* Buhl, *L. philippinensis* Buhl, *L. pteridis* Buhl and *L. semifusca* Buhl are reported for the first time from the Indian subcontinent and are redescribed.

L. bengalensis Mukerjee, *L. brachycerus* Mukerjee, *L. coorgensis* Mukerjee, *L. indica* Mukerjee, *L. keralensis* Ushakumari &Narendran, *L. malabarensis* Ushakumari & Narendran, *L. maldarensis* Mukerjee, *L. propodealis* (Mukerjee) Buhl, *L. thanensis* Mukerjee, *L. thrissurensis* Ushakumari & Narendran and *L. yercaudensis* Mukerjee, previously reported from India are re-described. The name *L. coorgensis* (Mukerjee), which is pre-occupied, is replaced by the junior synonym *L. propodealis*. All the 58 species are illustrated and a key is provided.

Two new species of *Apteroscelio, A. aureus* and *A. shyamala* are described and imaged. A new sexually dimorphic species of *Telenomus viz. T. chandishae* is also described. Genus *Phlebiaporus* and *Mantibaria mantis* are reported for the first time from India.

I.1.3 Molecular Characterization and DNA barcoding of agriculturally important parasitoids, predators and other insects

Different parasitoids, predators and other insects were collected from various crops in Jabalpur, Gujarat, Tamil Nadu, Arunachal Pradesh, Kerala, Karnataka, Andhra Pradesh, Haryana, Punjab & Rajasthan and were used for DNA barcoding studies. Molecular characterization and DNA barcodes were generated for 90 agriculturally important parasitoids, predators and other insects based on COI gene & ITS-2. *Parapanteles* are the important braconid parasitoids of several economically important pests and twenty one *Parapanteles* collected from different places in the country (MH071685, MH071686, MH071687, MH071688, MH071689, MH071690, MH071691, MH071692, MH071693, MH071694, MH071695, MH071695, MH071697, MH071698, MH071699, MH071700, MH071701, MH071702, MH071703, MH071704) were characterized using CO1 gene and Genbank acc. nos. obtained for the same. Nine populations of chrysopids collected from different states were identified as *Chrysoperla zastrowi sillemi* using CO1 gene: PTS-5-Delhi- KY039159); Dharwad-KY039160; Trichy (PTZ-17-TRI)-KY054900; Baroda-KY054901; Coimbatore-KY415602; Anand-KY654081; Trichy-2-KY881717. Further, chrysopid predators collected from different states were identified as *Chrysoperla zastrowi sillemi* based on ITS-2 region (Ludhiana CZS-LUD-KY511707; Guntur-CZS-3-GNT). *Trichogramma* collected from the tomato field at Coimbatore is identified as *Trichogramma chilonis* (TC-1-KY872646). Molecular characterization of braconid from Coimbatore identified as *Habrobracon hebetor* using CO1 gene. Syrphid occurring in Mandya has been identified as *Paragus serratus* using CO1gene (Genbank acc. no. MG194422). Molecular characterization of parasitoid belonging to Scelionidae from Maruteru, West Godavari, using Cytochrome C oxidase I (COI) gene was done (HKM 2017-Genbank Acc. No. MF616390). Molecular characterization of *Megachile anthracina* occurring at Attur, Bangalore was done using cytochrome c oxidase I (COI) gene (MF351742).

Standardized CO1-F primer for identification of genetic groups in *Bemisia tabaci*. Thirty one populations of *Bemisia tabaci* collected on different crops and from different states have been characterized and genbank acc. nos obtained. Different populations of brown plant hopper *Nilaparvatha lugens* collected on paddy from Jabalpur, Satna, Panna, Sidhi and Balaghat in Madhya Pradesh and were characterized using CO1 gene and Genbank acc. nos *viz*., MG7552, MG773575, MG775040, MG775041, and MG773576, respectively were obtained. The invasive pest rugose spiraling whitefly *Aleurodicus rugioperculatus* Martin collected from banana, Karnataka was identified using cytochrome oxidase subunit I (COI) gene (GenBank Acc. no. MF445090). Molecular characterization of invasive pest rugose spiraling whitefly,

Aleurodicus rugioperculatus Martin collected on Coconut from Karnataka using cytochrome oxidase subunit I (COI) gene (GenBank Acc. No. MF449463; MF685246). It was reported that rugose spiraling whitefly *A. rugioperculatus* has been found as a serious pest on coconut, guava and other crops in and around Bangalore. Therefore different populations of whitefly collected and subjected to molecular studies using CO1 gene. The results clearly proved that the whitefly is Spiraling whitefly *Aleurodicus dispersus* and not *A. rugioperculatus* and the same has been submitted in NCBI (Genbank acc. no. MF149998; MF186939). Spiraling whitefly *Aleurotrachelus trachoides* was identified using CO1 gene (Genbank Acc. no. MF 149999; MF371113).

I.1.4 Endophytic establishment of *Beauveria bassiana* and *Metarhizium anisopliae* in cabbage for management of diamond back moth (*Plutella xylostella* (L.)

Laboratory bioassay studies were conducted with 20 isolates each of *Beauveria bassiana* and *Metarhizium anisopliae* at the dose of $1x10^7$spores/ml against second instar larvae of *Plutella xylostella* by dipping method. Among the 20 isolates of *B. bassiana* tested, Bb-5a showed significantly higher mortality (77.36%) followed by Bb-45 isolate (51.14%). Among the 20 isolates of *M. anisopliae* tested, Ma-4 and Ma-35 showed significantly higher mortality (81.44 & 88.85%, respectively) (Fig. 2).

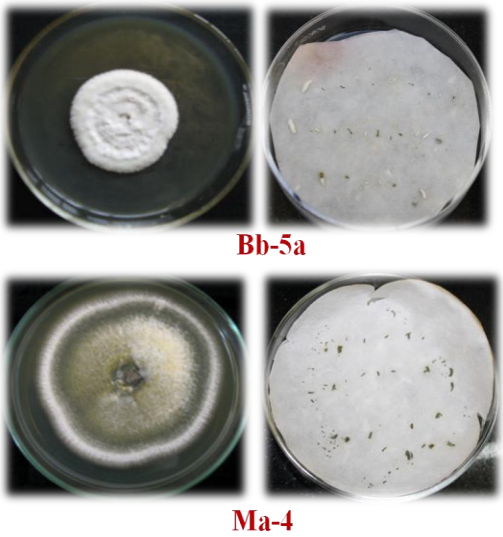


Fig. 2. Promising isolates entomophagous fungi against *P. xylostella*

A glasshouse experiment was conducted to examine the endophytic ability of four isolates of entomopathogenic fungi *B. bassiana* (Bb-5a & Bb-45) and *M. anisopliae* (Ma-4 & Ma-35) in leaf tissues of cabbage by foliar application and seedling dip method. Confirmation of endophytic establishment of these isolates in cabbage leaves was carried out using Plating technique and PCR method after 15, 30, 45 and 60 days after treatment (DAT). In foliar application method, all four isolates showed varied colonization and persistence in older and young leaf tissues of the cabbage during 15-60 DAT. In older leaves, all four isolates showed colonization up to 30DAT and no further colonization was observed thereafter. In young leaves,

colonization was observed during 30-60 DAT. Ma-4 isolate showed colonization up to 60DAT, Bb-5a & Bb-45 isolates up to 45DAT and Ma-35 isolate up to 30DAT. No colonization of any of the isolates was detected in the un-treated control. The results obtained in plating technique and PCR method were similar (Fig. 3). In seedling dip method, no colonization of any of the four isolates tested was observed in cabbage leaves during 15-60 DAT by plating method or PCR techniques.

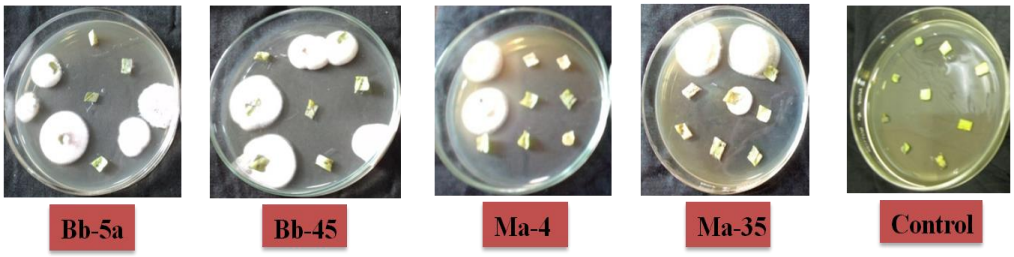


Fig. 3. *Beauveria bassiana* growth and *M. anisopliae* growth from the treated leaf bits

I.1.5 Diversity of Trichogrammatids

Seven states were surveyed for Trichogrammatidae in different ecosystem including agricultural, forest, natural and undisturbed ecosystem.Eight genera of Trichogrammatidae were recorded. Genera *Paracentrobia, Neocentrobiella, Megaphragma, Chaetostricha, Chaetogramma*, *Oligosita*, *Trichogramma* and *Trichogrammatoidea* were collected. The genus *Megaphragma* and *Neocentrobiella* collected from Maharashtra and Kerala for the first time, respectively. Total 1168 different host eggs were collected. *Trichogramma chilonis* and *T. achaeae* collected from eggs of *Helicoverpa armigera* and *Tuta absoulta* infesting tomato from Himachal Pradesh and Tamil Nadu, respectively. *Trichogrammatoidea armigera* collected from the egg, *Lampides boeticus* laid on *Crotalaria* whereas, *T. chilonis* and *Trichogrammatoidea* sp. were collected from the cabbage. The undetermined species*Trichogramma* collected from eggs of *Euthalia aconthea* attacking mango. *Trichogramma achaeae* was collected in tomato field for first time from Himachal Pradesh through sentinel trap card.

I.1.6 Diversity and predator-prey interactions in predatory mirids, geocorids, anthocorids and mites

Evaluation of *Geocoris ochropterus* against sucking insect pests (thrips, mites) was conducted under laboratory. *Geocoris ochropterus* 3rd instar nymph consumed 40 % of red spider mites (nymphal stage), while 5th instar and adult consumed 83 and 91 % of red spider mites (nymphal stage), respectively. However all the stages of *G. ochropterus* consumed more number of eggs of mite than nymphs. When *G. ochropterus* was evaluated against *Frankliniella schultzei* (blossom thrips) it was observed that immature stages consumed nymphs of thrips in range of 73-79%, while adult consumed 93% of thrips nymph. Feeding potential of *Amphiareus constrictus* (Stål) was studied on *Tuta absoluta*, an invasive pest of tomato in laboratory. It was observed that a nymph of *A. constrictus* can consume on an average of 191.46 of *T. absoluta* eggs during its total nymphal duration (20 days). Adult can consume an average of 12.65 eggs per day. Female consumed more number of eggs. Feeding preferences of *A. constrictus* and

Blaptostethus pallescens were also studied against parasitized egg of *T. absoluta* by trichogrammatids and it was found that in both choice and no-choice test, nymphs and adults of *A. constrictus* and *B. pallescens* did not consume any parasitized eggs. Nevertheless nymph and adult of *A. constictus* consumed average of 11.0 and 10.3 *T. absoluta* eggs in no-choice test, respectively. Same trend was observed in choice test also.

I.1.7 Taxonomy and biocontrol potential of entomopathogenic nematodes in Deccan Plateau of India

A total of 15 soil samples were collected randomly from potato growing regions and forest areas of Udhagamandalam, Tamil Nadu. A soil sample drawn from potato rhizosphere of ICAR-CPRS, Udhagamandalam and a positive sample was anticipated with *Steinernema* sp. nematode. Based on morphological and morphometrical studies. The EPN, *Steinernema* sp. was identified and designated as *S. cholashanense* (Nguyen *et al.,* 2008) strain CPRSUS01 which showed the resemblance of the species to *S. cholashanense* (Fig. 4). Further identity was confirmed with molecular characterization using the ITS-rDNA region. The genomic DNA was extracted from a single first generation female using a modified method of Joyce *et al*., 1994. The PCR reaction was performed for amplification of the complete ITS using forward primer TW81 (5'- GTTTCCGTAGGTGAACCTGC- 3') and the reverse primer AB28 (5'- ATATGCTTAAGTTCAGCGGGT- 3'). The amplification profile was carried out using a BioRad thermo-cycler, which was preheated at 94°C for 5 min followed by 35 cycles of 92°C for 60s, 60°C for 30s and 72°C for 60s and then 72°C for 10min. Amplified product was purified using a Qiagen Gel Purification Kit and DNA fragments were sequenced by Sanger's method (Eurofins Genomics India Pvt., Ltd, Bengaluru. India). The ITS region of rDNA yielded a single fragment of approximately 735 base pairs and sequence was deposited into the GenBank database (Accession no. MH065747). The sequence of this EPN revealed 99% similarity with *S. cholashanense* isolate from Nepal (GQ377419) and Pakistan (MF039642) and 96% with China population (EF431959).To our knowledge, this is the first report of *S. cholashanense* from India.

I.1.8 Taxonomy of Pseudococcidae, Coccidae and Diaspididae (Hemiptera: Coccoidea)

A new species of aphid, *viz., Kaochiaoja sikkimensis* Joshi and Blackman was described from Sikkim, India. *Pulvinaria indica* Avasthi & Shafee on chilli roots and *Contigapis coimbatorensis* Borchsenius & Williams on *Tephrosia purpurea* were recorded for the first time from Maharashtra. *Lopholeucaspis japonica* (Cockerell) was recorded on pomegranate from Gujarat. *Tuberaphis xinglongensis* (Zhang) on arecanut and *Lepidosaphes laterochitinosa* (Green) were recorded for the first time from India. A website was developed on 'Common soft scales of India'. It has factsheet on 32 species of soft scale insects which are commonly found in India and most of them are economically important.

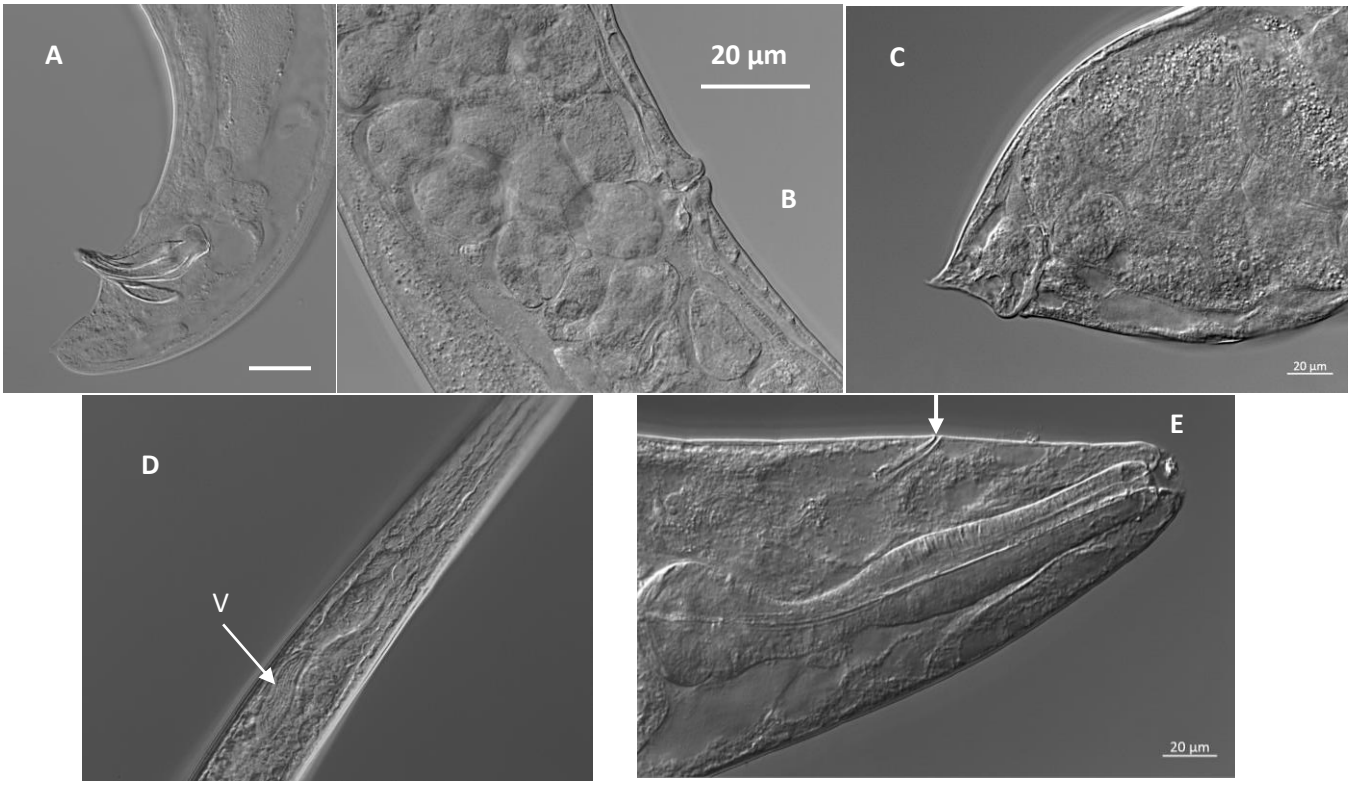


Fig. 4. Light microscope (LM) photographs of first- generation *Steinernema cholashanense* (A) Posterior region of a male showing spicule, gubernaculum and mucron at tail tip. (B) Protruding vulva. (C) Female tail with post-anal swelling. (D) Esophageal region of an infective juvenile showing basal bulb and bacterial vesicle (V). (E) Female with well circularised excretory pore (arrow)

I.1.9 Diversity of *Bacillus thuringiensis*

The *Bacillus thuringiensi*s strain NBAIR-BTAN4 was characterized as a novel isolate capable of expressing crystal proteins toxic to both lepidopteran and coleopteran pests. Sequence studies showed that it expresses Cry2Ab, Cry1Ac, Cry1Ia and Cry2Aa. It was also found to be expressing 20 other toxin proteins (Table 1). It was already characterized as toxic to coleopteran pests and during the period it was evaluated against lepidopteran pests namely *Helicoverpaarmigera*and*Plutellaxylostella*and the LC_{50} was calculated as 414 and 545 ng/ml respectively. It was also tested against *Holotrichiaserrata* and 50% mortality was observed in 15 days.It is developed as a technology for controlling both the group of pests.

As part of the objective for developing efficient fermentation medium and formulations of *Bacillus thuringiensis*, a strategy was developed to test use of molasses as carbon supplement in growth medium. Four different mediums were tested. Cell growth parameters showed that Medium-2 supported maximum cell growth of NBAIR-BTAN4 and HD-1 within 120h which showed log numbers of 11.04 and 10.7 (cfu/ml) respectively. However when protein parameter was taken into account maximum protein content of 13.6 mg/ml was obtained with Medium-3 for NBAIR-BTG4 followed by BTAN4 (12.4 mg/ml). Protein released was higher in Medium-3

for all the six organisms tested. Hence Medium-3 has been developed as process for *Bt* fermentation and technology development.

Table 1. Insecticidal crystal genes identified in NBAIR-BTAN4

1	Insecticidal crystal protein	CDS ID
2	Cry2Ab	AHMLFPGL_04725
3	Cry1Ac	AHMLFPGL_04730
4	Cry1Ia	AHMLFPGL_04731
5	Cry2Aa	AHMLFPGL_04738
Other Toxins		
6	Death on curing protein Doc toxin	AHMLFPGL_06333
7	Lmo0066 homolog within ESAT-6 gene cluster similarity to ADP-ribosylating toxins	AHMLFPGL_06433
8	Non-hemolytic enterotoxin A	AHMLFPGL_02331
9	Non-hemolytic enterotoxin lytic component L1	AHMLFPGL_02332
10	Enterotoxin C	AHMLFPGL_02333
11	Holin toxin secretion/phage lysis	AHMLFPGL_02761
12	Toxic anion resistance protein TelA	AHMLFPGL_02849
13	Holin toxin secretion/phage lysis	AHMLFPGL_06548
14	enterotoxin/cell-wall binding protein	AHMLFPGL_00021
15	enterotoxin/cell-wall binding protein	AHMLFPGL_03700
16	Holin toxin secretion/phage lysis	AHMLFPGL_03846
17	trifolitoxinimmunity domain protein	AHMLFPGL_00639
18	Cytotoxin K	AHMLFPGL_00661
19	enterotoxin/cell-wall binding protein	AHMLFPGL_04941
20	Putative toxin component near putative ESAT-related proteins repetitive	AHMLFPGL_01044
21	Zeta toxin	AHMLFPGL_05166
22	MOSQUITOCIDAL TOXIN PROTEIN	AHMLFPGL_05478
23	Programmed cell death toxin YdcE	AHMLFPGL_05630

I.2 Reports from different centres

I.2.1 YSPUHF, Solan

Geographical & other details	**Coccinellid beetles**
Scientific name of the insect	*Coccinella septempunctata, Hippodamia varigieta, Adalia tetraspilota,Cheilomenes sexmaculata,Propylealutio pustulata, Chilocorus infernalis, Priscibrumus uropygialis, Platynaspis saundersii, Harmonia eucharis, Oenopea sauzetii, Oenopia conglobata, Oenopia kirbyi, Oenopia sexareata, Oenopia billieti, Halyzia sanscrita,Illeis* sp. nr. *confusa,Scymnus nubilus, Scymnus posticalis, Coelophora bissellata, Harmonia dimidiata, Harmonia eucharis, Megalocaria dilatata, Oenopia souzeti*

Common name of the insect	Lady bird beetles
Location	Tapri (280km), Rekongpeo (310km),Telangi (315km), Kalpa (320km), Pooh (360km), Ponda (250km), Sangla (300km), Raksham (312km), Chhitkul (325km), Kullu (220 km) Manali (270km), Kelong (400km), Janjehli (200 km), Mandi (160 km), Una (165 km), Ghumarwin (140 km), Shimla (60 km), Solan (15 km), Sarahan (50 km), NainaTikkar (30 km) and Nauniof districtsBilaspur, Mandi, Kullu, Solan, Sirmaur, Shimla, Kinnaur and Lahaul &Spiti of Himachal Pradesh
Taluk, district & Agro- climatic zone	Sub-tropical to dry temperate high hills
Distance from the HQ	15-400 Km
Date of survey	April 2017 to October 2017
Host crop/ sole crop/ intercrop/ etc.	Tomato, cucumber, brinjal, okra, apple, apricot, peach, almond, cole crops, mustard, capsicum, carnation, rose, chrysanthemum, coriander and ground flora and wild flora
Stage of the crop	Vegetative growth stage
Insect pest	Aphids, mites and scale insects
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	-
GIS data	500 to 3100m amsl
Pesticide usage pattern	-
Geographical & other details	**Chrysopid**
Scientific name of the insect	*Chrysoperla zastrowi sillemi*
Common name of the insect	Green lace wing
Location	Nauni, Rekongpeo, Kalpa, Nainatikkar, Sarahanand Kullu
Taluk, district & Agro- climatic zone	Sub temperate to dry temperate zone
Distance from the HQ	0-320 Km
Date of survey	May-October
Host crop/ sole crop/ intercrop/ etc.	Apple, peach, okra and cucumber
Stage of the crop	Vegetative growth and Fruit bearing
insect pests	Aphids and whiteflies
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	-
GIS data	1150-3000m amsl.
Pesticide usage pattern	-
Geographical & other details	**Syrphids**

Scientific name of the insect	*Episyrphus balteatus, Eupeodes frequens, Melanostoma univitatum, Betasyrphus serarius, Sphaerophoria indiana, Ischiodon scutellaris, Metasyrphus corolla* and *Scaeva pyrastri*
Common name of the insect	Syrphid flies, hover flies
Location	Nauni, Solan, Nainatikkar, Ghumarwin, Una, Sarahan,Bhabanagar, Rekongpeo, Telangi, Kalpa, Sangla
Taluk, district & Agro- climatic zone	Sub-tropical to dry-temperate
Distance from the HQ	0-320km
Date of survey	March–October, 2017
Host crop/ sole crop/ intercrop/ etc.	Different flowering plants
Stage of the crop	flowering stage
Stage of the insect pest	Adults
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	-
GIS data	500-3000m amsl
Pesticide usage pattern	-
Geographical & other details	**Parasitoids of coccinellids**
Scientific name of the insect	*Dinocalpus coccinellae* and *Pediobius foveolatus*
Common name of the insect	Parasitoid of coccinellids
Location	Nauni and surroundings
Taluk, district & Agro- climatic zone	Sub-temperate
Distance from the HQ	Upto 30Km
Date of survey	July - August, 2017
Host crop/ sole crop/ intercrop/ etc.	Different vegetable and fruit crops
Stage of the crop	Vegetative and flowering stage
Host insects	*Coccinella septempunctata* and *Megalocaria dilatata*
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	-
GIS data	1150 -1300m amsl
Pesticide usage pattern	
Geographical & other details	**Parasitoids of DBM**
Scientific name of the insect	*Diadegma semiclausum* and *Diadromus collaris*
Common name of the insect	DBM parasitoids
Location	Nauni and surroundings
Taluk, district & Agro- climatic zone	Sub-temperate
Distance from the HQ	
Date of survey	March- April, 2017
Host crop/ sole crop/ intercrop/ etc.	Cauliflower and cabbage
Stage of the crop	Vegetative
Host insects	Larvae and pupae of *Plutella xylostella*
Weather parameters recorded (max, min temp;	

rainfall, no. of rainy days)	
GIS data	1150-1300m amsl
Pesticide usage pattern	
Geographical & other details	**Anthocorid bugs**
Scientific name of the insect	*Orius*sp and *Anthocoris*sp
Common name of the insect	Anthocorid bugs
Location	Nauni and surroundings, Ponda
Taluk, district & Agro- climatic zone	Sub-temperate to dry-temperate
Distance from the HQ	0-250km
Date of survey	April, 2017
Host crop/ sole crop/ intercrop/ etc.	Peach
Stage of the crop	Vegetative growth and fruit development
Host insects	Peach leaf curl aphid and thrips
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	
GIS data	1250m amsl
Geographical & other details	**Mirid bug and leafminer parasiotids**
Scientific name of the insect	*Nesidiocoris tenuis, Neochrysocharis formosa, Diglyphus* sp., *Quadrastichus plaquoi*
Common name of the insect	Tomato mirid bug, leafminer parasitoid
Location	Nauni, Nainatikkar
Taluk, district & Agro- climatic zone	Sub-temperate
Distance from the HQ	0-35Km
Date of survey	June 2017 to October 2017
Host crop/ sole crop/ intercrop/ etc.	Tomato
Stage of the crop	Vegetative and fruiting stage
Host insects	*Tuta absoluta,* greenhouse whitefly, serpentine leafminer and phytophagous mites
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	
GIS data	1150 to 1300m amsl
Pesticide usage pattern	

Besides above mentioned natural enemies, *Cotesia glomerata* parasitizing *Pieris brassicae* in cauliflower and *Campoletis chloridae* parasitizing *Helicoverpa armigera* in tomato, *Diplazon* sp. parasitizing syrphid flies, *Trathla* sp. parasitizing brinjal shoot and fruit borer were also collected at Nauni.

I.2.2 IGKV, Raipur

Bracon brevicornis was identified on cabbage. Other hymenopteran parasitoids identified were, *Goniozus* sp. (Bethelidae) from sapota, *Elasmus* sp. (Elasmidae). Maximum parasitization (32.0%) was recorded by *Cotesia flavipes* followed by *Bracon* spp. (20.0%) and *Bracon hebator* (10%). Many more parasitoids collected are under identification. The mealybugs on different host plants were recorded (Table 2 and Fig. 5). Maximum infestation of mealy bugs were noticed on ornamentals, followed by medicinal and weeds. Out of the crop plants surveyed for mealy

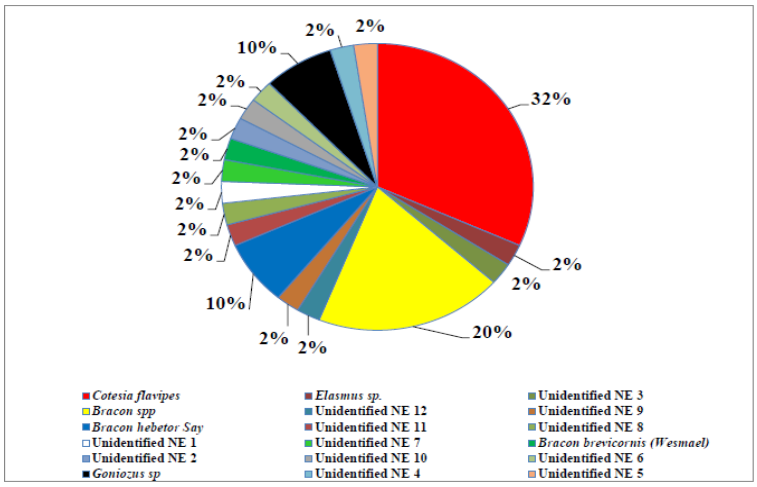


Fig. 5. Per cent parasitism by different parasitoids in Raipur

Table 2. Host plants of mealybugs recorded on different plants

S.N.	Plant category	No. of host plant species	Name of host plants
01.	Pulse crops	02	Soybean, Pigeon pea
02.	Oil seed crops	01	Sunflower
03.	Vegetable crops	10	Tomato, Brinjal, Cow pea, Potato, Okra, Bottle gourd, Khatta bhaji, Jari bhaji, Chech bhaji, Kanda bhaji
04.	Fruit crops	11	Cashew, Strawberry, Guava, Ber, Papaya, Mango, Tamarind, Aonla, Citrus, Custard apple, Pomegranate
05.	Fibre crop	01	Cotton
06.	Sugar crop	01	Sugarcane
07.	Ornamentals	18	Temple tree, Hibiscus, Marigold, Kaner, Satpatia, Croton, Periwinkle, Dumb cane, Mani plant, Rose, China rose, Phlox, Hollyhock, Verbena, Candy tuff, Champa, Amaranthus garden plants, Chrysanthemum
08.	Medicinal	15	Adusa, Bhringraj, Bawachi, Tulsi, Samander sokh, Ashwagandha, Sarpagandha, Chui mui, Patchouli, Nirgundi, Kasturi bhindi, Betelvine, Curry leaf, Gudmar, Akarkara
09.	Weeds	13	Chirchita, Congress grass, Lantana, Aak/ Madar, Dhoob grass, Baryara, Chirpoti, Chota dhatura, Water hyacinth, Indian mallow, Slender amaranth, Balloonvine, Sambong
10.	Forest trees	02	Karanj (*Pongamia pinnata*), Black babool (*Albizia lebek*)

bug attack 33.78% plants showed more than 50% plant area damaged by mealybugs. Eight species of mealybugs were identified on different crops from Chhattisgarh plains among which *Phenococcus solenopsis* was the most dominant followed by *Paracoccus marginatus*, *Ferrisia virgata* and *Rastrococcus iceryoides* (Table 3, 4 and Fig. 6). As per the identification report, two species of EPN's were identified as *Steinernema carpocapsae* from Yam at Raipur and *Heterorhabditis indica* from Rose at Durg.

Table 3. Host plants of mealybugs categorized on the basis of level of infestation

S.N.	Level of Infestation	Number of host plants	Name of host plants
01.	Category I - Low ((1 – 15% plant area damaged))	35 (47.30%)	Pigeon pea, Sunflower, Cow pea, Bottle gourd, Chech bhaji, Kanda bhaji, Ber, Tamarind, Citrus, Pomegranate, Sugarcane, Temple tree, Kaner, Satpatia, Periwinkle, Dumb cane, Rose, Phlox, Hollyhock, Verbena, Candy tuff, Champa, Chrysanthemum, Adusa, Sarpagandha, Aak/ Madar, Dhoob grass, Chirpoti, Chota dhatura, Water hyacinth, Black babool, Karanj, Slender amaranth, Balloonvine, Sambong
02.	Category II - Medium (16 – 50% plant area damaged)	14 (18.92%)	Khatta bhaji, Jari bhaji, Strawberry, Cashew, Marigold, Patchouli, Betelvine, Curry leaf, Gudmar, Akarkara, Mango, Chirchita, Lantana, Croton
03.	Category III - High (>50% plant area damaged)	25 (33.78%)	Tomato, Brinjal, Potato, Okra, China rose, Hibiscus, Cotton, Custard apple, Papaya, Guava, Baryara, Congress grass, Chui mui, Nirgundi, Kasturi bhindi, Bhringraj, Ashwagandha, Bawachi, Tulsi, Samander sokh, Amaranthus garden plants, Maney plant, Indian mallow

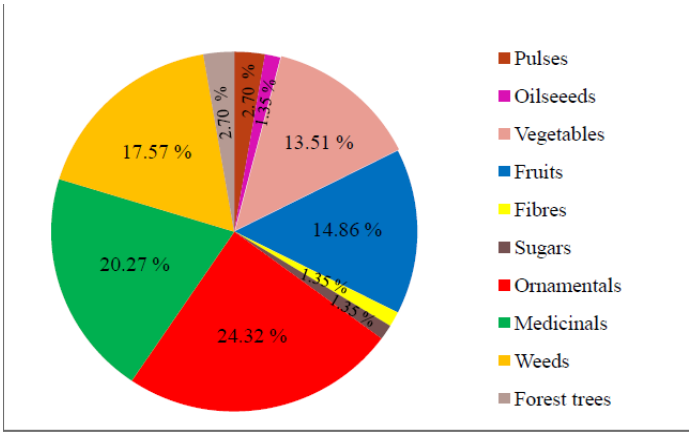


Fig. 6. Graphical representation of distribution of mealybugs on different crops

Table 4. Natural enemies on various species of mealybugs

S.N.	Name of natural enemies	Name of mealybug species	Name of host plants of mealybugs
Predators :			
01	*Cheilomenes sexmaculata* (Cole: Coccinellidae)	*Phenacoccus solenopsis*	Hibiscus, Okra, Ashwagandha, Parthenium
		Paracoccus marginatus	Amaranthus garden plants
		Ferrisia virgata	Guava
		Rastrococcus iceryoides	Cotton
02	*Brumoides suturalis* (Cole: Coccinellidae)	*Phenacoccus solenopsis*	Ashwagandha, Hibiscus
		Paracoccus marginatus	Amaranthus garden plants
03	*Scymnus* spp. (Cole: Coccinellidae)	*Phenacoccus solenopsis*	Ashwagandha, Hibiscus
		Paracoccus marginatus	Amaranthus garden plants
		Nipaecoccus viridis	Tulsi
04	*Chrysoperla sp.* (Neuroptera: Chrysopidae)	Unidentified	Aonla
05	Spiders	*Phenacoccus solenopsis*	Ashwagandha, Hibiscus
Parasitoids :			
06	*Aenasius bambawalei* (Hym: Chalcidoidae)	*Phenacoccus solenopsis*	Hibiscus, Ashwagandha, Lantana, Okra, Kasturi bhindi, Brinjal, Congress grass
07	*Pseudleptomastix mexicana* (Hym: Chalcidoidae	*Paracoccus marginatus*	Amaranthus garden plants

I.2.3 KAU, Thrissur

Study on seasonal abundance of spiders in rice ecosystem was carried out in farmer's field at Thanikkudam in Thrissur. Spiders were collected during the second crop season using pit fall traps. The collected spiders were sent to NBAIR for identification. Two species of spiders were collected consistently from the rice field and were identified as *Pardosa pseudoannulata* (Boesenbeg and Strand) and *P. irriensis* (Barrion and Litsinger). The former accounted for nearly 99 per cent of the catch (Table 5).

Table 5. Spider catch in pit fall trap in rice field at Thanikudam, Thrissur

Date	Spider catch in pit fall trap(Numbers)	
	Pardosa pseudoannulata	*Pardosa irriensis*
09/11/17	25	2
16/11/17	19	-
25/11/17	31	--
04/12/17	51	-
23/12/17	18	--
30/12/17	32	-

06/01/18	38	-
12/01/18	23	-
18/01/18	39	1
27/01/18	32	-

I.2.4 UBKV, Pundibari

Survey was done in the nearby villages to record the status of invasive pests. Papaya mealy bug (*Paracoccus marginatus*) was found to be most prevalent in this region. The pest was found on papaya, hibiscus and mulberry. A good population of apefly predator (*Spalgis epius*) was recorded from hibiscus plants growing under under natural condition.

Field trial (first year programme) was conducted to evaluate the efficacy entomopathogenic fungal formulation against sucking pests of chilli mite. Due to unavailability of local strains of the EPFs, market formulations of EPF s were used for comparative study. NBAIR strains of *Beauveria*, *Metarhizium* and *Lecanicililum* were found to give better control of chilli mite in comparison to formulations available in the market. Acaricidepyridaben 20% WP was used as chemical check and has given maximum mortality. The second is trial is going on.

Trichogramma population is being maintained in the laboratory for production of trichocards. These cards are being used for research purpose in field trials under biorational modules. Moreover undergraduate students are also engaged in the production of trichocards under ELP program

I.2.5 TNAU, Coimbatore

I.2.5.1 Survey and surveillance of natural enemies pinworm, *Tuta absoluta* on tomato

The occurrence of tomato pinworm, *Tuta absoluta* was monitored using water pan trap and sleeve trap in tomato growing areas of Coimbatore district viz., Kinathukadavu, Thondamuthur and Thudiyalur. The moth population was maximum during the months of Sept (3- 15), October (5-20), November (3-12) and December (2-10 adult moths trap) as compared to rest of the cropping period. The observation on per cent leaf damage and per cent fruit damage were recorded periodically. In Thondamuthur block, the damage to leaf was observed upto 20.5 per cent where as the fruit damage was noted in 7.2 per cent fruits and the mean adult catch per trap per week was 10 adults. The crop did not show any damage from seedling up to three weeks. The incidence of leaf damage by pinworm was observed (22%) in Kinathukadavu whereas it was absent in Thudiyalur block.The occurrence of pinworm was also recorded from other districts of Tamil Nadu, *viz*., Dharmapuri, Krishnagiri and Erode. It was not observed in any other alternate host crops like potato, brinjal, chilli and tobacco.

I.2.5.2 Monitoring and record of incidence of papaya mealy bug and its natural enemies on papaya and other alternate hosts

The infestation of *Paracoccus marginatus* was noted in crops like papaya, tapioca, mulberry, guava, brinjal, cotton, tomato and teak. The incidence of PMB was recorded in Coimbatore, Erode, Tiruppur, Salem, Karur, Theni, Madurai, Ariyalur, Villupuram, Karur, Cuddalore and Virudhunagar districts. The prevalence was high in Erode, Tiruppur and

Coimbatore. The occurrence of this pest escalated from moderate level of infestation in Erode, Tirupur, Coimbatore and Karur districts during June, to high infestation level in the month of July, August, September and October. The observation carried out clearly indicates that the vulnerable districts were Erode, Tirupur, Coimbatore and Karur (Table 6). The susceptible crops were tapioca, guava, mulberry and the period of severe infestation was July, August, September, October and November (Table 6). The PMB parasitoid *Acerophagus papayae* is widely spread and established in most of the districts of Tamil Nadu. Natural predators like *Cryptolaemus montrouzieri*, *Spalgius epius* and *Mallada igorotus* were also noted.

Table 6. Incidence of papaya mealybug on papaya and its natural enemies

Places surveyed	**Period**	***P.marginatus* incidence (%)**	**Natural Enemy/5 leaves**			
			A.papayae	***Cryptolaemus***	***Stethorus***	***Spalgis epius***
Coimbatore	July 17	2.0	4	2	0	0
	Aug 17	3.0	6	0	0	1
	Sep 17	2.0	1	0	0	0
	Oct 17	3.0	8	0	1	0
	Nov17	2.5	0	0	0	0
	Dec 17	0	0	0	0	0
	Jan 18	0	0	0	0	0
	Feb18	0	0	0	0	0
Tirupur	July 17	4.5	2	0	0	1
	Aug 17	4.0	1	2	0	0
	Sep 17	2.0	0	1	2	1
	Oct 17	3.5	3	1	0	0
	Nov17	5.5	2	0	0	1
	Dec 17	0	0	0	0	0
	Jan 18	0	0	0	0	0
	Feb18	0	0	0	0	0
Erode	July 17	2.5	2	1	0	0
	Aug 17	7.0	0	1	0	1
	Sep 17	6.5	2	0	1	0
	Oct 17	5.0	2	0	0	1
	Nov17	0	0	0	0	0
	Dec 17	0	0	0	0	0
	Jan 18	3.5	5	1	0	2
	Feb18	0	0	0	0	0
Salem	July 17	0	0	0	0	0
	Aug 17	4	1	0	0	1
	Sep 17	0	0	0	0	0
	Oct 17	0	0	0	0	0
	Nov17	0	0	0	0	0
	Dec 17	0	0	0	0	0
	Jan 18	0	0	0	0	0
	Feb18	0	0	0	0	0
Virudhunagar	July 17	1.2	1	0	0	0

	Aug 17	3	2	0	0	0
Karur	Aug 17	4.0	2	1	0	0
Cuddalore	Sep 17	3.0	2	0	0	1
Madurai	Oct 17	4.0	3.0	0	0	0

I.2.5.3 Survey for collection of natural enemies including spiders in in different agro-ecological zones and on different crops

The natural enemies, *viz*., *Trichogramma* sp., *Cryptolaemus montrouzieri*, *Chrysoperla zastrowi sillemi* and parasitoids of papaya mealybug, scales were collected and documented. The parasitoid of rugose whitefly in coconut was identified as *Encarsia guadeloupae*. The activity of egg parasitoid, *Trichogramma* sp. parasitizing fruit borer of tomato, bhendi and shoot and fruit borer of brinjal, bud borer of jasmine and DBM in cabbage was observe. The predators, *viz., C. montrouzieri*, *Chrysoperla zastrowi sillemi and Mallada sp* was seen on mealybug, scales, whiteflies, psyllids infesting the crops namely tapioca, papaya, brinjal, bhendi, curry leaf and coconut while *Dipha aphidivora* and *Micromus igorotus* were observed on sugarcane woolly aphid.

I.2.5.4 Monitoring of sugarcane woolly aphid incidence and impact assessment of natural enemies on its biosuppression

The incidence of sugarcane woolly aphid was only noted in Chithode area of Erode District during Jan 2018 at high intensity with 10.5 SWA/6.25 cm^2leaf. The natural enemies associated with woolly aphid observed were *Dipha aphidivora*, *Micromus igorotus* and *Encarsia* sp. (Table 7 & 8).

I.2.6 OUAT, Bhubaneswar

Survey was made in the coconut plantations of Khurda, Cuttack, Jajpur and Puri districts on the incidence of rugose whitefly, *Aleurodicus rugioperculatus* and its natural enemies. This whitefly was not noticed during the survey. Seasonal abundance of spiders in rice ecosystem by general collection, pitfall trap and sweep net method (specimens to be sent to NBAIR for identification). Ten samples of spiders were collected from the *kharif* rice ecosystem in 2017 and communicated to NBAIR, Bangalore for identification in the month of November 2017.

I.2.7 SKUAST, Srinagar

A total of twenty five natural enemies including parasitoids and predators belonging to the orders Coleoptera, Diptera, Neuroptera, Hymenoptera and Mesostigmata were collected from fruit orchards in different districts of Kashmir and Laddakh during 2017-18. These included eulophid parasitoid from apple leaf miner, *Coccinella undecimpunctata*, *Priscibrumus uropygealis* and syrphid on apple aphid, predatory mite, *Amblysieus* sp. on European red mite, *Chilocorus infernalis*, *C. septempunctata*, *Scymnus* sp. *Chrysoperla zastrowi*, *Encarsia perniciosi* and *Aphytis proclia* on San Jose scale. *Azotus kashmiriensis* and *Marietta* sp. acted as

Table 7. Mean incidence of Sugarcane woolly aphid and its natural enemies in different zones of Tamil Nadu

Districts surveyed	July 2017				August 2017				September 2017				October 2017			
	SWA/ 6.25 sq.cm	*Dipha*/ leaf	*Encarsia*/ leaf	*Micromus*/ leaf	SWA/ 6.25 sq.cm	*Dipha*/ leaf	*Encarsia*/ leaf	*Micromus*/ leaf	SWA/ 6.25 sq.cm	*Dipha*/ leaf	*Encarsia*/ leaf	*Micromus*/ leaf	SWA/ 6.25 sq.cm	*Dipha*/ leaf	*Encarsia*/ leaf	*Micromus*/ leaf
Erode	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cuddalore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coimbatore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salem	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Karur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vellore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Contd-

Table 8. Mean incidence of Sugarcane woolly aphid and its natural enemies in different zones of Tamil Nadu

Districts surveyed	November 2017				December 2017				January 2018				February 2018			
	SWA/ 6.25 sq.cm	*Dipha*/ leaf	*Encarsia*/ leaf	*Micromus*/ leaf	SWA/ 6.25 sq.cm	*Dipha*/ leaf	*Encarsia*/ leaf	*Micromus*/ leaf	SWA/ 6.25 sq.cm	*Dipha*/ leaf	*Encarsia*/ leaf	*Micromus*/ leaf	SWA/ 6.25 sq.cm	*Dipha*/ leaf	*Encarsia*/ leaf	*Micromus*/ leaf
Erode	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8	0.0	0.0	0.0	16.4	0.4	2.0	0.6
Cuddalore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coimbatore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salem	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Karur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vellore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

hyper parasitoids of *Encarsia perniciosi* and *Aphytis proclia*. *Aphelinus mali* was found a promising parasitoid of Woolly apple aphid, *Eriosoma lanigerum* displaying a maximum of over 75.0% parasitism. *C. septempunctata* and *Chrysoperla zastrowi* were found associated with woolly aphid colony. *C. undecimpunctata* was first time recorded from Kargil on apricot. *Harmonia dimidiata* was found preying on Walnut aphid, *Panaphis juglandis.* Plum as usual showed active association of *Chilocorus infernalis* with *Parthenolecanium corni*. Encyrtid parasitoid *Metaphycus* sp. was also reared from the scale. An unidentified hemipteran bug was also discovered from the scale on plum. Three predators, *C. septempunctata*, *Coccinella undecimpunctata* and *Chrysoperla zastrowi* were also recorded first time on Pear psylla on pear in University campus, Shalimar. Apple orchards in different ecological zones of Kashmir province, including Drass of district Kargil, Anantnag, Budgam, Baramullah, Pulwama, Kupwara, Bandipora, Ganderbal and Srinagar were surveyed during May to October' 2017 for Codling moth, *Cydia pomonella*. None of the apple orchards from above mentioned areas indicated its presence. Although lepidopteran pests like *Archipspomivora*, Fire worm, *Rophobota naevana* (Hubner), Jairy caterpillar etc. were found at many places. Fire worm, *Rophobota naevana* (Hubner) was reported from almost all the districts of Kashmir, attacking apple from flowering to fruit 3rd stage. Codling moth, *Cydia pomonella* was found almost confined to Ladakh region only. However, intensive surveys will be conducted during 2018-19 to confirm its absence from Kashmir province (Table 9).

Table 9. Natural enemies associated with insect pests on some fruit crops in Kashmir

S. No.	Fruit Crop	Host	Natural enemies	Order/ family	Location
1	Apple	Apple leaf miner, *Lyonetia* sp.	eulophid*	Hymenoptera : Eulophidae	Srinagar
2	-do-	Apple aphid, *Aphis pomi*	*Coccinella undecimpunctata*	Coleoptera : Coccinellidae	Srinagar
3		-do-	*Priscibrumusuropygialis*	-do-	
4.	-do-	-do-	Syrphid sp.	Diptera : Syrphidae	Srinagar
5.	-do-	European red mite, *Panonychus ulmi*	*Amblysieus* sp.	Mesostigmata: Phytoseiidae	Shalimar
6.	-do-	San Jose scale, *Quadraspidiotus perniciosus*	*Chilocorus infernalis*	Coleoptera : Coccinellidae	Shalimar
7.	-do-	-do-	*C. septempunctata*	-do-	Ganderbal
8.	-do-	-do-	*Scymnus*sp.	-do-	Srinagar
9.	-do-	-do-	*Chrysoperla zastrowi*	Neuroptera	Ganderbal
10.	-do-	-do-	*Encarsia perniciosi*	Hymenoptera : Aphelinidae	Budgam
11.	-do-	-do-	*Aphytis proclia*	-do-	Srinagar
12.	-do-	-do-	*Azotuskashmiriensis*	-do-	-do-
13	-do-	-do-	*Marietta sp.*	-do-	-do-
14.	-do-	Woolly aphis, *Eriosoma lanigerum*	*Aphelinusmali*	Hymenoptera : Aphelinidae	Srinagar

15	-do-	-do-	*C. septempunctata*	Coleoptera : Coccinellidae	Srinagar
16	-do-	-do-	*Chrysoperla zastrowi*	Neuroptera	Budgam
17	Apricot	aphid	*C. undecimpunctata**	Coleoptera : Coccinellidae	Kargil
18.	Walnut	Walnut aphid, *Panaphis juglandis*	*Harmonia dimidiata*	-do-	-do-
19.	Plum	Plum scale, *Parthenolecaniumcorni*	*Chilocorus infernalis*	Coleoptera : Coccinellidae	Shalimar
20.	-do-	-do-	*Metaphycus* sp.	Hymenoptera : Encyrtidae	Shalimar
21.	-do-	-do-	Hemipteran bug*	Hemiptera	Budgam
22.	Pear	Pear psylla	*C. septempunctata**	Coleoptera : Coccinellidae	Srinagar
23.	-do-	-do-	*C. undecimpunctata**	-do-	-do-
24	-do-	-do-	*Chrysoperla** *zastrowi*	Neuroptera	-do-
25.	Pomegranate	Pomegranate aphid	*Harmonia eucharis*	Coleoptera : Coccinellidae	Budgam

- First record

I.2.8 AAU, Jorhat

The seasonal abundance of spider was recorded, covering an area of 1 hectare at ICR farm, AAU, Jorhat under unsprayed condition (Table 10). The entire field was subdivided into 5 equal blocks and from each block 10 spots were randomly selected measuring 1 sqm. Observations of spider population were recorded from the 1 sqm. by visual count , pitfall traps and sweep net methods at 15 days interval starting from 2nd week of August (35 DAT) to till maturity of crop. For sweep net method, 10 catches per unit effort was made randomly from each block to collect the spiders from the field. Similarly, 10 numbers of pitfall traps was randomly placed in the rice field in each block at a distance of 100 m and replaced it after 48 hrs. Total numbers of spiders collected by three methods were:

General collections (visual methods) = 78 numbers
Sweep net methods = 33 numbers
Pitfall traps = 13 numbers

Table 10. Seasonal abundance of predatory spiders (Av)

Period of observation	Visual count	*Sweep net	Pitfall traps
2nd wk. of August	1.0	0.4	-
1st wk. of September	0.8	0.5	-
2nd wk. of September	1.0	0.7	0.1
1st wk. of October	1.2	0.8	0.2
2nd wk. of October	0.8	0.8	0.2
1st wk. of November	1.0	-	0.1
2nd wk.of November	0.9	-	0.3

1st wk. of December	0.7	-	-
2nd wk. of December	0.4	-	-

*Sweep net was not used from first week of November, 2017 due to reproductive growth phases of the crop.

A total of six species were recorded from the rice field. Relative abundance of *Oxyopes spp.* was 35.76 per cent and it was the most predominant species followed by *Lycosa pseudoannulata* (28.45%) and *Tetragnatha* spp. (22.76%), respectively (Table 11).

Table 11. Diversity of the Spiders in rice during 2017

Species	Family	Period of activity	Relative abundance (%)
Lycosa pseudoannulata	Lycosidae	Thorough out the *kharif* season	28.45
Oxyopes javanus	Oxyopidae	-do-	26.01
Oxyopes lineatipes	Oxyopidae	-do-	9.75
Argiope catenulata	Araneidae	September-October	8.13
Neoscona theisi	Araneidae	-do-	4.87
Tetragnatha spp.	Tetragnathidae	Thorough out the *kharif* season	22.76

Extensive surveys were conducted in ICR farm, AAU, Jorhat as well as in farmers' fields located at Rajabahar, Teok, allengmara, Garumora and Titabar during 2017-18 to record the population of natural enemy complex of rice and vegetables of Jorhat districts.

Visual counts per m^2 were adopted to record the number of spiders and coccinellids from rice ecosystem. In case of dragonfly and damselfly, visual as well as catch /unit efforts was adopted. The vegetable crops like brinjal, tomato, okra, cole crops cucurbits, papaya, bhut jolokia were surveyed for the presence of of natural enemy. In case of vegetables, coccinellid predators were recorded by visual counts per plant basis. Moreover, collection of egg masses and larvae of lepidopteran pests were made and rared in the laboratory for emergence of parasitoids. In rice and vegetables, *Corcyra* cards containing 100 numbers of eggs were placed for parasitization by Trichogrammatids .The spiders collected from different rice and vegetable fields were preserved in 70% alcohol.

Highest number of spider population (0.70 to 1.84 spider/ m^2) was recorded in rice fields. Altogether 68 numbers of spiders from 4 different families (lycosidae, Oxyopidae, araneidae and Tetragnathidae) were collected from different rice fields. The predominant spider was *Lycosa pseudoannulata* (25) and *Oxopes javanus* (22). Both the spiders were active throughout the cropping season. In vegetative growth stage of rice crop, more number of odonates(10 dragonfly and 17 damselfly) followed by reproductive stage (15) damselfly and (dragonfly) was recorded. The most dominant damselfly and dragonfly species were *Ceiagrion coromandelianum* and *Diplacodes trivialis*.

Seventy eight numbers of cocccinellids predators were recorded from August to October, 2017, from rice fields. The predator was *Micraspis discolor, Marmonia octomaculatus*, and *Chilomenes sexmaculatus*. *Micraspis discolor* was the the most dominant predator amongst the predators collected from rice fields.

During survey period, 48 numbers of egg masses of stem borer was collected and per cent parasitasation by parasitoids was 8.6. The eggs are mostly parasitized by *Trichogramma* sp., *Telenomous* sp. and *Tetrastichus* sp. The per cent parasitasation by *Cotesia* sp. (leaf folder larvae) was 11.2.

From vegetable ecosystem, maximum number of spiders was collected from tomato (12) and brinjal (14) crop. Moreover, 62 numbers of predators like *Micraspis discolor* (11), *Brumoides susturalis* (9), *Coccinella septempunctata* (12), *C. transvrsalis* (9), Syrphids (unidentified) (3), *Chrysoperla* sp (8), *Cheilomenes sexmaculata* (8) and *Cryptolaemus* sp. (2). Parasitasation of *Acerophagous papaya*e per 5 leaves/ plant was 3,2,1,0 during August, September, October and November' 2017. The spiders collected from vegetable ecosystem have been sent to NBAIR, Bangalore.

I.2.9 UAS, Raichur

The incidence of thrips was noticed during August month and continued till harvest of the crop and the peak activity was noticed during last week of September (4.18 thrips/leaf). Highest leafhopper activity was noticed during last week of November (15.12 leafhopper/leaf) and continued till harvest of the crop. The aphid activity was noticed from September second week (0.16 aphids/leaf) and its peak was noticed during last week of December (8.82 aphids/leaf). Overall the activity of whiteflies was negligible throughout the cropping period. Predator's *Viz*; spiders and coccinellids activity was coincided with the pest population. Syrphid activity was coincided with the peak activity of aphid population (Table 12).

Overall during current year the mirid bug activity was negligible and maximum mirid bug population was noticed during second week of November (1.88 mirid bugs/25 squares). At later stage of the crop mealy bug activity was noticed and maximum of 26.12 per 2.5 cm apical shoot length was noticed during the last week of January and activity of coccinellids and its primary parasitoid coincided with the peak activity of the host. Maximum coccinellids 1.02 per plant was noticed during third week of January and similarly the parasitoid activity was high (11.18/plant) during last week of January. The mealy bug activity was completely checked by the parasitoid at harvest of the crop (Table 13). The PBW moth activity started from second week of September and continued till harvest of the crop. Highest moth catches were noticed on last week of November (115.38 moths/trap/week) and continued till the last week of January (15.50 moths/trap/week). Highest larval population (35.50/10 bolls) were noticed during the last week of November and minimum during last week of January (2.00 larvae/10 bolls) the population declined thereafter. Overall the square damage was negligible but highest damage of 1.58 per cent was noticed during second week of November. Highest locule damage of 60.5 % was noticed during the third week January and continued till harvest of the crop (Table 14).

Table 12. Incidence of early sucking pests and their natural enemies in *Bt* cotton during 2017-18

Standard weeks	Thrips/ leaf	Leaf hoppers/ leaf	Aphids/ leaf	Whiteflies/ leaf	No. per plant		
					Spiders	Coccinellids	Syrphids
August							
33	0.58	0.00	0.00	0.00	0.00	0.00	

34	1.20	0.12	0.00	0.00	0.00	0.00	0.00
35	1.42	0.44	0.00	0.00	0.00	0.00	0.00
September							
36	2.13	0.62	0.00	0.00	0.00	0.00	0.00
37	2.20	0.78	0.00	0.00	0.00	0.00	0.00
38	3.42	1.86	0.16	0.00	0.06	0.00	0.00
39	4.18	1.94	0.34	0.00	0.09	0.00	0.00
October							
40	3.64	2.36	1.12	0.10	0.12	0.04	0.00
41	3.08	3.18	1.28	0.10	0.18	0.08	0.00
42	2.86	6.24	1.36	0.16	0.20	0.10	0.00
43	2.14	6.98	2.02	0.10	0.24	0.12	0.00
44	2.02	8.44	1.76	0.18	0.38	0.14	0.04
November							
45	1.44	10.18	2.82	0.32	0.42	0.36	0.18
46	1.26	12.36	3.16	0.48	0.40	0.32	0.32
47	1.18	14.08	5.82	0.66	0.38	0.28	0.44
48	1.02	15.12	6.98	0.92	0.32	0.26	0.82
December							
49	0.86	5.56	5.88	1.20	0.58	0.46	0.46
50	0.72	7.32	3.62	1.44	0.52	0.52	0.24
51	0.68	7.18	3.14	1.58	0.46	0.68	0.18
52	0.62	6.32	8.82	1.62	0.32	0.40	0.12
January							
1	0.18	4.24	1.86	1.06	0.28	0.36	0.06
2	0.22	3.84	1.32	0.84	0.24	0.28	0.02
3	0.16	3.18	1.08	0.72	0.18	0.22	0.00
4	0.14	2.04	1.02	0.68	0.12	0.14	0.00

Table 13. Incidence of mirid bug, mealy bug and their natural enemies in *Bt* cotton during 2017-18

Standard weeks	Mirid bugs /25 squares	No. of mealy bugs/2.5 cm of aphid shoot	Coccinellids	*Aenasius arizonensis*
August				
33	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0.00
35	0.00	0.00	0.00	0.00
September				
36	0.00	0.00	0.00	0.00
37	0.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00
39	0.12	0.00	0.00	0.00
October				
40	0.18	0.00	0.00	0.00
41	0.24	0.00	0.00	0.00
42	0.36	0.00	0.00	0.00
43	0.42	0.00	0.00	0.00

44	0.68	0.00	0.00	0.00
November				
45	1.76	0.00	0.00	0.00
46	1.88	0.00	0.04	0.00
47	1.62	0.00	0.00	0.10
48	1.44	5.50	0.00	0.20
December				
49	1.26	10.68	0.18	1.06
50	1.08	11.32	0.26	1.18
51	0.96	15.64	0.34	2.02
52	0.82	17.38	0.38	2.56
January				
1	0.26	20.08	0.42	5.84
2	0.18	22.42	0.68	9.36
3	0.06	25.86	1.02	10.92
4	0.00	26.12	0.84	11.18
February				
5	0.00	15.28	0.86	10.84
6	0.00	15.04	0.92	9.72
7	0.00	11.05	0.98	9.36
8	0.00	6.42	0.74	9.08

Table 14. Monitoring and incidence of Pink bollworm in *Bt* cotton during 2017-18

Standard Weeks	**No. of moths / trap /week**	***P. gossypiella* larvae per 10 bolls**	**Square damage (%)**	**Locule damage (%)**
August				
33	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0.00
35	0.00	0.00	0.00	0.00
September				
36	0.00	0.00	0.00	0.00
37	5.62	0.00	0.00	0.00
38	6.84	0.00	0.00	0.00
39	7.18	0.00	0.00	0.00
October				
40	15.36	0.10	0.00	0.00
41	18.82	0.30	0.00	0.00
42	26.58	0.50	0.15	0.00
43	20.44	1.00	0.54	2.50
44	30.58	2.50	1.32	5.25
November				
45	50.25	15.00	1.25	28.50
46	58.30	20.25	1.58	30.75
47	104.26	30.05	0.80	40.50
48	115.38	35.50	0.60	35.25
December				

49	80.85	20.00	0.25	41.75
50	70.38	25.00	0.18	45.00
51	50.50	18.00	0.06	50.50
52	30.25	12.00	0.10	55.25
January				
1	20.75	10.00	0.00	50.75
2	18.50	8.00	0.00	60.50
3	22.68	4.00	0.00	55.00
4	15.50	2.00	0.00	45.00

Seasonal abundance of spiders in rice ecosystem by general collection, pitfall trap and sweep net method (Specimens to be sent to NBAIR for identification)

Spiders collected from rice ecosystem were sent (once) to NBAIR for identification.

I.2.10 AAU, Anand

Location and agro climatic sub region: Middle Gujarat
Work carried out during the current year:

The activity of biocontrol agents was monitored during *kharif* and *rabi* season in different crops. With a view to know the activity of egg-parasitoid *i.e., Trichogramma* species sentinel cards with eggs of *Corcyra cephalonica* were placed in various crop fields *i.e*., tomato, castor, cotton, maize, okra and observed for egg parasitism. The diversity of *Chrysoperla*, coccinellids, spiders, entomopathogenic fungi (EPF) and entomopathogenic nematodes (EPN) was studied.

Methodology

Regular survey was conducted in different districts of middle Gujarat region to determine the biodiversity of indigenous natural enemies of crop pests. Farmers' fields were visited at fortnightly interval and different stages of natural enemies of insect pests were collected and preserved in the laboratory. The unidentified natural enemies were sent to National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru for identification.

1) ***Trichogramma***
   The geographical population was collected from different crop ecosystems by placing sentinel cards with eggs of *C. cephalonica*
2) ***Chrysoperla***
   Five geographical populations (at least 20 in each population) were collected.
3) ***Coccinellids***
   Five geographical populations (at least 20 in each population) were collected.
4) **Spiders**
   In *kharif* season spider samples were collected from rice ecosystem by general collection, sweeping net and pit fall trap method.
5) **Antagonists/bioagents:** Sixty soil samples were collected from different groundnut fields of Saurashtra region in Gujarat and analyzed for the presence of EPF and EPN

6) Others

1) *Trichogramma*

During 2017-18, sentinel cards with eggs of *C. cephalonica* were placed in tomato, cotton, castor, maize and okra fields for parasitism by *Trichogramma* species collected after 3-4 days and observed in the laboratory for emergence of *Trichogramma*. *Trichogramma chilonis* was the only *Trichogrammatid* recorded as evident from Table 15.

Table 15. Biodiversity of *Trichogramma* species in different crops

Crop	No. of *Trichogramma* adults emerged per installation (100 eggs/card)				
	I	II	III	IV	V
Tomato	0	4	4	3	0
Castor	2	3	0	4	1
Cotton	3	4	3	2	0
Maize	2	3	2	0	0
Okra	0	2	3	3	0

2) *Chrysoperla*

Geographical population of green lacewing was collected. *Chrysoperla zastrowi sillemi* was found in all the population.

3) Coccinellids

Diversity of coccinellids from various crop ecosystem of the region was studied. The natural population of *Cryptolaemus montrouzieri* was observed.

4) Spiders

Total 41 spider specimens were collected from rice ecosystem (Table 16). The samples were belonging to four families namely Araneidae, Oxyopidae, Tetragnathidae and Salticidae. Out of 41 samples 17 turned to be *Neoscona theisi*.

5) Antagonists/bioagents

Sixty soil samples were collected from different groundnut fields of Saurashtra region in Gujarat. Insect pathogenic fungi *Beauveria* spp was isolated by following standard plating techniques and further confirmed the pathogenicity on *Corcyra cephalonica* larvae (2^{nd} and 3^{rd} instar). Twelve soil samples found positive for *Beauveria* spp. The isolates were tentatively identified as *Beauveria* spp based on morphological and microscopic studies. Insect pathogenic assays and molecular work are in progress. EPN was not found in all the soil samples tested

The detailed studies pertaining to insect pathogenic*/Bt* isolates obtained from previous year (2016-17) soil samples are also in progress. Eleven isolates have been shortlisted based on bioefficacy studies on *C. cephalonica* larvae and 16s rRNA characterization revealed four new native insect pathogenic isolates.

Table 16. Diversity of spiders in paddy ecosystem of middle Gujarat

Vial No.	Sex/stage	Family	Genera	Species	Author
1	♀	Araneidae	*Argiope*	*pulchella*	Thorell
2		Araneidae			
3	♀	Araneidae	*Argiope*	*pulchella*	Thorell
4	♀	Araneidae	*Argiope*	*pulchella*	Thorell
5	Sub adult♀	Araneidae	*Argiope*	*pulchella*	Thorell
6	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
7	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
8	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
9	♀	Araneidae	*Argiope*	sp.	
10	♂	Oxyopidae	*Oxyopes*	*javanus*	Thorell
11	Spiderling	Tetragnathidae	*Leucauge*	sp.	
12	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
13	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
14	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
15	♂	Oxyopidae	*Oxyopes*	*javanus*	Thorell
16	♀	Oxyopidae	*Oxyopes*	*javanus*	Thorell
17	♂	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
18	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
19	Sub adult♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
20	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
21	Sub adult♀	Tetragnathidae	*Tetragnatha*	sp.	.
22		Araneidae			
23	♀	Tetragnathidae	*Tetragnatha*	*javana*	Thorell
24	Sub adult♂	Araneidae	*Neoscona*	*?theisi*	(Walckenaer)
25	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
26	♂	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
27	Sub adult♂	Araneidae			
28	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
29	Spider ling	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
30	♀	Araneidae	*Araneus*	*ellipticus*	(Tikader& Bal)
31	♀	Salticidae	*Bianor*	*incitatua*	Thorell
32	--				
33	Sub adult♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
34	♀	Araneidae	*Neoscona*	*theisi*	(Walckenaer)
35	Sub adult ♂	Oxyopidae	*Oxyopes*	*javanus*	Thorell
36	Sub adult♂	Tetragnathidae	*Leucauge*	sp.	NA
37	♂	Tetragnathidae	*Tetragnatha*	sp.	NA
38	Sub adult♂	Tetragnathidae	*Tetragnatha*	sp.	Okuma
39	Spider ling	Araneidae	*Argiope*	sp.	NA
40	♀	Araneidae	*Argiope*	*pulchella*	Thorell
41	Sub adult♀	Tetragnathidae	*Tetragnatha*	sp.	

The samples were belonging to four families namely Araneidae, Oxyopidae, Tetragnathidae and Salticidae. Out of 41 specimens, 17 turned to be *Neoscona theisi.*

7) Anthocorids

Regular survey was carried out for anthocorid predators on thrips and mites infested plants. No predators were recorded.

Seasonal abundance of spiders in rice ecosystem by general collection, pitfall trap and sweep net method

Location and agro climatic sub region: Middle Gujarat

Work carried out during the current year:

a) During *kharif* 2017-18 periodical survey was conducted in Tarapur region of Anand district for the collection of spider samples from rice ecosystem.
b) Total 41 spider samples were collected and preserved as per the standard methodology and sent to ICAR-NBAIR for identification.
c) Further, the survey and collection of samples from *summer* paddy is under progress.

Methodology:

a) Five fields of paddy were randomly selected from intense paddy growing area (Tarapur and Anand).
b) All the spiders were collected from 10 quadrates (1x1m) from each field at weekly interval
c) Collected specimens were preserved in 70% ethanol
d) Five pitafall traps on border (20/field) were installed in each field and collections were made on alternate days
e) Species richness, species diversity and species evenness will be calculated by analysing the data and making comparison between *kharif* and *summer* season

I.2.11 PAU, Ludhiana

Regular surveys were conducted to collect spiders from rice growing areas (Ludhiana, Patiala, Barnala) of Punjab. Collected specimens were brought back to the laboratory and were preserved in 70% alcohol. A total of eleven species were recorded from the rice fields. The detail of relative abundance is given in Table 17. *Neoscona theisi* was the predominant species (74.48%) at all the locations followed by *Tetragnatha javana* (13.54%). Species diversity (1.025) was calculated as per Shannon-Weiner index of diversity. Species evenness (0.445) and dominance index (0.555) was worked out as per formulae given by Krebs and Southwood, respectively.

Table 17. Diversity of spiders in rice during 2017

Sr. No.	Species	Family	Relative abundance (%)
1	*Neoscona theisi*	Araneidae	72.05
2	*Tetragnatha javana*	Tetragnathidae	14.29
3	*Tetragnatha maxillosa*	Tetragnathidae	6.21
4	*Argiope catenulata*	Araneidae	2.80
5	*Leucage decorata*	Tetragnathidae	2.48

6	*Oxyopes kusumae*	Oxyopidae	0.93
7	*Thomisus* sp.	Thomisidae	0.62
8	*Dolomedes fimbriatus*	Pisauridae	0.31
9	*Bianor* sp.	Salticidae	0.31
10	*Lycosa mackenziei*	Lycosidae	0.31
11	*Simaetha* sp	Salticidae	0.31
H (diversity index) : 1.0252870 Species evenness : 0.4452764 Dominance index : 0.5547235			

I.2.11.1 Monitoring of whitefly, its natural enemies and pink bollworm in cotton in Punjab

Whitefly

Regular surveys were conducted in cotton growing areas of Punjab (Fazilka, Bathinda, Mansa and Muktsar districts) to monitor whitefly population on cotton crop during *kharif* 2017 by the team comprising scientists from PAU campus, Regional Stations, Krishi Vigyan Kendras (KVKs) and Farm Advisory Service Scheme (FASS) centres.

The population of whitefly low to moderate except in some late sown crops. No major outbreak was recorded. The PAU recommended strategy was successfully implemented in cotton growing areas through the joint efforts of farm experts from PAU and Department of Agriculture (Punjab). The execution of IPM strategy involving regular monitoring and surveillance and timely advisement to farmers regarding non-chemical and chemical approaches did not allow whitefly population to build up and it remained under control during *kharif* 2017 season.

As a part of strategy, application of neem based biopesticides (Nimbecidine/Achook) were carried as initial sprays to conserve the natural enemies. Farmers were also acquainted with identification of natural enemies in cotton ecosystem. Besides this, weed eradication campaign and training programmes on cotton production and protection technology were also carried out by PAU and Department of Agriculture in all the cotton growing villages to create the awareness and farm literature regarding whitefly management was also distributed. The cooperation of farmers in execution of whitefly management strategy paid dividends and it was successfully managed through joint efforts.

Natural enemies

The population of predators was recorded on whole plant basis from 20 plants selected at random. Infested cotton leaves (nymphs & pupae of whitefly) were collected and brought to the Biocontrol laboratory to record the emergence of parasitoids. Ten species of natural enemies of *B. tabaci* were observed, including 8 predators and two species of parasitoid.

Predators

Among predators, *Coccinella septempunctata* (Linneaus), *Cheilomenes sexmaculata* (Fabricius) and *Brumoides suturalis* (Fabricius), *Serangium* sp., *Chrysoperla zastrowi sillemi* (Esben-Peterson), *Zanchius breviceps* (Wagner), *Geocoris* sp. and spiders were most commonly

recorded predators. Out of these, *Chrysoperla* was the predominant species. The population of coccinellids, *Chrysoperla*, spiders and *Zanchius* sp. varied from 0.0 to 2.0, 0.0 to 44.0.0, 0.0 to 18.0 and 0.0 to 2.0 per 10 plants, respectively (Table 18). The population of *Chrysoperla* was maximum till end July, but declined thereafter. However, spider population was at peak during August month (Fig. 7). The *Chrysoperla* and spider population for 2016 is given in Fig. 8 & Plate 1 & 2.

Table 18. Population of predators recorded during survey in cotton (*Kharif*, 2017)

Date	Districts	Villages covered	Population of predators/ 10 plants			
			Chrysoperla*	**Spiders**	**Coccinellids**	***Zanchius***
21.6.17	Muktsar, Fazilka, Faridkot	Khara, Aulakh, Khuban, Rupnagar Bakainwala, Koil Khera, Haripura	1.3 (1.0-5.5)	1.0 (1.0-3.0)	(0.1) 0.0-1.0	0.0
4.7.17	Mansa	Tamkot, Sardulewala Jatana	4.0 (1.0-9.0)	2.7 (1.5-4.5)	0.0	0.0
7.7.17	Muktsar, Fazilka, Faridkot	Waada Daraka, Khara, Aulakh , Ena Khera, Koliawaali, Bahadur Khera, ShaamKhera Khuban, Sitogono	16.3 (8.0-30.0)	4.2 (1.0-12.0)	0.0	(0.1) 0.0-1.0
18.7.17	Muktsar, Fazilka, Faridkot	Waada Daraka, Khara, Aulakh, Dhaani Udawaali, ShaamKhera, Khuban, Sitogono, Dhaani Udawaali	19.7 (8.0-44.0)	1.6 (1.0-5.0)	(0.1) 0.0-1.0	0.0
27.7.17	Muktsar, Fazilka, Faridkot	Waada Daraka, Khara, Aulakh , Ena Khera, Koliawaali, ShaamKhera Khuban, Sitogono, Chakra	10.1 (5.0-19.0)	5.0 (1.0-11.0)	0.0	0.0
3.8.17	Mansa, Bathinda	Aklia, Joga, Ralla, Tamkot, Khiala, Gehla, Musa, Gaguwal, Maakha, Behniwal, Jagga Ram Tirth, Nawan Pind, Bhagi wander, Jeewan Singh Wala, Kot Shamir, Phus Mandi, Bhagu	5.4 (1.0-19.0)	7.6 (1.0-17.0)	0.1 (0.0-2.0)	0.1 (0.0-2.0)
8.8.17	Muktsar, Fazilka, Faridkot	Waada Daraka, Aulakh, Ena Khera, Khema Khera, Khuban, Rup Nagar	4.3 (2.0-18.0)	7.0 (2.0-14.0)	0.0	0.0

17.8.17	Muktsar, Fazilka,	Bhai Ka Kera, Khema Khera, Khuban, Sitoguno, Sukhchain, Khairpura, Sardarpura, Do Tarawaali, Raipura	2.5 (1.0-7.0)	9.9 (6.0-18.0)	0.0	0.0
7.9.17	Muktsar, Fazilka, Faridkot	Waada Daraka, Khara, Aulakh , Ena Khera, Koliawaali, Khema Khera, Khuban, Sham Khera	3.5 (2.0-21.0)	4.8 (1.0-12.0)	0.18 (0.0-2.0)	0.0
13.9.17	Muktsar, Fazilka	Bhai Ka Kera, Khema Khera, Khuban, Shaam Khera, Sitoguno	2.4 (1.0-9.0)	2.8 (0.0-8.0)	0.0	0.0
19.9.17	Muktsar, Fazilka	Bhai Ka Kera, Koliawaali, Khema Khera, Khuban	2.0 (1.0-5.0)	2.2 (0.0-6.0)	0.0	0.0

* include eggs, larvae, pupa & adults; Figures in parentheses indicates range at different locations

Plate 1. Crop Calendar

Plate 2. On-spot advisement of whitefly management at farmer field

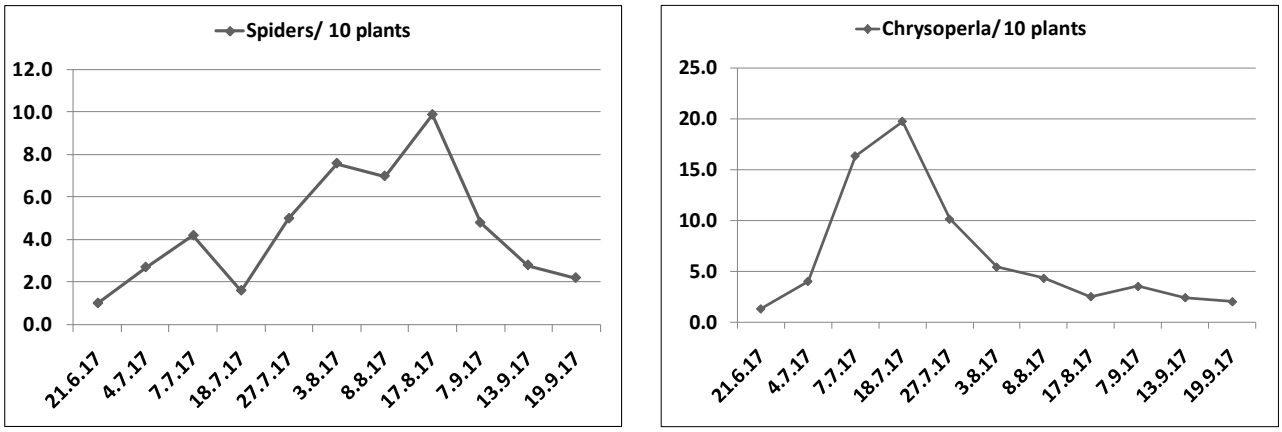


Fig. 7. Population trends of *Chrysoperla* and spiders in growing areas of Punjab during 2017

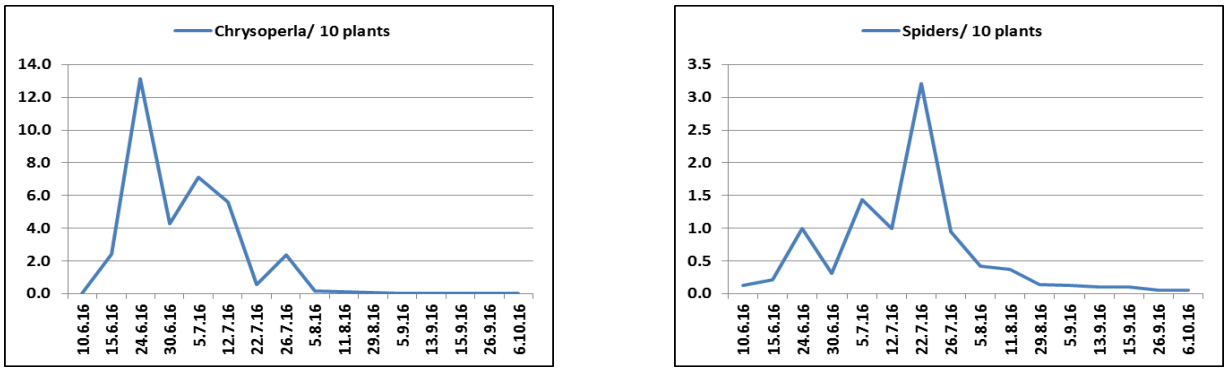


Fig 8. Population trends of *Chrysoperla* and spiders in growing areas of Punjab during 2016

Parasitoids

Encarsia lutea (Masi) and *Encarsia sophia* (Girault & Dodd) were the two parasitoids that emerged from whitefly pupae (Plate 3). Out of 6349 nymphs observed, 330 were found to be parasitized (Table 19 & Fig. 9). The mean parasitization of whitefly by *Encarsia* spp. in different cotton growing areas of Punjab was 5.20 per cent (range = 1.5 to 9.1%). The parasitoids have been got identified from Dr Mohd. Hayat, Aligarh Muslim University, Aligarh.

Table 19. Parasitization of whitefly by *Encarsia* sp. on cotton in Punjab during 2017

Districts	Number of whitefly nymphs observed	Number of parasitized nymphs	Per cent parasitization
Mansa	2302	210	9.12
Muktsar	1522	36	2.36
Bathinda	952	29	3.05
Faridkot	605	9	1.49
Ludhiana	462	30	6.49
Fazilka	389	16	4.11
Total/Mean	6349	330	5.20

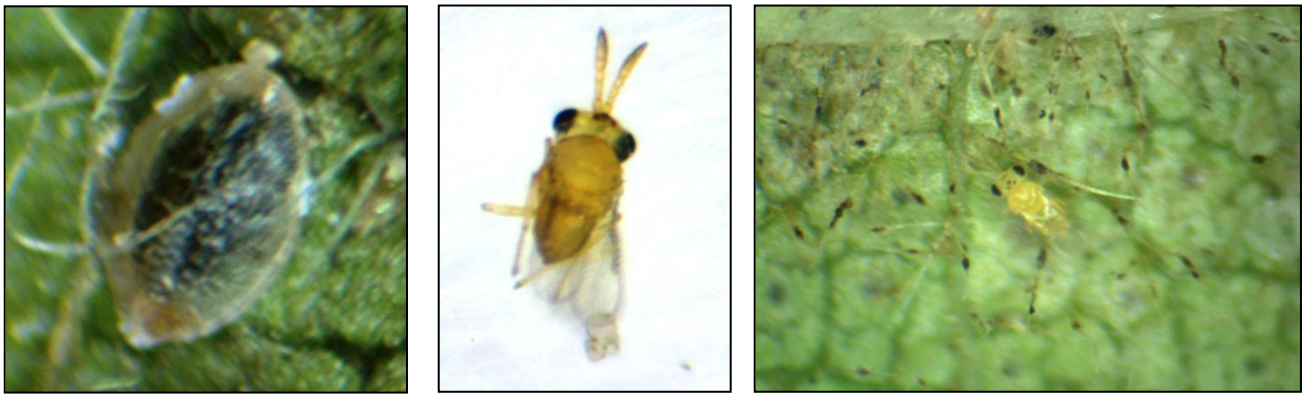


Plate 3. Parasitized whitefly nymph and adult of parasitoid *Encarsia* sp.

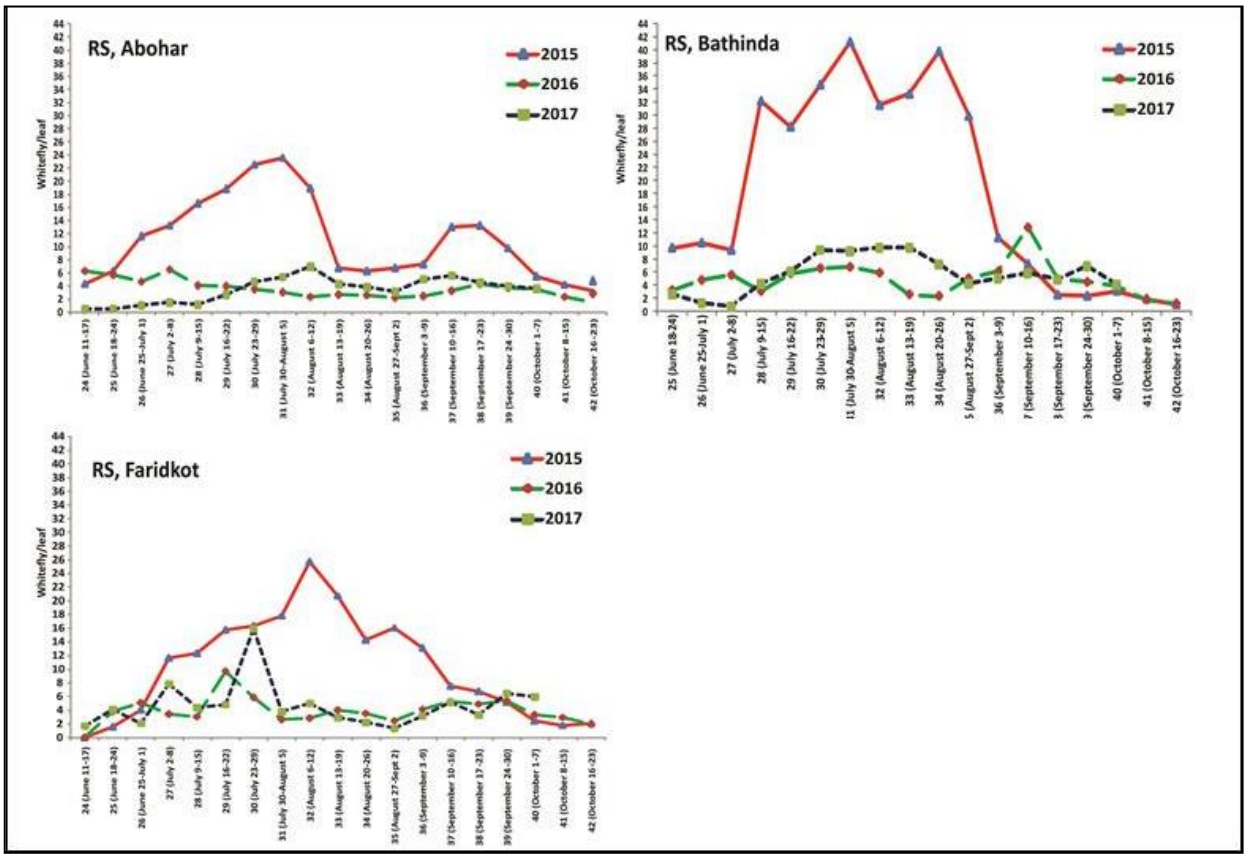


Fig. 9. Comparative incidence of whitefly on cotton during 2015, 2016 and 2017

(Source: Department of Entomology, PAU, Ludhiana)

Pink bollworm: No pink bollworm damage was recorded on Bt cotton crop.

I.2.12 MPKV, Pune

Survey and collection of natural enemies- *Trichogramma, Chrysoperla, Cryptolaemus*, spiders, entomopathogens

1. ***Trichogramma*-** Sentinel cards with the eggs of *Corcyra cephalonica* (100 eggs/card) were displayed at seven locations in a cropped area for 24 hrs in cotton, pigeon pea sugarcane, maize, soybean, tomato, brinjal and repeated at fortnightly intervals during the pest activity. Retrieved cards were kept in glass vials for *Trichogramma* emergence.
2. ***Chrysoperla*-** About 20 live individuals (eggs/larvae/adults) were collected from five geographic locations crop-wise for the record.
3. ***Cryptolaemus*-** Live individuals (grub/ adults) collected from five geographic locations in different orchards.

4. **Spiders**- Adult spiders were collected from field and orchard crops and the specimens preserved in 70 per cent ethyl alcohol in screw cap tubes.
5. **Entomopathogens**- The cadavers of insects infected by entomopathogenic fungi and NPV were collected in dry sterile vials.

Different stages of insect pests and bioagents were collected and sent for identification to the NBAIR, Bangalore.The specimens are maintained in the Biocontrol laboratory for further reference.

The natural enemies inclusive of coccinellids like *Coccinella septempunctata* L. *Menochilus sexmaculata* F., *Scymnus* sp., *Dipha aphidivora* Meyrick, *Micromus igorotus* Bank. and syrphid, *Eupeodes confrater* and the parasitoid *Encarsia flavoscuttellum* were recorded on SWA in sugarcane, *Coccinella transversalis* F., *M. sexmaculata, Brumoides suturalis* F., *Scymnus coccivora, Triomata coccidivora* Ayyar and *B. suturalis* in mealybug colonies on custard apple, *Acerophagus papayae* N. & S., *Mallada boninensis* Okam. and *Spalgis epius* Westwood on papaya mealybug.

The sentinel egg-cards of *Corcyra* were displayed in the crops like cotton, maize, soybean, pigeon pea, sugarcane, tomato and brinjal to record parasitism of *Trichogramma* in Pune region, but the parasitoid was not recorded. The chrysopid, *Chrysoperla zastrowi sillemi* was observed in cotton, maize, bean, jawar, okra and brinjal, while, *Mallada boninensis* on cotton, beans, mango, papaya and ornamental plants. The *Cryptolaemus* adults were recovered from the custard apple and papaya orchards, cotton and ornanmental hibiscus. The entomopathogens particularly the cadavers of *S. litura* and *H. armigera* infected with *Nomuraea rileyi, Metarhizium anisopliae, Sl*NPV, *Ha*NPV were collected from soybean, cabbage, pigeon pea and tomato crops in farmers fields (Table 20).

Table 20. Natural enemies recorded from Western Maharashtra

Natural Enemies	Crop	Remarks /Natural enemies recorded
Trichogramma sp.	Cotton, maize, sugarcane, soybean, pigeon pea, tomato, brinjal	Sentinel cards of *Corcyra* eggs for *Trichogramma* were displayed in the fields from April to November, 2016 at various crop stages and prevalence of caterpillar pests, but parasitoids were not recovered.
Chrysopid: *Chrysoperla zastrowi sillemi*	Cotton, maize, bean, jawar, okra, brinjal	Eggs, grubs and adult stages were collected and identified locally.
Mallada boninensis	Cotton, bean, mango, papaya and hibiscus	Recorded from aphid colonies on cotton, mango hoppers, mealybugs and identified locally.
Coccinellids: *Coccinella septempunctata* L. *Menochilus sexmaculata* F.	Cotton, sugarcane, jawar, maize, cowpea, okra, binjal, soybean, beans, papaya, pomegranate	Eggs, grubs, pupal and adult stages were recorded in the aphid colonies on leaf surfaces.
Cryptolaemus montrouzieri Mulsant	Custard apple, papaya, cotton, hibiscus	The grubs and adult stages were collected and identified locally.
Spiders	Cotton, sugarcane,	The specimens were collected and sent for

	maize, soybean, papaya, mango, brinjal, okra, beans, pigeon pea	identification.
Entomopathogens: *Nomuraea rileyi*	Soybean, cabbage	*N. rileyi* diseased cadavers of *S. litura* were collected and isolated the pathogen.
*Sl*NPV *Ha*NPV	Soybean, cabbage capsicum, tomato, pigeon pea	Cadavars of *Sl*NPV and *Ha*NPV infected larvae of *S. litura* and *H. armigera* were collected.
Metarhizium anisopliae	Pigeon pea	*H. armigera* larvae, mango hoppers and white grubs infected with *M. anisopliae* were collected and isolated the pathogens.

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

The incidence of sugarcane woolly aphid (SWA) and occurrence of natural enemies (*Dipha aphidivora, Micromus igorotus*, syrphid, spiders, *Encarsia flavoscutellum*) recorded from five agro-ecological zones of western Maharashtra. Incidence of sugarcane woolly aphid in village covering Pune, Satara, Sangli, Kolhapur, Solapur, Ahmednagar and Nashik districts. The SWA incidence, pest intensity rating (1-6 scale) and natural enemies' population on leaf were recorded at five spots and five clumps per spot in each plot during crop growth period.

The sugarcane fields surveyed during the period from June to November, 2017. The SWA incidence was observed along riverside and canal areas with natural enemies in sugarcane fields. The pest incidence was relatively low during this year. The SWA incidence was observed in Mulshi, Haveli, Indapur, Baramati, Daund Tahasils of Pune district, Shrigonda in Ahmednagar District Karad, Patan, Wai, Phaltan and Javali Tahasils and Padegaon, Hamdabaj, Kidgaon, Nele, in Satara district along with its predator *Micromus igorotus* and *Dipha aphidivora* and *Encarsia flavoscutellum* in Walwa, Shirala, Palus Kadegaon area in Sangali district, Kagal, Panhala, Shahuwadi, Chandgad, Gadhinglaj, Ajra and Radhanagari Tahasils of Kolhapur district, Sangamner, Shrigonda Tahasils of Ahmednagar district, Malashiras, and Pandharpur Tahasils of Solapur district and Niphad area in Nasik district.

The predatory population was recorded from July onwards. The *Micromus igorotus* and *Encarsia flavoscutellum* noticed during July to November, 2017 and *Dipha aphidivora* observed from August to November 2017. These predators were predominant and well established in the sugarcane growing areas of western Maharashtra. Moreover, the parasitoid *Encarsia flavoscutellum* which was brought from Assam and release in Maharashtra is well established, which was also observed in most of the sugarcane growing areas of western Maharashtra.

It seems from the data in Table 21 that the incidence of SWA was relatively low in Sangli, Satara and Kolhapur districts during this year. However, the natural enemies were noticed soon after the pest incidence. The average SWA incidence and pest intensity rating were 1.65 and 2.00 per cent, respectively. The natural enemies recorded in the SWA infested fields were mainly the predators like *D. aphidivora* (0.10-2.40 larvae/leaf), *M. igorotus* (1.33-4.66 grubs/leaf), syrphid *Eupoderes confractor* (0.40-1.20 larvae/leaf) and spider (0.10-0.60 /leaf) during August to November, 2017. The parasitoid *Encarsia flavoscutellum* found distributed and well established in almost all sugarcane fields and effectively suppressed the SWA incidence in western Maharashtra.

Table 21. Effect of natural enemies on incidence of sugarcane woolly aphids in western Maharashtra

Districts surveyed	SWA incidence (%)	Pest intensity rating (1-6)	Natural enemies/leaf				Spiders
			D. aphidivora	*M. igorotus*	*E. flavoscu-tellum*	*E. confractor*	
Pune	1.80	2.00	1.30	2.00	1.42	0.60	0.40
Satara	2.10	2.00	1.40	2.80	2.12	0.80	0.60
Sangli	2.90	2.00	1.60	3.20	3.50	1.00	0.20
Kolhapur	3.40	3.00	2.40	4.66	4.50	1.20	0.60
Ahmednagar	0.20	2.00	0.10	1.33	0.50	0.40	0.10
Solapur	0.40	2.00	0.30	1.50	3.50	0.80	0.40
Nashik	0.80	2.00	0.60	2.16	0.50	0.90	0.10
Average Range	1.65 (0.20-3.40)	2.00 (2.00)	1.10 (0.10-2.40)	2.52 (1.33-4.66)	2.29 (0.50-4.50)	0.73 (0.40-1.20)	0.34 (0.10-0.60)

* Pest intensity rating: 1=0, 2=1-20, 3= 21-40, 4=41-60, 5=61-80, 6=81-100 % leaf covered by SWA

Survey and record of incidence of pin worm, *Tuta absoluta* on tomato

The Survey and surveillance of natural enemies of pin worm, *Tuta absoluta* on tomato was conducted during April to November, 2017. The less infestation of this pest was observed in Junnar and Ambegaon Tahasil of Pune district. It is revealed from table 22 that the leaf damage is ranged between 8 to 12 trifoliate / 10 plants with an average of 2.50 trifoliate / 10 plants. The leaf damage percentage due to pin worm was 3.13 % and fruit damage is ranged between 12 – 20 with an average of 4.0 fruits/ plant. The maximum incidence of the pin worm was recorded in the months April-May 2017.

Table 22. Survey and incidence of pin worm, *Tuta absoluta* on tomato

Month	Leaf damage 5 trifoliate/ plant (10 plants)	Fruit damage/ 10 plants
April, 2017	12	20
May, 2017	08	12
June, 2017	00	00
July, 2017	00	00
August, 2017	00	00
September, 2017	00	00
October, 2017	00	00
November, 2017	00	00
December,2017	00	00
January,2018	00	00
February,2018	00	00
March, 2018	00	00
Average	2.5	4.0
Range	8 to 12	12 to 20
% damage	3.13 %	5.00%

Monitoring the incidence of papaya mealy bugs (PMB) and its natural enemies on papaya and other alternate hosts

The papaya orchards were surveyed for the incidence of papaya mealy bugs (PMB) in various agro-ecological zones of western Maharashtra and recorded its associated natural enemies as well as alternate host plants. The intensity rating of mealy bug was recorded in 1-5 scale from 5 plants per orchard. Besides, the natural enemies in mealybug colonies and alternate hosts of PMB in the vicinity of papaya orchards were also recorded.

The data presented in Table 23 revealed that the negligible incidence of PMB was noticed to the extent of 1.0 to 5.00 per cent in all districts of western Maharashtra. It was relatively very low with 1.0 pest intensity rating during this year. The pest incidence noticed maximum in Shahada (Nandurbar), followed by Shirpur (Dhule) and Chopada (Jalgaon) areas. The encyrtid parasitoid *Acerophagus papayae* found parasitizing the mealybugs in almost all the papaya orchards surveyed and it was ranged from 0.6 to 2.8 adults/leaf.

Table 23. Survey and record of papaya mealy bugs in western Maharashtra

District surveyed	PMB incidence (%)	Pest intensity rating	*A. papayae* popu./leaf
Pune	1.0	1.0	0.8
Ahmednagar	1.0	1.0	0.6
Jalgaon	3.0	1.0	1.7
Dhule	5.00	1.0	2.6
Nandurbar	5.00	1.0	2.8
Nashik	1.0	1.0	0.8
Solapur	1.0	1.0	0.6
Kolhapur	1.0	1.0	0.6
Satara	1.0	1.0	0.6
Sangli	1.0	1.0	0.8
Average	2.00	1.0	1.19
Range	1.0 – 5.0	1.0	0.6 – 2.8

1-5 scale (1= very low; 2=low; 3=medium; 4=high; 5= very high population)

Natural enemies recorded in papaya mealy bug colonies:

i. Encyrtid parasitoid, *Acerophagus papayae* N. & S.
ii. *Spalgius epius* (Westwood)
iii. *Coccinella septempunctata* Linn.
iv. *Scymnus* sp.
v. *Monochilus sexmaculatus* (Fab.)
vi. Anthocorids
vii. *Mallada* sp.
viii. *Brumoides* sp.
ix. Spiders

Alternate hosts of papaya mealy bug in Maharashtra:

During survey, the papaya mealybug was observed on following plants/weeds as alternate hosts in the vicinity of papaya orchards.

1. Parthenium (*Parthenium hysterophorus* L.)
2. Safed chafa (*Plumeria alba*)
3. Mulberry (*Morus alba*)

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

The *Bt* cotton *var*. Ajab, Bollgard II was sown on 13/07/2017 on ridges and furrows at 90 x 60 cm spacing in 48 x 30 m size plots on the Research Farm of Agril. Entomology Section, College of Agriculture, Pune. All the recommended agronomic practices were followed except pesticide application. The sucking pests and natural enemies were recorded from randomly selected and tagged 5 plants from the plot at fortnightly interval. The pest population recorded on three leaves (top, middle, lower portion) per plant. Simultaneously, the natural enemies were also recorded on the plant.

The data in Table 24 revealed that the incidence of aphids and thrips was recorded from 1st week of August 2017 (31st MW), while jassids and white flies were observed in the subsequent week. All these sucking pests were prevalant during the period from August to November 2017. The incidence of aphids (15.87-53.40), jassids (4.42-9.47), thrips (6.53-10.47) and white flies (4.27-5.87) per three leaves per plant found relatively high from 1st week of August till end of November 2017. The peak incidence of aphid and jassids was recorded during 2nd fortnight of October (42 &43rd MW), while highest population of thrips was observed in 4th week of August (34th MW) and peak of white fly population was noticed in 4th week October (43rd MW).Initially the infestation of Mealy bug *P. solenopsis* was meager throughout the season in the experimental field. Later on the mealy bug incidence was increased from January 2018 and reached to severe stage in February 2018. But the 70-80 per cent parasitization by *Aenaseus arizonensis* was observed in experimental field.

Table 24. Incidence of sucking pests and their natural enemies in *Bt* cotton

Date of record	Av. population / 3 leaves / plant							
	Aphids	Jassids	Thrips	White flies	Mealy bug	Chrysopid	Coccinellids	Spiders
24.07.2017	4.33	4.20	6.53	1.87	0.00	0.67	1.13	0.00
31.7.2017	8.93	4.42	9.80	4.27	0.00	0.27	0.53	0.40
07.08.2017	15.87	3.53	6.67	2.60	0.00	0.20	1.93	0.47
14.08.2017	16.47	6.93	5.20	2.33	0.00	0.07	1.20	1.00
21.08.2017	20.40	7.00	10.47	2.00	0.00	0.00	0.67	1.27
28.08.2017	33.80	5.80	3.73	1.40	0.08	0.00	1.00	0.67
11.09.2017	10.87	1.27	1.33	1.00	0.08	0.40	0.47	0.47
25.09.2017	12.80	1.53	0.87	2.73	0.27	0.33	0.53	0.33
09.10.2017	29.27	3.73	0.00	1.87	0.52	0.13	0.47	0.60
16.10.2017	52.13	6.53	0.00	3.67	0.00	0.00	0.80	0.53
23.10.2017	50.27	9.47	0.00	5.87	1.20	0.00	1.27	0.73
30.10.2017	53.40	3.60	0.00	2.47	0.08	1.60	1.13	1.13

14.11.2017	40.30	2.10	0.00	1.00	0.00	0.47	0.87	0.27
27.11.2017	20.10	1.53	0.00	1.33	0.00	0.00	0.53	0.00
Range	15.87-53.40	4.42-9.47	6.53-10.47	4.27-5.87	0.08-1.20	0.07-1.60	0.47-1.93	0.27-1.27

The natural enemies *viz.*, coccinellids, *Menochilus sexmaculata* Fab., and *Coccinella septempunctata* Linn. were recorded from first week of August to 4th week of November 2017 (48th MW). The highest population of coccinellids (1.27 grubs and/or beetles/plant) was observed in 4th week of October, 2017 (43rd MW). The chrysopid, *Chrysoperla zastrowi sillemi* Esben observed from 3rd week of July, 2017 (30th MW) and peak population (1.6 grubs/plant) was recorded in 4th week of October 2017. The spiders were noticed through the crop growth period and it was highest in 4th week of August 2017 (34th MW).The infestation of pink bollworm and red cotton bug was observed on Bg II cotton in western Maharashtra.

Monitoring the pink bollworm infestation in western Maharashtra

Survey was carried out to record the infestation of pink bollworm on *Bt* cotton in western Maharashtra comprising four districts viz., Ahmednagar, Dhule, Jalgaon and Nandurbar where cotton crop is predominantly grown. The observations were taken on randomly selected five plants and 20 bolls were collected per five plants and dissected for the presence of pink bollworm larvae. The observations were recorded from the initiation of the incidence from 41th to 48th meteorological weeks i.e. from first fortnight of October to second fortnight of December 2017 and presented in table 25.

Table 25. Infestation of pink bollworm in western Maharashtra

MW	Date	PBW larve / 20 green bolls	Per cent open boll damage by PBW
41	8/10/2017-14/10/2017	2.60	13.00
42	15/10/2017-21/10/2017	9.80	49.00
43	22/10/2017-28/10/2017	10.20	51.00
44	29/10/2017- 4/11/2017	11.40	57.00
45	5/11/2017-11/11/2017	13.20	66.00
46	12/11/2017-18/11/2017	13.80	69.00
47	19/11/2017-25/11/2017	15.20	76.00
48	26/11/2017-02/12/2017	16.40	82.00

The data presented in the table 11 revealed that the incidence of pink bollworm was noticed to the extent of 13 to 82 per cent. The pest infestation was ranged from 2.60 to 16.40 pink bollworm larvae per 20 green bolls. The highest damage of PBW was 76-82 per cent recorded in second fortnight of December 2018 (48th MW).

I.2.13 PJTSAU, Hyderabad

Bio diversity monitoring of sucking pest complex, Pink Boll Worm (PBW) and their natural enemies in cotton belt of Telangana state

Monitoring of whiteflies, jassids, thrips and aphids was done by quantifying the nos. from 3 leaves from base, middle and terminal leaves. PBW was monitored by Pheromone Application Technology (PAT) through use of funnel traps during the crop season. The cotton growing belt of Telangana was surveyed extensively for quantification and specimens were collected from all types of habitats of cotton ecosystem of the state.

The *Bt* cotton growing areas of Telangana, *viz.*, were surveyed for infestation and intensity of sucking pest incidence.

- Surveys conducted in Adilabad, Warangal, Rangareddy, Nalgonda and Khammam districts of Telangana in cotton and other host plants
- Four species of Mealy bugs, *viz.*, *Paracoccus marginatus, Maconellicoccus hirsutus, Phenacoccus solenopsis,* and *Ferrisia virgata* were recorded
- *P. solenopsis* was the predominant species recorded on cotton
- Jassid attack was found to be more in Warangal & & Nalgonda.
- PBW was recorded around ETL in Adilabad & Warangal
- The natural enemies, *viz.*, *Acerophagus papayae, Cryptolaemus montrouzieri, Coccinella septumpunctata* and *Chrysoperla* were recorded on different species of mealy bugs

The incidence of jassids, white flies and thrips was recorded while there was a patchy appearance of mealy bug in Nalgonda Dt.

Survey for natural enemies of pinworm, *Tuta absoluta* on tomato

The vegetable growing areas of Telangana were surveyed for infestation and intensity of *Tuta absoluta* incidence. The overall scenario showed marginal incidence of the pest. The surveys are in progress and quantification of the incidence levels will be finalized after completion of surveys (Table 26).

Table 26. Status of *Tuta absoluta* in terms of incidence in vegetable growing areas of Telangana

District	Crop plants infested	Non hosts crop & weeds infested	Existing NEs in 25 randomly selected plants	Grade
Rangareddy	Tomato	Nil	Nil	1 (9-12%)
Nalgonda	Tomato	Nil	Nil	1 (8-12%)

II. SURVEILLANCE FOR PEST OUTBREAK AND ALIEN INVASIVE PESTS

II.1 Surveillance

II.1.1 YSPUHF, Solan

Different vegetable and fruit ecosystems at Solan,Sarahan, Nainatikkar, Una, Ghumarwin, Rekongpeo, Kalpa, Ponda, Kullu, Manali were surveyed for the collection of pests like, *Aleyrodicus digessi*, *Phenacoccus manihoti*, *Paracoccus marginatus*, *Phenacoccus madeirensis* and *Tuta absoluta* but only *Tuta absoluta* was recorded on tomato. Under polyhouse conditions the pest was also found to infest brinjal besides tomato at Nauni.

Survey and surveillance of pin worm, *Tuta absoluta* on tomato

A survey was conducted to record the incidence of the American pin worm, *Tuta absoluta* from May to October, 2017 at 15 locations of districts Solan, Sirmour, Shimla, Kinnaur and Bilaspur which are the major tomato growing areas of Himachal Pradesh (Table 27 & Fig. 9). The incidence of *Tuta absoluta* was also recorded under polyhouse conditions at Nauni of district Solan (HP) on tomato and brinjal. Under open field conditions the pest infested tomato at ten locations namely Nauni, Dolanji, Dharja, Maryog, Nainatikkar, Deothi, Subathu, Sarahan, Bagthan and Sanaura. At these locations 11 to 83 per cent of the tomato plants were infested with *T. absoluta* with the number of mines/leaf/infested plant varying from 1-7 and fruit damage varying from 0-7 per cent at different locations. Under polyhouse conditions the pest was found to attack tomato and brinjal. The severity of the pest was more on tomato than on brinjal. In tomato when no control measures were applied, 100 per cent infestation was recorded. In brinjal, however the incidence was only low. Survey reveals that the pest is more severe under polyhouse conditions than in open field conditions and prefers tomato over other host plants. During the survey a mirid predatory bug, *Nesidiocoris tenuis* was recorded preying on eggs and early instars of the leafminer. Besides, a parasitoid *Neochrysocharis arasit* was also collected.

Table 27. Infestation of *Tuta absoluta* on tomato under open field conditions at different locations in Himachal Pradesh

Location	District	Plants infested (%)	Number of mines/leaf/infested plant	Fruit damage (%)
Nauni	Solan	43–79	1-7	0-5
Dolanji	Solan	40-72	2-5	1-3
Dharja	Solan	38–61	2-6	0-3
Maryog	Sirmaur	11-33	1-3	0-2
Nainatikkar	Sirmaur	51–67	2-5	1-5
Deothi	Solan	12-21	1-2	0-2
Subathu	Solan	46–59	2-5	0-5
Sarahan	Sirmaur	60–76	1-7	0-3
Kandraur	Bilaspur	Nil	Nil	Nil

Duttnagar (Rampur)	Shimla	Nil	Nil	Nil
Bagthan	Sirmaur	67-83	2-6	2-5
Sanaura	Sirmaur	64-78	2-6	1-7
Kalpa	Kinnaur	Nil	Nil	Nil
Nichar	Kinnaur	Nil	Nil	Nil
Urni	Kinnaur	Nil	Nil	Nil

Fig. 9. Tomato crop infested with of *Tuta absoluta* under polyhouse condition at Nauni, Solan

II.1.2 ANGRAU, Anakapalle

Techniques adopted: Visit, survey and surveillance of pests and diseases in major crops and interaction with state/line department officials and local farmers.

Conducted 18 field visits in 35 locaions of Visakhapatnam, Vizianagaram and Srikakulam districts in Andhra Pradesh. The survey was taken up in collaboration with DAATTCentres of three districts for overall coverage. Monitored severe oubreak of BPH and sheath blight in paddy during kharif season; severe incidence of early shoot borer and internode borer in rainfed areas. Monitored severe outbreak of white grub and yellow leaf disease in sugarcane in endemic areas. Monitored low to moderate incidence of stem borer and leaf folder in paddy; stem borer in maize (Table 28). Interacted with farmers and advised remedial measures to farmers. Crop Pest Outbreak Report was submitted to ICAR- NBAIR, Bangalore every month.

Surveillance for pest outbreak and alien invasive pests helps in educating state departments and farmers for timely management of pests and diseases. Surveillance for pest outbreak and alien invasive pests also helps in cataloguing major pests and diseases to fix up research priorities for emerging problems (Table 28).

Table 28. Crop pest outbreak during 2017-18 at Visakhapatnam district

S. no	Date	Locations	Crops	Pest/ disease incidence	Advises
1	4.7.17	Varada, K.Kotapadu mandal Achyyapalem, Devarapalli mandal, Visakhapatnam dist.	Groundnut	Leaf miner, aphids, thrips, collar rot, leaf spot – low	Monitoring groundnut leaf miner incidence and spraying with monocrotophos @1.6 ml/lt at ETL. 2.Soil drenching with Dithane M-45 @ 2 g/lt ; Seed Treatment with *Trichoderma viridae* @ 4 g/kg seed before sowing . Soil application of *Trichoderma viridae* @ 2.5 kg/ha at the time of planting .
		KDpeta, D.Agraharam, K.Kotapadu mandal, Visakhapatnam dist.	Sesame	Aphids,Thrips, Leafwebber, Capsule borer Moderate	Monitoring leaf webber , capsule borer and spraying with monocrotophos @ 1.6 ml/lt or chlorpyriphos @ 2.5 ml/lt .
		KDpeta, D.Agraharam, K.Kotapadu mandal, Visakhapatnam dist.	Greengram	Yellow mosaic virus Aphids	Collection and removal of mosaic diseases plants
		Kothapalli, Devarapalli mandal, Visakhapatnam dist.	Sugarcane	Early shoot borer – moderate	Field release of trichogramma chilonis @50,000/ha/release 4 times from 30 days after planting and 4 times at node formation or Spraying with chlorpyriphos @ 2.5 ml/lt from 30 DAP , 4 times at weekly interval.
		A.Kothapalli, Devarapalli mandal, Visakhapatnam dist.	Paddy	Hispa, thrips- low	Monitoring hispa damage and Spraying with monocrophos @ 1.6 ml/lt or profenophos @ 2ml/lt.
2.	14.7.17	Naikampalli, G. Rangampeta, Ramavaram, Virava, chebrolu, East Godavari dist.	Sugarcane	White grub – low to high Early shoot borer – low to sever YLD- low	Monitoring white grub. Application of EPF/ EPN/ Chlorantaniliprole against white grub Release of Temparature tolerant Trichocards against early shoot borer.

3.	26.8.17	Denkada, Denkada mandal, Vizianagaram dist.	Paddy , Groundnut, ragi	Hispa, stemborer, blast in paddy - low Pink stem borer in ragi – moderate Groundnut – aphids, rosette virus – low to moderate	Spray tricyclozole (0.6.g/lt) against blast Spray propiconazole (1 ml/lt) against sheath blight Carbofuran application in paddy nursery against stem borer
4.	21.9.17	Singavaram, Denkada mandal, Vizianagaram dist.	Paddy	Stem borer, leaf folder - low Blast – low	Release of Trichocards for the management of paddy stem borer, leaf folder in paddy (*T. japanicum* @ 1,00000/ha and *T. chilonis* @ 1,00,000/ha weekly three releases . Advised monitoring blast and spray tricyclozole (0.6 g/lt) against paddy blast if needed. Application of carbofuran 3 G @ 10 kg/ acre at 30 days after transplanting against paddy stem borer. Monitoring blast and Spray tricyclozole (0.6.g/lt)
5.	12.10.17	Narayanapuram , Mamidivada, Yelamanchili mandal Dimili, rambilli mandal, Visakhapatnam dist.	Paddy	Leaf folder in paddy – low to moderate BPH , sheath blight in paddy – moderate sheath blight in paddy- low to high	Monitoring leaf folder, sheath blight Spray acephate (1.5 g/lt) +propiconazole (1 ml/lt) against leaf folder and sheath blight Spray monocrotophos 2.2ml/lt+ nuvan 1 ml/lt against BPH.
6.	30.10.17	Vukumpeta, Gollugunda mandal, Kotturu,Koyyuru, Koyyuru	Paddy	Leaf folder , BPH, WBPH - low to moderate	Spray acephate (1.5 g/lt) against leaf folder . Spray propiconazole (1 ml/lt) against sheath blight,. Spray acephate (1.5 g/lt) followed

		mandal, Visakhapatnam dist.			by monocrotophos 2.2ml/lt+ nuvan 1 ml/lt against BPH
7.	6.11.17	Varada, K.Kotapadu mandal, Visakhapatnam dist.	Paddy	Stem borer, sheath blight, panicle mite -low	Use of biocontrol agent as trichocards for the management of paddy stem borer and leaf folder in organic paddy cultivation (Zero budget natural farming).Spraying with profenophos (2 ml/lt) with carbrendazim (1 g/lt) against panicle mite and sheath rot.
8.	8.11.17	Lakkavaram, Chodavaram mandal, Visakhapatnam dist.	Sugarcane , paddy	Apids in sugarcane – low Ring spot in sugaracne – severe Panicle mite , sheath blight in paddy - low	Spray mancozeb (2.5 g/lt) against sugarcane ring spot . Monitoring aphids in sugarcane; panicle mite, sheath rot in paddy
9.	13.11.17	Mycherlapalem, Damanapalli and Laxmipuram villages of Chaodavaram mandal, Visakhapatnam dist.	Paddy	WBPH, BPH, Sheath blight	Requested farmers to drain out the water from the fields. Spraying of Pymetrozine @ 120 gm per acre or Monocrotophos @ 2.2 ml along with Dichlorovos @1 ml per liter of water or Acephate @ 1.5 g along with Dichlorovos @ 1 ml per liter of water. Requested the farmers to spray Hexaconozole @ 400 ml per 200 liters of water per acre
10.	14.11.17	Rambilli, Narayanapuram /Rambilli mandal; Munagapaka village, Anakapalle mandal, Visakhapatnam dist.	Paddy	WBPH, BPH, Sheath blight	Requested farmers to drain out the water from the fields. Intermittant wetting and drying of field for management of BPH. Spraying of Pymetrozine @ 120 gm per acre or Monocrotophos @ 2.2 ml along with Dichlorovos @1 ml per liter of water or

					Acephate @ 1.5 g along with Dichlorovos @ 1 ml per liter of water. Requested the farmers to spray Hexaconozole @ 400 ml per 200 liters of water per acre Monitoring of leaf folder and sheath blight . Clipping trichocards against stem borer, leaf folder Spraying propiconazole @ 1 ml/lt against sheath blight. Spraying acephate @ 1.5 g/lt + propiconazole @ 1 ml/lt against leaf folder and sheath blight. Monitoring of leaf folder and spraying acephate @ 1.5 g/lt at ETL . Spraying Propiconazole 1 ml/lt against sheath blight .
11.	7.12.17	Lakkavaram, Chodavaram mandal, Visakhapatnam dist.	Sugarcane	Internode borer in sugarcane – moderate Yellow leaf disease – severe. Ring spot – severe.	Crop harvesting at early date . Not to use the infested cane as seed material.
12.	13.12.17	Lakkavaram, Chodavaram mandal, Visakhapatnam dist.	Green gram, blackgram	Flea beetle, Yellow mosaic virus- low	Removal and destruction of YMV diseased plants followed by spraying neem formulation (5 ml/lt) followed by monocrotophos (1.6 ml/lt) for the management of YMV. Spraying monocrotophos (1.6 ml/lt) or chlorpyriphos (2.5 ml/lt) against flea beetles
13.	27.12.17	Lakkavaram, Chodavaram mandal, Visakhapatnam, dist.	Green gram, blackgram	Flea beetle , Maruca webber	Removal and destruction of YMV diseased plants . Spraying neem formulation (5 ml/lt) as first spray followed by neem formulation (5 ml/lt) with monocrotophos (1.6 ml/lt) for the management of YMV and Maruca webber.

14.	30.12.17	Singavaram, Denklada, Denkada mandal; Kumili, Pusapatirega mandal, Vizianagaram dist.	Maize	Stem borer –low to moderate	Release of *Trichogramma chilonis* (75,000 parasitoids/ ha/ release) three times at 7-10 day interval from 15 days afte seedling emergence or whorl application of carbopfuran 3G @ 3 kg/acre at 15-20 days after seedling emergence.
15.	12.1. 18	Anakapalle, Anakapalle mandal, Visakhapatnam dist.	Maize	Stem borer -low	Clipping of trichocards (field release of Trichogramma chilonis @ 75,000/ ha /release from 15 days after seedling emergence , 3 times at 7 – 10 day interval or whorl application of carbofuran 3 G granules @ 3 kg/ ha at 20-30 days after sowing or Spraying with chlorantarniliprole @0.3 ml/lt at 20-30 days after sowing.
16.	24.1. 18	Padmanabham,Padmanabham mandal, Visakhapatnam dist.	Maize	Stem borer -low	Clipping of trichocards (field release of Trichogramma chilonis @ 75,000/ ha /release from 15 days after seedling emergence , 3 times at 7 – 10 day interval or whorl application of carbofuran 3 G granules @ 3 kg/ ha at 20-30 days after sowing or Spraying with chlorantarniliprole @0.3 ml/lt at 20-30 days after sowing.
17	19.2.18	Pathiwadapalem , Venkata raopeta, Ranasthalam mandal, Srikakulam dist.	Maize	Stem borer- low Cob borer-low Tursicum blight - low	Clipping of trichocards (field release of Trichogramma chilonis @ 75,000/ ha /release from 15 days after seedling emergence , 3 times at 7 – 10 day interval or Advised whorl application of carbofuran 3 G granules @ 3 kg/ ha at 20-30 days after sowing or Spraying with chlorantarniliprole @0.3 ml/lt at 20-30 days after sowing.
18.	21.2. 18	Sinagvaram; Chollangipeta, Denkada mandal,	Maize	Stem borer- low to moderate	Clipping of trichocards (field release of Trichogramma chilonis) @ 75,000/ ha /release from 15

		Vizianagaram dist.		Cob borer-low Tursicum blight - low	days after seedling emergence , 3 times at 7 – 10 day interval or whorl application of carbofuran 3 G granules @ 3 kg/ ha at 20-30 days after sowing or Spraying with chlorantarniliprole @0.3 ml/lt at 20-30 DAS

II.1.3 IIVR, Varanasi

For record of natural enemies associated with American Pin Worm, *Tuta absoluta*, the population dynamics of the *T. absoluta* was monitored weekly using nano-pheromone traps installed in the tomato field at experimental farm of the institute and the larvae collected from the infested plants were also reared individually for emergence of parasitoids, if any. The maximum trap catches were recorded during the 13th SMW (23.33 adults / trap) initiating from the last week of February (9th SMW) thereafter, it declined gradually being minimum during 15th SMW (8.33 / trap). As regards to parasitoids, no parasitoids were noted to be associated with the pest in the region. However, a polyphagous predator namely *Nesidiocoris tenuis* was observed in abundance (maximum 5.7 bugs / apical twigs) feeding on early instar larvae. Besides, it also feeds on soft-bodied insects like whitefly, jassid and aphis in tomato field (Plate 4 & Fig. 10).

Plate 4. *N. tenuis* on tomato leaf

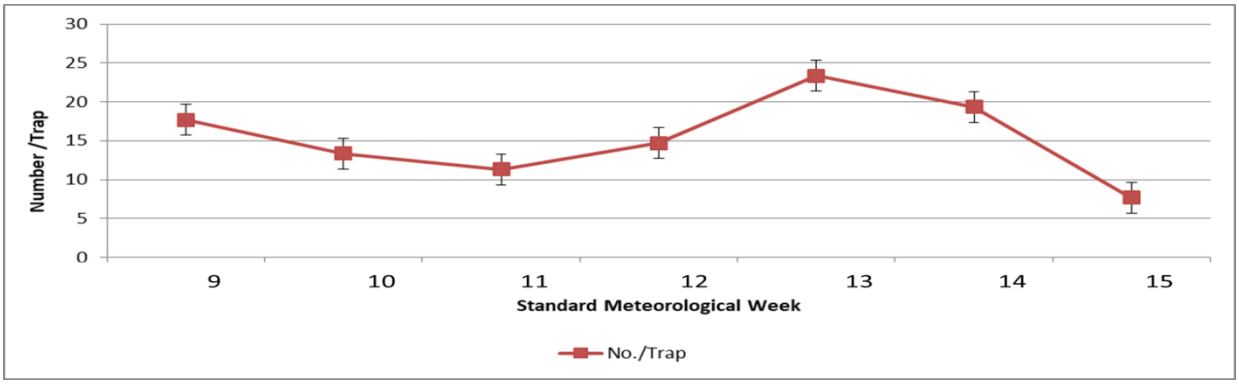


Fig. 10. Periodical incidence of *Tuta absoluta* infesting tomato

II.1.4 TNAU, Coimbatore

Monitoring the diversity and outbreaks of invasive mealybug and other sap sucking pests on Cotton

Six species of mealybugs *viz., Paracoccus marginatus, Maconellicoccus hirsutus, Phenacoccus solenapsis, Coccidohystrix insolitus, Pseudococcus jackbeardsleyi,* and *Ferrisia virgata* were observed on various host plants during the period under report in Coimbatore, Erode, Tirupur, Salem, Karur, Namakkal, Ariyalur, Madurai, Dharmapuri and Villupuram districts of Tamil Nadu (Table 29). Out of which the predominant species was *Paracoccus marginatus*. The incidence of papaya mealybug was noted in papaya, cotton, tapioca, mulberry, guava, tomato and teak. The natural enemies *like Acerophagus papayae, Cryptolaemus montrouzieri, Spalgis epius, Coccinella septumpunctata, Chrysoperla zastrowi sillemi* and *Chilomenes sexmaculatus* were recorded on different species of mealybugs in the surveyed fields.

Surveillance for pest outbreak and alien invasive pests

Survey was conducted in different districts of Tamil Nadu for the occurrence of the following insect pests.

a. Coconut leaf beetle - *Brontispa longissima*
b. The Giant whitefly - *Aleurodicus dugesii*
c. Tapioca mealybug - *Phenacoccus manihoti*
d. Papaya mealybug - *Paracococcus marginatus*
e. Madeira mealybug - *Phenacoccus madeirensis*
f. Jack Beardsley mealybug - *Pseudococcus jackbeardsleyi*
g. Alien invasive pests of fruits and vegetables in the market yards.
h. Others

During the investigation period the incidence of papaya mealybug *P. marginatus* in crops like papaya, tapioca, guava, cotton, mulberry, brinjal and the Jack Beardsley mealybug *Pseudococcus jackbeardsleyi* in cotton and tapioca were observed.

During the survey the alien invasive pests, viz., *Brontispa longissima, Aleurodicus dugesii, Phenacoccus manihoti, Phenacoccus madeirensis* were not recorded during the year 2017-2018

The occurrence of rugose whitefly *Aleurodicus rugioperculatus* was recorded from new areas in Tamil Nadu, *viz.,* Theni, Tanjore and Erode district apart from Coimbatore and Tirupur Dt.

Table 29. Incidence of mealybugs on various crops and their natural enemies

Districts surveyed	Crop	Mealybug incidence (%)						Natural Enemy/5 leaves		
		Phenacoccus solenapsis	*Paracoccus marginatus*	Ferrisia virgata	*Maconellicoccus hirsutus*	*Pseudococcus jackbeardsleyi*	*Coccidohystrix insolitus*	*A.papayae*	*Cryptolaemus*	*Spalgis epius*
Coimbatore	Mulberry	0.0	0.0	0.0	3.0-8.0	0.0	0.0	0.0	0.0	0.0
	Tapioca	0.0	4.0-6.0	0.0	0.0	0.0	0.0	2.0-3.0	0.0	1
	Cotton	0.0	1.0-2.5	0.0	0.0	0.0-1.5	0.0	0.0	0.5-1.5	0.0
	Grapevine	0.0	0.0	0.0	2.5-5.0	0.0	0.0	0.0	1.0-2.0	0.0
	Tomato	0.0	2.0-3.5	0.0	0.0	0.0	0.0	1 – 1.5	0.0	0.0
	Guava	0.0	0.5-2.0	1.0-3.0	0.0	0.0	0.0	0.0	1.0-2.0	0.0
	Brinjal	0.0	0.0	0.0	0.0	0.0	2.0-3.0	0.0	0.0	0.0
Tirupur	Mulberry	0.0	2.0-5.0	0.0	5.0-13.5	0.0	0.0	1.0 -3.0	1.0 – 2.0	2
	Tapioca	0.0	4.0-8.0	0.0	0.0	0.0-2.5	0.0	1.-2.0	0.0-1.0	0.0
	Brinjal	0.0	0.0	0.0	0.0	0.0	12.0-16.0	0.0	0.0	0.0
Erode	Tapioca	0.0	3.0-6.5	0.0	1.0-2.0	1.5-2.0	0.0	4- 5	1 – 3	0.0
	Guava	0.0	0.0	6-10.0	0.0	0.0	0.0	-0.0	3-5	0.0
	Brinjal	0.0	0.0	0.0	0.0	0.0	10-15	0.0	2.0	0.0
	Tube rose	0.0	0.0	0.0	2.5-8	0.0	0.0	0.0	0.0	0.0
Salem	Tapioca	0.0	3.0-10.5	0.0	0.0	0.0	0.0	1.0 -3.5	0.0 – 2.5	1
Namakkal	Tapioca	0.0	2.0-5.0	0.0	0.0	0.0	0.0	2.0-6.0	0.0	1
Ariyalur	Guava	0.0	3.0-4.0	0.0	0.0	0.0	0.0	1.0-2.0	0.0	0.0
Dharmapuri	Tapioca	0.0	2.0-5.0	0.0	0.0	0.0	0.0	1.0-2.0	0.0	0.0
Madurai	Guava	0.0	1.5-2.0	3.0-4.0	0.0	0.0	0.0	1.0-2.5	2.0 -3.0	0.0
Villupuram	Tapioca	0.0	3.0-4.0	0.0	0.0	0.0	0.0	2.0-3.0	0.0	0.0
	Guava	0.0	0.0	2.0 - 6.0	0.0	0.0	0.0	0.0	1.0 - 2.0	0.0
Karur	Cotton	0.5-3.0	2.5 - 4.0	0.0	0.0	0.0-1.5	0.0	0.0	0.0	1.0
	Teak	0.0	3.0-4.5	0.0	0.0	0.0	0.0	2.0-3.5	0.0	0.0
	Tapioca	0.0	2.0-4.0	0.0	0.0	0.0	0.0	2.0-4.0	0.0	0.0

II.1.5 UAS, Raichur

Pest outbreak reports were submitted for September, October and December months of 2017-18. The survey indicated that the severe incidence of armyworm was noticed in Ballari and Chitradurga districts and sporadic incidence of armyworm was also noticed on rice ecosystem of Koppal district Brown planthopper incidence was high during October month in Sirguppa, Gangavathi and Deodurga with an average incidence of 50- 60 per cent. During 2017-18 the incidence of Pink bollworm was high in almost all cotton growing areas with peak during November and December months. Severe incidence of pink bollworm was noticed in irrigated cotton (> 80%) compared to dryland cotton ecosystem (Table 30).

Table 30. Incidence of pest outbreaks in North Eastern Karnataka during 2017-18

Month	Place	Crop	Crop stage (in days)	Pest	Per cent Damage (%)
September					
11.09.2017	Hagaribommanahalli	Maize	70-80	Army worm	40-60
19.09.2017	Sakralli	Maize	70-80	Army worm	40-60
28.09.2017	Huvinahadagali	Maize	70-80	Army worm	40-60
October					
03.10.2017	Dinni, Garaldinni	Cotton	60-70	PBW	20-30
13.10.2017	Devadurga	Paddy	80-90	BPH	30-40
27.10.2017	Sirguppa, Gangavathi	Paddy	80-90	BPH	30-40
November					
10.11.2017	Nelahal, Marchatal Dinni	Cotton	100-110 110-120	PBW	60-70
17.11.2017	Gabbur and Maski	Cotton	100-110	PBW	60-70
24.11.2017	Jewargi and B Gudi	Cotton	100-110	PBW	60-70

II.1.6 OUAT, Bhubaneswar

Survey was made in the first week of every month starting from June 2017 in and around Bhubaneswar for the outbreak of insect pests in different crops as per decision taken in the 26th annual group meet held at YSPUAF, Solan during 16-17 May 2017. The CPOR reports along with photographs were communicated to NBAIR, Bangalore in the specified proforma along with photographs in the 1st week of every month through e-mail. The month wise outbreaks of pests are as follows (Table 31).

II.1.7 AAU, Anand

Periodic survey was carried out but none of the invasive pests listed above were recorded except *Tuta absoluta* and *Paracoccus marginatus.*

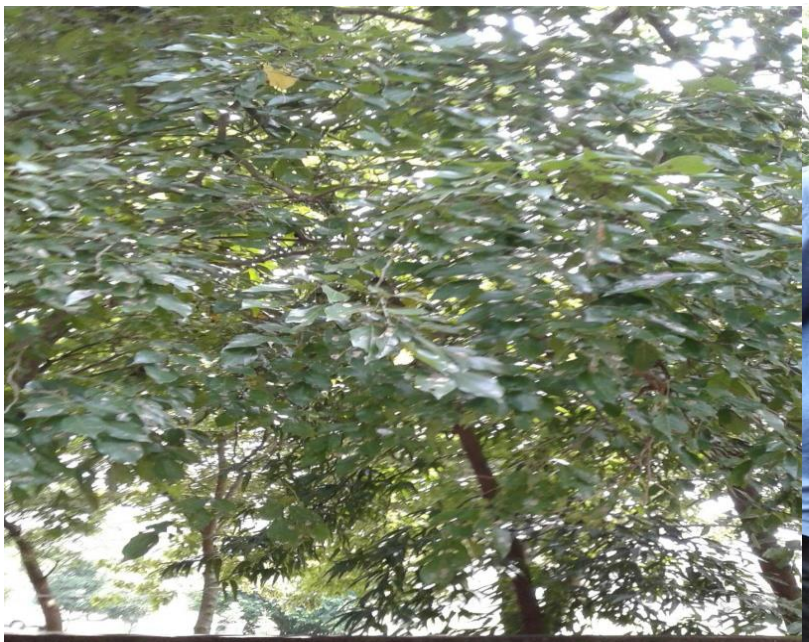
Table 31. Surveillance of different pests in Bhubaneswar

Month and year	Crop	Pest	Level of infestation	Site	Remarks
June 2017	Coconut	Black headed caterpillar (*Opisina arenosella*)	Severe	Handiali and Sahadebpur villages of Brahamagiri block of Puri districrt.	*Bracon hebetor* cocoons @ 10/adult palm.
July 2017	Brinjal	Hadda bettle (*Epilachna* spp.)	Severe	Baramunda, Bhubaneswar	Lambda cyhalathrin 2.5 EC@ 2ml/l
August 2017	Tagara *Tabernamontana* spp.)	Leaf roller (*Partotis* sp.)	Severe	Baramunda, Bhubaneswar	Chlorpyriphos 20EC @2ml/l.
September 2017	Dare Devils Tree (*Alstonia scholaris)*	Psyllid (*Pauropsylla tuberculata*)	Severe	College of Forestry, Bhubaneswar	Imidacloprid 17.8 SL@ 3ml/10l
	Karanja (*Pongamia pinnata*)	leaf miner (*Acrocercups syngramme)*	Severe	Avenue plantations, Bhubaneswar	Imidacloprid 17.8 SL@ 3ml/10l
October 2017	Gambhari (*Gmelina arborea)*	Bud weevil (*Alcidodes ludificator*)	Moderate	College of Forestry, Bhubaneswar	Chlorpyriphos 20EC @2ml/l
	Kadamba (*Neolamarckia cadamba*)	Kadamba defoliator (*Arthroschista hilaralis*)	Moderate	Avenue plantations, Bhubaneswar	Chlorpyriphos 20EC @2ml/l
November 2017	Paddy	Brown plant hopper (*Nilaparvata lugens*)	Severe	Ganjam, Sambalpur Baragarh, Balasore and Bhadrak	Pymeterozine 50% WG @ 7g/15l
December 2017	Krushna chuda (*Delonix regia*)	Bag worm (*Pteroma plagiophleps*)	Severe	Avenue Plantations, Bhubaneswar	
January 2018	Maharukh (*Ailanthus excelsa*)	Maharukh defoliator (*Eligma narcissus*)	Severe	Avenue Plantations, Bhubaneswar	
February 2018	Maharukh (*Ailanthus excelsa*)	Maharukh webber (*Atteva fabriciella*)	Severe	Avenue Plantations, Bhubaneswar	
March 2018	Dimiri (*Ficus racemosa*)	Psyllid (*Pauropsylla depressa*)	Severe	Silviculture research station, Bhubaneswar	
April 2018	China rose (*Hibiscus rosasinensis*)	Mealy bug (*Phenacoccus solenopsis*)	Severe.	Baramunda, Bhubaneswar	

Coconut BHC 01.06.2017

Brinjal Hadda beetle 03.07.2017

Tagar Leaf Roller 03.08.2017



Psyllid galls of Dare Devils Tree 03.09.2017

Kadamba defoliator 03.10.2017

Bud weevil of Gambhri 03.10.2017

Hopper burn in paddy 06.11.2017

Bag worm in Krushnachuda 05.12.2017

Maharukh defoliator 05.01.2018

Maharukh webber 07.02.2018

Dimiri psyllid 06.03.2018

Chinarose mealy bug 08.04.2018

II.1.8 MPKV, Pune

The fields, horticultural crops and ornamental plants were observed during survey in western Maharashtra covering five agro-ecological zones. The fields and orchards in and around Pune and Ahmednagar region as well as fruits and vegetables market areas around Pune were visited for record of pests species *viz.*, coconut leaf beetle *Brontispa longissima*, spiralling white fly *Aleurodicus dugessi*, mealy bug species *Phenacoccus manihoti*, *Paracoccus marginatus*, *Phenacoccus madeirensis*, *Pseudococcus jackbeardsleyi*, American pin worm *Tuta absoluta* on tomato and other alien invasive pests. The pests infested fruits and vegetables samples were collected from the market yards and nearby village markets and observed for alien invasion of pest species and natural enemies.

Nymphs and females of mealybug species *Pseudococcus jackbeardsleyi* and *Paracoccus marginatus* were recorded on custard apple and papaya respectively, in Pune and Ahmednagar region. The encyrtid parasitoid, *Acerophagus papayae* N and S, predatory larvae of *Spalgis epius*, coccinellids, anthocorids, chrysopids, syrphids and spiders were recorded in Pune region. Amongst the target pests, *Tuta absoluta* was recorded in Ambegaon and Junnar Tahasils of Pune district at low level during April to May 2017 on tomato crop.

II.1.9 PJTSAU, Hyderabad

Information recorded:

1. Specific site & date visited-District, Mandal, village.
2. Area covered in ha
3. No. of crops specifically examined and Variety grown
4. Major insects and disease (s) noticed and natural enemy occurrence Severity of damage (low, moderate, severe)
5. Age of crop in severely damaged field(s) (in DAT/DAS and years for field and tree/ horticultural crops, respectively)
6. Plant protection measures adopted by the farmer prior to the visit
7. Advice given to the farmer and follow up report if any

Outcome of the collected data:

- PBW: Tamsi, Panneri (Adilabad); Jangaon (Warangal)
- BPH: Rangareddy, Nalgonda
- Jassids : Warangal

II.2 Pest Outbreak (CPOR)

Location specific and timely advisories based on scientific observations, which will help in judicious use of biological and chemical pesticides and thereby, reducing the pesticide load. The status of pests across different crop was monitored through **Surveillance for pest outbreak and alien invasive pests - Crop Pest Outbreak Report (CPOR)** on monthly basis by different AICRP-BC centres between June 2017 and March 2018 are presented hereunder.

II.2.1 AAU, Anand

Surveys undertaken during July2017-March 2018 at Karena village in Karjan taluk of Vadodara district recorded the incidence of the following cotton pests, pink bollworm, *Helicoverpa armigera*, thrips, mealybug and white fly. Cotton sucking pest incidence at Puniyad village in Karjan taluk was severe during October 2017. Severe pink boll worm damage was recorded at several places in Anand district (22.031N, 73.096E) during the survey undertaken at November 2107. During December 2017, red cotton bug and dusky cotton bug severity was recorded on cotton crop grown at Karjan taluk of Vadodara district. Rice crop were damaged by stem borer and leaf folder as witnessed from the surveys undertaken during July-August 2017 at Runaj in Sojitra taluk of Anand district.

II.2.2 AAU Jorhat

Severe incidence and damage of swarming caterpillar was observed in rice crop during August to September 2017 in the regions of Nalbari, Bongaigaon, Alengmora and Dergaon taluks of Jorhat district of Assam. Severe diamond back moth incidence in cabbage was reported in Allengmora, TeokBoloma villages of Jorhat district during March 2018.

II.2.3 ANGRAU, Anakapalle

Rice crop grown at Visakhapatnam and Vizianagaarm districts in Devarapalli, Chodavaram, Yelamanchili, Rambili, Gollugunda, Koyyuru, K. Kotapadu, Munagapaka, Denkada and Gajularega mandals during July-November 2017 were infested by the following pests, thrips, hispa, BPH, leaffolder and stem borer. BPH infestation was moderate to severe (20-25 hoppers/hill) recorded during November 2017.

Severe early shoot borer infestation (>50 %) was observed in the sugarcane ratoon crop during July 2017 in the surveys undertaken at several villages at Ravikamatam, Narsipatnam, Kotavuratla, Devarapalli and Chodavaram mandals in Visakhapatnam district. Moderate incidence of inter node borer was also observed during the period and November 2017 at Lakkavaram mandal in Visakhapatnam district. During November 2017, severe ring spot disease was reported at Chodavaram mandal. Maize stem borer incidence was recorded at Chodavaram mandal from the survey undertaken during December 2017.

II.2.4 GBPUAT, Pantnagar

Severe infestation of leaffolder and yellow stem borer (35-40%) was observed in rice during August 2017 and February 2018 at Ramnagar district. Severe incidence of white rust

disease was reported in mustard crop grown in Udham Singh Nagar district during January 2018. Severe incidence (60-70%) of mango thrips was found in major mango growing belts of UP and Uttarakhand during March 2018.

II.2.5 HRS, Ambajipeta

Extensive survey undertaken from July 2017 to February 2018 in the coconut plantations grown with hydrid/variety like Godavari Ganga hybrid and East coast tall at East and West Godavari districts revealed occurrence of the following pests, Rugose spiralling Whitefly (RSW), rhinoceros beetle, red palm weevil and scale. Severe rhinoceros beetle damage was observed during July and September 2017 in Ratnagiri, Tadikalapudi village(16.9032N, 81.1533E) of Pedavegi mandal of West Godavari and Vizianagaram districts.

During December 2017-January 2018, coconut plantations at several villages at Kadiyam and Chagallumandals were severely infested with RSW. 20-30 egg spirals/leaf let was recorded from these areas. High infestation of RSW was observed in the oil palm plantations as well during December 2017 at Kalavalapalli, Chikkala villages at Chagallu mandal. The RSW infestation was also noticed in the border trees grown nearby namely, Annona, Jackfruit@10 egg spirals/leaf and papaya. Good parasitization by *Encarsia guadeloupae* on RSW resulted a moderate infestation of RSW at Ravada in Ranasthalam mandal of Srikakulam district during February 2018.

II.2.6 MPKV, Pune

Low to severe incidence (>30/leaf)) of thrips was reported from PGI Field (19.20334°N; 74.38509°E; 535m), MPKV, Rahuri Dhule, Ahmednagar, Jalgaon, Nandurbar districts of Maharashtra during July to October 2017. Moderate to severe infestation of sugarcane whitefly was observed in Sangamner, Rahata, Shevagaon and Kopargaon tehsils of Ahmednagar, Jalgaon, Rahuri and Nandurba rdistrict during June to October 2017.

II.2.7 OUAT, Bhubaneswar

Severe incidence of black headed caterpillar, *Opisina arenosella* damage was reported in coconut in Handiali, Sahadevpur villages in Brahmagiri block of Puri district during June 2017. Severe *Epilachna* beetle infestation in the Baramunda of Khurda district and severe incidence of BPH at Akalapur in Sorada block of Ganjam district was reported during the month of July and October 2017.

II.2.7 PAU, Ludhiana

Surveys undertaken during July-September 2017 covering Hoshiarpur, Sangrur, Patiala, districts intercepts with maximum tillering and panicle bearing stage of rice crop (Basmati Cv.) was moderately infested by leaffolder and planthoppers. In sugarcane crop for the period, low to moderate infestation of whitefly, leafhopper, top borer and stalk borer was observed from the surveys undertaken at Hoshiarpur, Fazilka and Roopnagar districts. Whitefly, leafhopper and thrips infestation was observed in the cotton for the period July-September 2017 from the

surveys undertaken at cotton growing areas of Punjab like Fazilka, Muktsar, Bathinda, Mansa districts. First record of South American tomato pinworm, *Tuta absoluta* in Punjab was reported from Patiala and Ludhiana districts in a survey undertaken at July 2017.

II.2.8 RARS, Kumarakoam

During August 2017, severe incidence of brown planthopper and bacterial blight disease in rice was reported in Vaikom in Kottayam district. In banana, severe infestation of burrowing nematode and moderate infestation of pseudostem and rhizome weevil was observed in Kottayam district during October 2017. Severe incidence of Giant African Snail, *Achatinafulica* on vegetables and fruit crops was reported in the Kottayam District during October 2017.

II.2.9 SKUAST, Kashmir

There was moderate to severe infestation of apple San Jose scale reported in the Zawoora in Srinagar district, Quilmuqam in Bandipora district of Kashmir druing August to December 2017. Severe incidence of diamond back moth in cabbage was reported in Bogam in Budgam district during July to October 2017.

II.2.10 TNAU, Coimbatore

Severe infestation of rugose spiralling whitefly (RSW) was observed in the Pollachi taluk of Coimbatore district and Udumalpet taluk of Tiruppur district between June and October 2017. Moderate to severe infestation of papaya mealybug was recorded in the Anthiyur taluk of Erode district druing the months of August to October 2017.

II.2.11 UAS, Raichur

During November 2017, surveys undertaken in several villages at Raichur, Jewargi and Kalburgi areas in Karnataka was observed for severe pink boll worm incidence in cotton. For the same area, chilli crop was witnessed with very severe leaf curl virus infestation. Rice crop grown at Raichur, Devadurga areas were severely affected by BPH. During September 2017, maize crop grown at Hagaribommanhalli and Huvinhadgali taluks were witnessed severe damage by army worm. Cotton grown at Masarkal village over an area of 100 acres was severely damaged by *Helicoverp aarmigera*. The farmers purchased illegal *Bt* seeds was the reason for such high infestation by the pest.

II.2.12 YSPUHF, Solan

Tomato variety Him Sons grown at Sarahan, Sanauramandals in Srimaur and Solar districts during the period between July and December 2017 were moderately infested by the following insects, *Tuta absoluta*, *Trialeurodes vaporariorum*, *Liriomyz atrifolli* and *Helicoverpa armigera.*

III. BASIC WORK

III.1 List of *Trichoderma/ Pseudomonas* isolates used in various experiments (Table 32)

S.No.	*Trichoderma / Pseudomonas* isolates	Source
1.	TCMS-36 (*T. asperellum*)	GBPUAT-Pantnagar
2.	PBAT-3 (*T. asperellum* Th14 + *Pseudomonas fluorescence* Psf 173)	GBPUAT-Pantnagar
3.	Th-14 (*T. asperellum*)	GBPUAT-Pantnagar
4.	Th-17(*T. asperellum*)	GBPUAT-Pantnagar
5.	Th-39	GBPUAT-Pantnagar
6.	Th-19	GBPUAT-Pantnagar
7.	Psf-173 (*Pseudomonas fluorescence*)	GBPUAT-Pantnagar
8.	Psf-2 (*Pseudomonas fluorescence*)	GBPUAT-Pantnagar
9.	NBAIR-1 (*T. harzianum*)	NBAIR –Bangalore
10.	NBAIR-2 (*T. asperellum*)	NBAIR –Bangalore
11.	Sanjeevni (*T. viride*)	International Panacea Pvt. Limited
12	*T. harzianum*	BARC- Mumbai

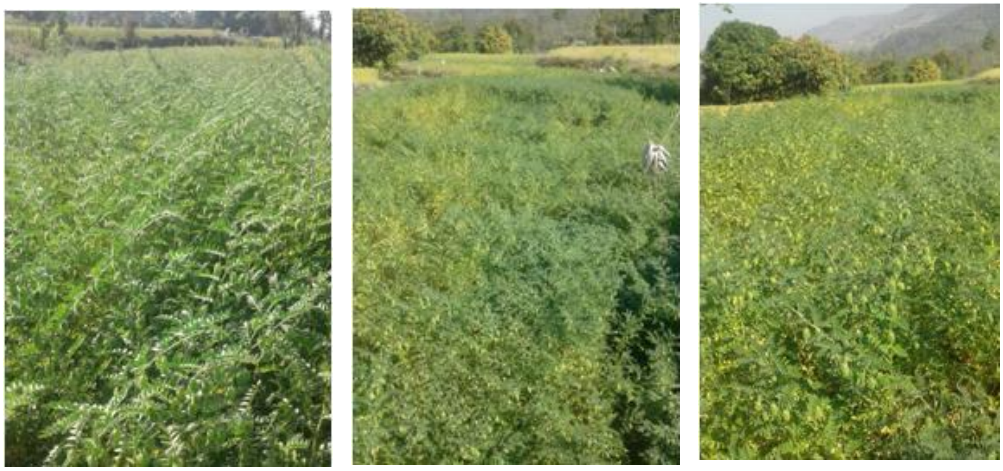
III.2 Large scale demonstration of biocontrol technology in Chickpea and Lentil

Large scale field demonstrations of bio-control technologies were conducted at certified organic growers (**100 no**.) in Chickpea and lentil at three different blocks, *viz*., Kotabagh, Patkot (Ramnagar dist.) and Batalghat, (Nainital dist.) covering an area of **35.0 ha. & 34.0 ha,** respectively in association with Nature Bio-Foods Ltd. to manage wilt complex disease (*Rhizoctonia solani* & *Fusarium oxysporum*). Two quintals of PBAT-3 (Th-14 + Psf-173) were distributed to the farmers for conduct of demonstrations (Plate 5).

Bio- control technologies adopted by farmers were given as below:

Seed treatment (10 g/kg seed)
Soil drenching (three times) with PBAT-3, at 30 days interval

The experiment is in progress.



Chickpea at Batalghat

Chickpea at Patkot

Lentil at Patkot

Plate 5. Chickpea and lentil crops at farmers fields (organic growers)

III.3 Development of consortium using promising *Trichoderma* and *Pseudomonas* isolates

a. Dual culture study to test combination of two bioagents for their compatibility: Compatibility among *Trichoderma* isolates and between *Trichoderma* and *Pseudomonas* isolates was studied by dual culture method. Results indicatedthat all the combinations i.e. *Trichoderma* with *Pseudomonas* and *Trichoderma* with *Trichoderma* were found compatible with each other as they were growing simultaneously without antagonizing the growth of other in the compatibility test (Table 33; Fig. 11).

Table 33. Dual culture study to test combination of two bioagents for their compatibility

Dual combination	Reaction	Dual combination	Reaction
TCMS-36+ Psf-173	compatible	TCMS-36+ Psf-2	compatible
Th-19+ Psf-173	compatible	Th-19+ Psf-2	compatible
Th-14+ Psf-173	compatible	Th-14+ Psf-2	compatible
Th-17 + Psf-173	Compatible	Th-17 + Psf-2	compatible
Th-17+ TCMS-36	+ compatible		
Th-19+ TCMS-36	compatible		
Th-14+ TCMS-36	compatible		
Th-17+ Th-19	compatible		
Th-19+ Th-14	compatible		
Th-14+ Th-17	compatible		

b. Testing compatibility of combination of two bioagents in mixed formulations:

Compatibility among the different bioagents in mixed talc formulations was tested by plating the formulations on PDA petri plates. These Petri plates were incubated at 28±°C for the growth of both the bioagents. The results revealed that all the combinations of bioagents tested were found compatible as there was no growth inhibition of any of the tested bioagent in the mixed formulations (Fig. 12).

c. Testing compatibility of bioagents by using secondary metabolites:

The experiment is in progress.

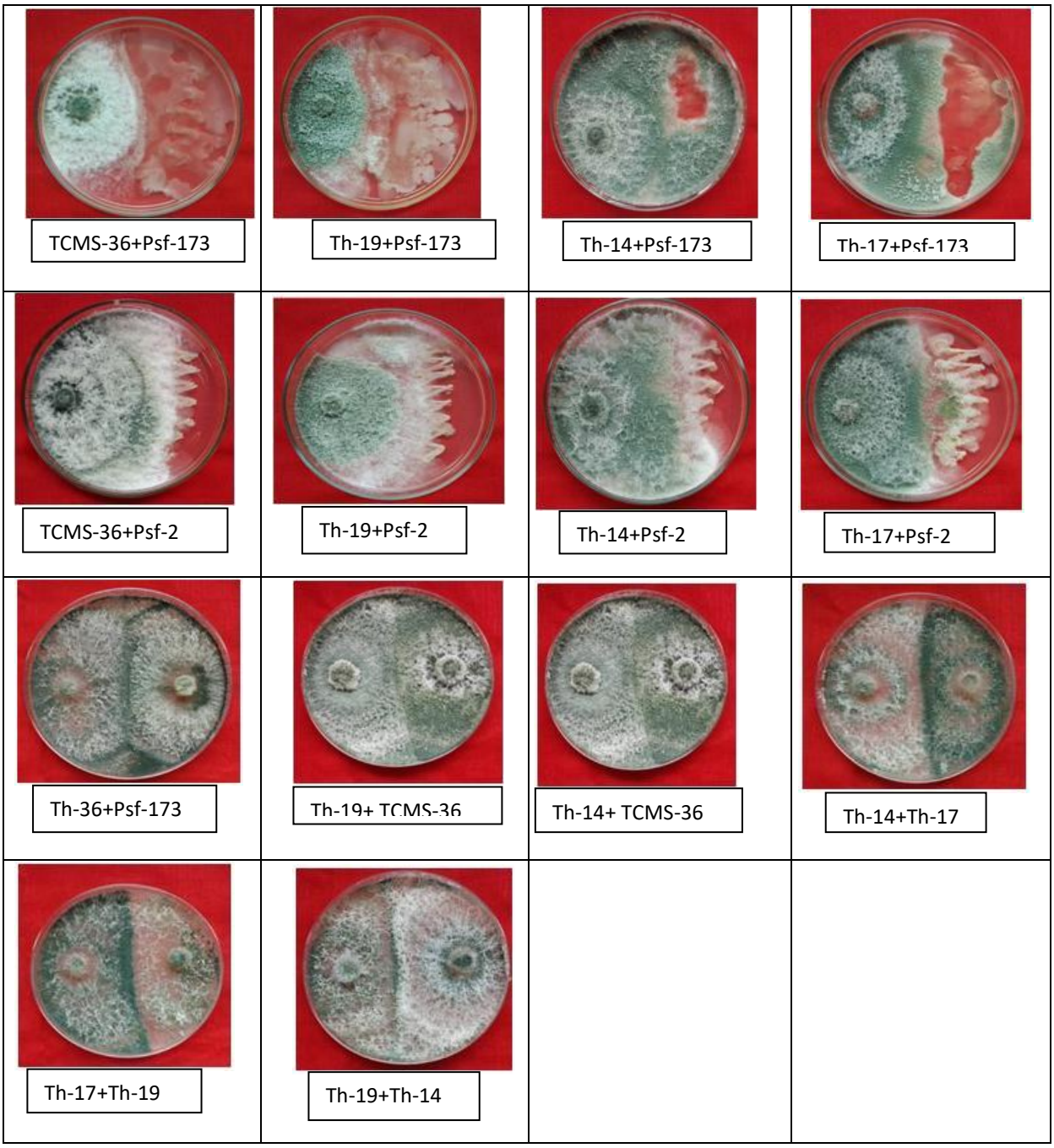


Fig. 11. Compatibility of bioagents in the dual culture plates as shown by simultaneous growth of both the bioagents

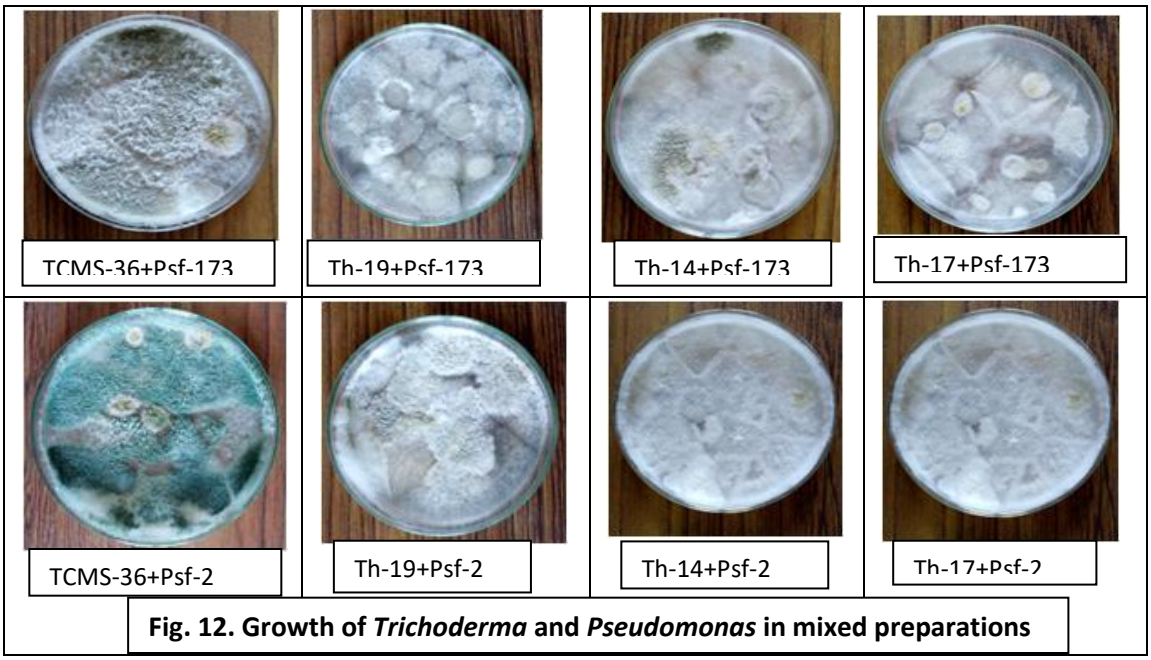


Fig. 12. Growth of *Trichoderma* and *Pseudomonas* in mixed preparations

III.4 Effect of consortia of bioagents on seed germination and plant growth of chickpea

Mixed talc-based preparations of compatible combinations of bioagents were prepared and tested for their effect on seed germination and plant vigour of chickpea in pots under glasshouse conditions. The observations on seed germination revealed that mixed preparations of Th-19+TCMS-36 showed significantly highest per cent of seed germination (98.33%) followed by TCMS-36+Psf-173, Th-19+Psf-2 and Th-14+Psf-2 (96.67%) and Th-17+Psf-2 (95.00 %) as compared to control (70.33 %). At 30 and 60 DAS, no statistically significant differences were observed with regard to plant height in the treated (individual and mixed) and untreated control plants. (Table 34).

Table 34. Efficacy of consortium for seed germination and growth of chick pea in glasshouse

Treatment	Seed germination (%)	Plant height (cm)	
		30 DAS	60 DAS
TCMS-36+ Psf 173	96.67	27.93	45.47
Th-19+ Psf-173	91.67	26.40	45.50
Th-14+ Psf-173	93.33	27.93	47.80
Th-17 + Psf-173	88.33	27.43	44.30
Th-17+ Psf-2	96.67	28.50	45.03
Th-17+ TCMS-36	96.67	28.23	46.93
Th-19+ TCMS-36	91.67	28.07	44.07
Th-14+ TCMS-36	95.00	27.23	45.47
Th-17+ Th-19	93.33	27.53	48.20
Th-19+ Th-14	98.33	27.90	42.23
Th-14+ Th-17	83.33	27.97	45.63
TCMS-36 (Control)	91.67	28.50	41.27

Th-19 (Control)	90.00	29.03	46.47
Th-17 (Control)	88.33	26.57	42.43
Th-14 (Control)	93.33	26.57	41.80
Psf-2 (Control)	86.67	27.30	36.67
Psf -173 (Control)	75.00	28.07	39.77
Control (without any treatment)	70.33	27.87	40.37
CD	**2.72**	**2.00**	**8.77**
C.V	**8.938**	**2.447**	**7.926**

III.5 Molecular signatures of promising *Trichoderma* isolates validated under AICRP biological control at Pantnagar

Seven promising isolates of *Trichoderma* (Th 14, TCMS 5, TCMS 14(2), TCMS 36, TCMS 16, TCMS 32, Th 3 and Th 17) validated under AICRP biocontrol experiments were got identified at ICAR-NBAIR, Bangalore as *Trichoderma asperellum* by amplification of ITS and TEF1 genes using *Trichoderma* specific ITS and TEF primers. The bar-coding of the promising isolates were not done due to lack of funds.

CEREALS

1. RICE

1.1 Management of rice stem borer and leaf folder using entomopathogenic nematodes and entomopathogenic fungi (KAU, ANGRAU)

1.1.1 KAU, Thrissur

The microbials, *i.e., Steinernema carpocapsae. Heterorhabditis indica, Bacillus thuringiensis* (NBAIR strain), *Beauveria bassiana* and *Metarrhizium anisopliae* were evaluated for the management of rice stem borer and leaf folder in farmer's field at Anchumoorthy in Vadekkenchery during June to October, 2017. The treatments comprised of T1: *Steinernema carpocapsae* (NBAIR strain) @ $1.2x10^9$ IJs ha^{-1}, T2: *Heterorhabditis indica* (NBAIR strain) @ $1.2x10^9$ IJs ha^{-1}, T3: *Bacillus thuringiensis*(NBAIR strain) 2g/l twice at 10 and 25 DAT, T4: *Beauveria bassiana* (NBAIR strain) @10^8 spores/ml., T5: *Metarhizium anisopliae* (NBAIR strain) @10^8 spores/ml, T6: Flubendiamide 25g.a.i.ha^{-1} and T7: Untreated control. All the treatments were applied twice at 15 and 25 days after transplantation. Mean number of dead hearts, mean number of rolled leaves and mean yield per plot were recorded (Table 35; Fig. 13)

Table 35. Effect of entomopathogens on leaf folder infestation in rice

Treatment	Mean no. of rolled leaves /m^2	Mean yield (Kg/plot)
Steinernema carpocapsae ($1.2x10^9$ IJs/ha)	5.0	0.76
Heterorhabditis indica ($1.2x10^9$ IJs/ha)	8.0	0.70
Bt (NBAIR strain) 2g/l	8.6	0.68
Beauveria bassiana (10^8 spores/ml)	5.0	0.74
Metarhizium anisopliae (10^8 spores/ml)	7.0	0.70
Flubendiamide 25g.a.i/ha	1.0	0.70
Untreated control	4.0	0.69

Fig. 13. Application of treatments for management of rice stem borer and leaf-folder using entomopathogenic nematodes and entomopathogenic fungi

The stem borer attack was negligible while leaf roller damage was low. No significant difference between the different treatments in terms of infestation or yield was observed.

1.1.2 ANGRAU, Anakapalle

Seven treatments, *viz*., T1: *Steinernema carpocapsae* (NBAIR strain) @ $1.2x10^9$ IJs ha^{-1}; T2: *Heterorhabditis indica* (NBAIR strain) @ $1.2x10^9$ IJs ha^{-1}; T3: *Bt* (NBAIR strain) 2g/l twice at 10 and 25 DAT; T4: *Beauveria bassiana* (NBAIR strain) @10^8 spores/ml (5g/lt)**;** T5: *Metarhizium anisopliae* (NBAIR strain) @10^8 spores/ml (5 g/lt)**;** T6: Flubendiamide 25 g.a.i.ha^{-1}**;** T7: Untreated control were evaluated.

Paddy stem borer and leaf folder incidence was low during kharif, 2017-18. The damage by both the pests was significantly low in entomopathogenic nematodes, entomopathogenic fungi and chemical treatments compared to control. The leaf folder damage was 1.33 to 2.78 rolled leaves/ square meter in the treatments and was 5.67rolled leaves/ square meter in control. Yellow stem borer damage was 2.44 to 2.78 white ear/square meter in treatments and 4.00 white ear/ square meter in control at 20 days after second spraying.

Per cent reduction in leaf folder damage was high in *Beauveria bassiana* (78.48%) and percent reduction in stem borer damage recorded high in *Metarhizium anisopliae* (39%) over untreated control. Higher grain yield was recorded in *B.bassiana* (NBAIR strain) (5.7 t/ha) followed by *B.thuringiensis* (NBAIR strain) (5.03 t/ha) compared to flubendiamide 40SC @ 0. 1 ml/lt (4.47 t/ha) and control (3.4 t/ha) (Table 36).

Table 36. Management of rice stem borer and leaf folder using entomopathogenic nematodes and entomopathogenic fungi

Treatment	Number of rolled leaves/ sq.m				Number of deadhearts or white ear/sq.m			Grain yield (t/ha)	Per cent increase in yield over control
	Before 1st spray	After 1st spray	Per cent reduction after 1st spray	Per cent reduction over control	After 1st spray	After 2nd spray	Per cent reduction over control		
Steinernema carpocapsae	3.78	2.78	26.46	50.97	0.0 (1.0)	2.56	36.0	4.6	35.29
Heterorhabditis indica	4.67	1.89	59.53	66.66	0.33 (1.15)	2.78	30.5	4.87	43.24
Bt (NBAIRstrain)	3.56	1.44	59.55	74.6	0.22 (1.1)	2.67	33.25	5.03	47.94
Beauveria bassiana	5.78	1.22	78.89	78.48	0.22 (1.1)	2.67	33.25	5.7	67.65
Metarhizium anisopliae	4.56	1.56	65.79	72.49	0.11 (1.05)	2.44	39.0	4.17	22.65
Flubendiamide	5.0	1.33	73.4	76.54	0.0 (1.0)	2.78	30.5	4.47	31.47
Untreated control	4.56	5.67	24.29 increase		0.67 (1.41)	4.0		3.4	
CD (0.05)	NS	2.01			0.2	NS		NS	
CV%	23.2	49.28			9.92	19.5		17.74	

Values in parenthesis are square root transformed values

1.2 Evaluation of *Beauveria bassiana* and *Lecanicillium lecanii* against brown plant hopper *Nilaparvata lugens* Stål (KAU)

1.2.1 KAU, Thrissur

The experiment could not be initiated due to non availability of infested fields. However, several farmers in Palghat reported BPH infestation close to harvest.

1.3 Management of plant hoppers through BIPM approach in Organic basmati rice (PAU) / rice (ANGRAU)

1.3.1 PAU, Ludhiana (on Organic Basmati Rice)

The experiment was carried out with two treatments in a plot size of 600 m2 each, I. BIPM (comprising i. use of recommended variety (Pusa 1121), ii. Optimum time of transplanting (15.7.17), iii. Green manuring or FYM, iv. Optimum plant spacing (20 x 15 cm), v. Alleyways of 30 cm after 2 m, vi. Water management: Alternate wetting and drying , vii. Increasing floral diversity through flowers on bunds –Marigold, Balsam, viii. Erection of straw bundles @ 20/ha, ix. Need based application of botanical (Azadirachtin 1500 ppm @ 2ml/litre) and microbial *Metarhizium anisopliae* @ 5g/litre) – Not applied due to low pest level and II. Untreated control

The population of plant hoppers varied from 0.0 to 0.63/ hill in BIPM and 0.0 to 0.68/ hill in untreated control (Table 37). Due to low pest level (below ETH level, *i.e*., 5 hoppers/ hill) throughout the cropping season, botanical/ microbial sprays were not carried out. The experiment will be repeated in the next crop season.

Table 37. Population of plant hoppers and spiders in BIPM and control treatments in organic *basmati* rice during 2017

Treat-ments	*Plant hoppers population / hill											
	Aug. 15	Aug. 22	Aug. 29	Sept. 4	Sept. 11	Sept. 18	Sept. 25	Oct. 3	Oct. 10	Oct. 17	Oct. 23	Oct. 30
BIPM	0.00	0.00	0.07	0.20	0.43	0.63	0.24	0.58	0.37	0.51	0.43	0.33
Control	0.00	0.00	0.20	0.20	0.44	0.66	0.30	0.67	0.68	0.56	0.60	0.30
Spider population / hill												
BIPM	0.09	0.20	0.33	0.40	0.57	0.53	0.83	1.07	1.33	1.17	1.23	1.10
Control	0.11	0.20	0.31	0.30	0.56	0.44	0.70	0.80	1.12	0.94	1.06	1.00

*include BPH and WBPH

1.3.2 ANGRAU, Anakapalle (on Rice)

Three treatments, *viz*., T1: BIPM [Recommended variety, BPT 5204 , Optimum time of sowing/transplanting, Green manuring or FYM, Optimum plant spacing , Formation of alleyways 30 cm at every 2 m distance, Water management- alternate wetting and drying, Application of *Beauveria bassiana* $1x10^8$ conidia/ml and Application of *Metarhizium anisopliae* $1x10^8$ conidia/ml (5 g/lt)], T2: Farmers' practice (Two sprays of monocrotophos followed by acephate) and T3: Untreated control were evaluated.

Hopper incidence was low during kharif, 2017-18. Hopper population was negligible in BIPM plot (0.44 hoppers/hill) and significantly low in farmers practice plot (2.06 hoppers/hill) compared to 4.33 hoppers /hill in control plot. Reduction in hopper population over control was high in BIPM (89.84%) and farmers practice (52.42 %). Grain yield was significantly high in BIPM practice, *i.e*., *B.bassiana* (5g/lt), *M. anisopliae* (5 g/lt) as two sprayings (5.0 t/ha) compared to farmers' practice (4.33 t/ha) and untreated control (4.24 t/ha) (Table 38).

Table 38. Management of plant hoppers through BIPM approach in rice

Treatment	Number of hoppers /hill			% reduction in hopper population		Grain yield (t/ha)
	Before first spray	After first spray	After second spraying	After 1st spray	After 2nd spraying	
T1 – BIPM	7.36	9.88	0.44 (3.16)	13.19	89.84	5.0
T2 - Farmers' practice	7.54	9.82	2.06 (8.16)	13.63	52.42	4.33
T3 - Control	7.04	11.38	4.33 (11.96)			4.24
CD (0.05)	NS	NS	1.70			0.64
CV%	9.66	14.85	20.25			13.11

Values in parentheses are square root transformed values

1.4 Large scale bio-intensive pest management on rice [ANGRAU (5 ha); PAU (50 ha)); KAU (100 ha); AAU-A (2 ha); AAU-J (10 ha); CAU (2 ha); OUAT (2 ha); NBAIR & GBPUAT (25 ha)]

1.4.1 ANGRAU, Anakapalle

Paddy stem borer damage was low in BIPM package (1.78 %dead heart) compared to farmers practice (2.14% dead heart and 4.62%white ear) in singavaram plot of BPT 5204 paddy variety. Leaf folder was negligible (0.08%) and sheath blight incidence was nil at singavaram. Grain yield recorded at Singavaram village, Denkada mandal, Vizianagaram district was 6.3 t/ha in BIPM plot compared to farmers practice plot (5.8 t/ha) with BPT 5204 variety.

Sheath blight incidence was low in BIPM plot (6.79%) and high in farmers practice plot (10.5%). Grain yield recorded at Narayanapuram village, was 7.24 t/ha in BIPM plot compared to farmers practice plot (7.07 t/ha) with RGL 2537 variety (Table 39). Adoption of BIPM package resulted in high percent reduction in stem borer (100%), leaf folder (73.73%) and sheath blight (58.89 %) and increased yields (8.47 %) over farmers practice.

Table 39. Pest and disease incidence in bio-intensive pest management of rice in farmers' fields

Location	Stem borer damage (%DH & % White ear)	Leaf folder damage (%)	Sheath blight (%)	Grain yield t/ha	Cost benefit ratio
Singavaram, Vizianagaram district					

	T1-BIPM	T2-FP	T1-BIPM	T2-FP	T1-BIPM	T2-FP	T1-BIPM	T2-FP	T1-BIPM	T2-FP
BPT 5204	1.78 DH	2.14 DH 4.62 WE	0.08	0.44	-	-	6.30	5.80	2.56	1.93
MTU1121	1.29 DH	1.91 DH 2.35 WE	0.07	0.36	-	-	5.12	4.64		
MTU1001	1.24 DH	1.37 DH 1.66 WE	0.16	0.35	-	-	5.56	4.93		
Narayanapuram, Visakhapatnam dist.										
RGL2537	-	0.81 WE	0.22	1.93	6.79	10.56	7.24	7.07	2.94	2.35
	-	2.06 WE	0.41	1.12	0.5	2.79	6.84	6.32		
Average	0.86 DH	1.08 DH 1.83 WE	0.19	0.84	1.46	2.67	6.21	5.75		

DH – Dead heart; WE- white ear

1.4.2 PAU, Ludhiana

Large scale demonstrations on the bio-suppression of yellow stem borer, *Scirpophaga incertulas* and leaf folder, *Cnaphalocrocis medinalis* were conducted in field areas of Jalandhar, Ludhiana, Patiala and Sangrur districts in organic *basmati* rice (*var*. Pusa 1121) over an area of 202 acres. The demonstrations included six releases of *T. chilonis* and *T. japonicum* each @ 100,000 parasitoids/ha at weekly intervals starting from 30 days after transplanting (DAT) and were compared with untreated control. The dead hearts due to stem borer and leaf damage due to leaf folder were recorded at vegetative stage (45 and 60 DAT) and White ear incidence was recorded a week prior to harvest.

The mean dead heart incidence in biocontrol fields was 1.80 and 2.38 per cent at 45 and 60 DAT, respectively compared to untreated control (3.80 and 5.46 per cent). The mean reduction of dead heart incidence in release fields was 54.52 per cent over control (Table 40). The leaf folder damage was 2.20 and 2.60 per cent at 45 and 60 DAT, respectively as compared to 4.90 and 6.23 per cent in untreated control with a mean reduction of 56.20 per cent. The mean incidence of white ears was significantly lower in biocontrol field (2.91 %) as against untreated control (5.82 %) resulting in a reduction of 50.00 per cent. Grain yield in biocontrol field was 27.20 q/ha, as compared to 24.00 q/ha in untreated control. The yield increase in biocontrol plots was 13.33 per cent more than untreated control and an additional benefit of Rs. 8200/- per hectare was obtained.

Table 40. Large scale demonstrations of biocontrol of rice pests in organic *basmati* rice during 2017

Treatments	Dead hearts (%)				Leaffolder damaged leaves (%)			
	45 DAT	60 DAT	Mean	% reduction over control	45 DAT	60 DAT	Mean	% reduction over control
Biocontrol*	1.80[a]	2.38[a]	2.09[a]	54.52	2.20[a]	2.66[a]	2.43[a]	56.20
Untreated control	3.80[b]	5.46[b]	4.63[b]	-	4.90[b]	6.23[b]	5.57[b]	-

DAT – days after transplanting; *6 releases of *T. chilonis* and *T. japonicum* each @ 1,00,000/ha at weekly interval starting from 30 DAT

1.4.3 KAU, Thrissur

Large scale validation of BIPM in rice was carried out over an area of 100 ha in Vadekkenchery Panchayat of Palghat District from Sept 2017 to January 2018. The variety used was Uma.

The BIPM package (T1) comprised of i. **s**eed bio-priming *Pseudomonas fluorescens* @ 10g/kg of seeds, ii. Seedling dip with *Pseudomonas fluorescens* 2% solution, iii. Spray of NSKE 5% @ 3ml/litre at 45 and 65 DAT against foliar and sucking pest, iv. Erection of need based bird perches, v. Spray of *Pseudomonas fluorescens* @ 1.5 kg/ha against foliar diseases and vi. Release of *Trichogramma* spp. six times@ 100,000/ha at 10 days interval starting from 10 DAT for stem borer and leaf folder infestation. The farmers practices -T2, included**,** i**.** Seed treatment with *Pseudomonas* @ 10g/kg of seeds, ii. flubendiamide applied twice at 25 g.a.i/ha against rice stem borer and leaf folder and iii. Spray of malathion 0.05% against rice bug

Adoption of BIPM practices led to substantial reduction in infestation by major pests. The mean stem borer population in BIPM plots was 43 per cent lower as compared to non BIPM plots. Similarly, the dead hearts and white ear head symptoms recorded 86 and 78 per cent reduction in IPM plots as compared to non BIPM plots. Greater parasitoid activity was again observed in BIPM plots. The mean spider population in BIPM plots was 7.5/m^2, the same for non BIPM plots was only 5/m^2 (Table 41).

The yields in BIPM plots was 8000 kg/ha, approximately 20 per cent more than that from non BIPM plots (6800 kg/ha). The cost of cultivation also was 14 per cent lower in the former. The increase in profit was Rs 35,800/ha. The cost benefit ratio, at 2.96 was almost double in BIPM fields as compared to 1.90 for non BIPM fields.

Table 41. Comparison between BIPM and non BIPM plots at Anakkappara, Vadekkenchery

Particulars	BIPM plot (Mean no/m^2)	Non BIPM plot (mean no/m^2)
Dead heart	2.0	14.0
White ear head	2.5	11.25
Stem borer	3.5	6.5
Green leaf hopper	2.5	2.5
Leaf roller damage	4.5	10.25
Rice bug	3	3.3
Spiders	7.5	5.0
Ophionea sp	4.2	6.0

Parasitoids	3.0	2.3
Yield (kg/ha)	8000 kg	6800 kg
Returns per ha (@Rs. 23.5/kg)	Rs. 188,000	Rs. 159,800
Cost of cultivation (Rs/ha)	Rs. 47,500	Rs. 55,100
Net return per ha	Rs. 140,500	Rs. 104,700
Cost benefit ratio	2.96	1.90

1.4.4 AAU, Anand

The experiment was conducted in Farmers field at Runaj, Sojitra Taluk uin an area of 2 ha. on paddy variety "Suryamoti". The following treatments were imposed – T1 i) Seed bio-priming *Pseudomonas fluorescens* @ 10g/kg of seeds; ii) Seedling dip with *Pseudomonas fluorescens* 2% solution; iii) Spray of Azadirachtin 1500 ppm @ 3ml/litre at 45 and 65 DAT against foliar and sucking pest. There were 8 blocks with three replications. T2 Farmers practices Observations on pest incidence were recorded on 10 randomly selected hills in each replication at fortnightly interval starting from 15 DAT. The dead hearts, silver shoots, damaged leaves, number of plant hoppers/ hill were recorded. The yield and Cost-benefit ratio was worked out.

Among the different insect pests, the infestation of paddy leaf folder was very low (1-2%). No incidence of dead hearts, silver shoots and BPH was recorded. Very high incidence of false smut disease (50-60%) was recorded in both the modules.

1.4.5 AAU, Jorhat

The experiment was carried out at Rajabahar (Panchyat- Titabor) and Teok (Panchayat – Kaliapani), Jorhat district, on variety "Ranjit" in an area of 10 ha. There were three treatments.

T1 - BIPM package: i) Seedling root dip treatment with *Pseudomonus fluorescens* @ 2 % solution; ii) Two sprays of Azadirachtin 1500 ppm @3 ml/litre at 45 and 65 DAT against foliar and sucking pests; iii) Erection of bird perches @ 15 nos /ha; iv) Spray of *P. fluorescens* @ 1.5 kg/ha against foliar diseases; v) Six releases of *T. japonicum* @ 1,00,000 /ha at ten days interval starting from 30 DAT against *Scirpophaga* spp. and *Cnaphalocrocis* spp; T2 - Chemical control (Farmers' practice) where four alternate spray with chlorpyrifos @ 2.5ml/litre and quinalphos @2.5ml/litre was applied at 30, 40 , 50 and 60 DAT; T3: Untreated control

Observations on the major pest incidence and natural enemies' population were recorded fortnightly interval starting from 30 DAT after the release of bioagent and spraying of biopesticides. The population of *Nephotetix* spp. and per cent dead heart due to *Scirpophaga* spp. and leaf damage due to *Cnaphalocrocis* spp. were recorded at vegetative stages (45 and 60 DAT). White earhead incidence (WEH) was recorded at 120DAT before harvesting the crop. Population of GLH, Caseworm, hairy caterpillar and skipper were too low and disease incidence was also negligible in all the areas.

The per cent incidence of dead heart in BIPM plots was 5.10 and 3.15 at 45 DAT and 60DAT, respectively and in Farmers practice it was 5.05 and 3.78 per cent, respectively. The mean per cent incidence of white ear head was significantly better in BIPM package (2.57%) as against farmer's practice (3.76%) and untreated control (4.82%) at 120 DAT (Table 42). In BIPM plots at 60 DAT, the per cent damaged leaves due to leaf folder *Cnaphalocrosis sp*. was 4.10 as compared to 4.72 in farmers practice plots. Higher numbers of spiders and coccinelids population of 1.84/ m^2 and 1.72/ m^2 was recorded at BIPM package as against 1.14 and 1.56/ m^2 in

untreated control after 60 DAT whereas in chemical control plot they were only 0.70 and 0.70/ m^2, respectively at 60 DAT.

Grain yield in BIPM package (4680.94 kg/ha) was significantly better as compared to 4313.80 and 3270.38 kg/ha in farmers practice and untreated control plots, respectively. The net returns over control in BIPM package were Rs. 18,011.2 as compared to Rs. 11,668.40 in farmers practice plot with cost: benefit ratio of 1:1.76 and 1:126, respectively.

Table 42. Observation on incidence of Dead heart, WEH, LFDL and grain yield of rice

Treatments	Dead heart (%)		WEH (%)	LFDL (%)		Grain yield (kg/ha)
	45DAT	60DAT	120DAT	45DAT	60DAT	
BIPM Package	5.10	3.15[a]	2.57[a]	2.25	4.10[a]	4680.94[a]
Farmers practice	5.05	3.78[a]	3.76[b]	2.76	4.72[b]	4313.80[b]
Untreated control	5.14	9.82[b]	4.82[c]	2.56	6.14[c]	3270.38[c]
CD = 0.05	NS	0.63	0.68	NS	0.59	292.12

1.4.6 CAU, Pasighat

Demonstration of large scale bio-intensive pest management of rice was not conducted due to lack of field and convince to the farmers. Next year the same experiment will be conducted on the farmer's field.

1.4.7 OUAT, Bhubaneswar

The experiments were carried out at two places viz.,.Dalabanapur village, Nimapada block, Puri and 2. KVK, Sakhigopal, Puri. on rice variety "Swarna Sub-I" and the treatments were T1: BIPM package i) Seed bio-priming with *Pseudomonas fluorescens* 10g/kg of seed; ii) Seedling dip with *Pseudomonas fluorescens* 2% solution; iii) Spray of azadirachtin 1500 ppm @ 3ml/l at 45 and 65 DAT against foliar and sucking pests; iv) Erection of bird perches; v) Spray of *Pseudomonas fluorescens* @ 1.5 kg/ha against foliar diseases; vi) Release of *Trichogramma japonicum* @100,000/- (6 releases were made) at 10 days interval starting from 25 DAT for stem borer and leaf folder infestation. T2: Farmers Practice (Application of Carbofuran 3G, Lambda Cyhalothrin 2.5EC, Lambda cyhalothrin 2.5EC + Cartap hydrochloride 50% WP, Cartap hydrochloride 50% WP + Emamection benzoate 5% SG), and T3: Untreated control

The dead heart (DH), white ear head (WEH) and leaf folder (LF), incidence in BIPM demonstrated plots were 4.72, 5.20 and 3.56%, respectively as compared to 4.50, 4.80 and 3.32% infestation in their respective farmers practice (FP) with the use of chemical pesticides. Significantly higher DH (13.48%), WEH (17.09%) and LF (10.96%) infestation was noticed in untreated control. The yield of BIPM plots (53.22 q/ha) were next to chemical control (57.96 q/ha), but significantly higher than untreated control (46.08 q/ha). The benefit cost ratio in BIPM treated plots was found highest (1.84) as against 1.61 and 1.32 in FP and untreated control, respectively (Table 43).

Table 43. Effect of BIPM package on stern borer and leaf folder incidence in paddy (Swarna sub1)

Treatments	DH (%)	WEH (%)	LF (%)	Yield (q/ha)	B:C ratio
BIPM package	4.72 (2.28)	5.20 (2.38)	3.56 (2.01)	53.22	1.84
Famers' practice	4.50 (2.23)	4.80 (2.29)	3.32 (1.95)	57.96	1.61
Untreated control	13.48 (3.76)	17.00 (4.18)	10.96 (3.49)	46.08	1.32
S.E.(m) ±	- (0.06)	- (0.06)	- (0.12)	0.33	-
C.D. (0.05)	- (0.21)	- (0.21)	- (0.38)	1.07	-

1.4.8 NBAIR, Bangalore & GBPUAT, Pantnagar

1.4.8.1 GBPUAT, Pantnagar

Large scale field demonstrations of bio-control technologies were conducted at certified organic growers (515 no.) of Basmati rice, in three different blocks viz. Kotabagh, Patkot (Ramnagar) and Batalghat, in Nainital district covering an area of 189.0 ha in association with Nature Bio-Foods Ltd. (Table 44). Five quintals of PBAT-3 (Th-14 + Psf-173) was distributed to the farmers to conduct field trials.

The bio- control technologies adopted by farmers were i) Seed bio-priming (10 g/kg seed); ii) Seedling dip treatment (10 g/lit water) for 30 min. prior to transplanting, and iii) five foliar sprays with PBAT-3, at 30 days interval.

Rice blast (*Pyricularia oryzae*), sheath blight (*Rhizoctonia solani*) and Brown spot (*Drechslera oryzae*) diseases were observed at all the locations. However, Bacterial leaf blight (*Xanthomonas oryzae*), False smut (*Ustilaginoidea virens*) and Bakanae disease (*Fusarium fujikuoroi*) were also observed at some locations. The disease severity in PBAT-3, ranged from 2-10% while in organic practices it ranged from 5-20%. An average yield of 29.0 q/ha was recorded by the farmers adopting bio-control technologies along with need based organic practices as compared to an yield of 24.66 q/ha by the farmers adopting stray recommendations under organic practices for the management of insect pests and diseases. Maximum yield of 36 q/ha was obtained where the farmers used PBAT-3 along with Tricho card and need based organic practices (Table 44).

Table 44. Demonstration trials at organic rice growers

Treatment	Kotabagh		Patkot		Batalghat	
	Farmer (no.)	Yield (q/ha)*	Farmer (no.)	Yield (q/ha)*	Farmer (no.)	Yield (q/ha)*
PBAT-3	149	35.0	179	28.0	188	24.0
Trichocard+ PBAT-3		36.0		-		-
Farmers Practices suggested by organizers		29.0		25.0		20.0

*Mean yield of 08 different fields

Blast at leaf and ear head stages at few locations was managed by farmers by giving two consecutive foliar applications (5-7 days interval) of PBAT-3 + molasses (2%). Blackening of grains was also managed by two consecutive foliar applications (5-7days interval) of PBAT-3 + molasses (2%) + cow urine (5%).

Table 45. Additional income to the farmers (organic rice growers) by adopting biocontrol practices

Block	***Bio Control Practices**	***Farmers' Practices**	**Additional yield by adopting biocontrol practices**	**Selling price**	**Additional income by adopting biocontrol practices**
	Yield q/ha	Yield q/ha	(q/ha)	Rs/q	Rs/ha
Kotabagh	36.0	29.0	7.0	3000.00	21,000.00
Patkot	28.0	25.0	3.0	3,000.00	9,000.00
Batalghat	24.0	20.0	4.0	3,000.00	12,000.00

Cost of production of both the practices was almost same

The net profit in biocontrol practices was Rs. 62,000/- compared to conventional practice (Rs. 46,500/-), with a cost-benefit ratio 1:2.48 and 1:1.55, respectively (Table 45).

1.4.8.2 NBAIR, Bangalore

Large scale demonstration of biocontrol of yellow stem borer, *Scirpophaga incertulas* and leaf folder, *Cnaphalocrocis medinalis* were conducted in Kotabagh, Kyari, Dhamola village (24 ha) and in GBPUA&T Pantnagar (0.5 hactare) in rice (Variety: CSR-30) over an area of 24.5 ha. Six releases of *T. japonicum* were made @ 100,000 parasitoids/hectare at weekly intervals starting from 25 days after transplanting (DAT) and it was compared with farmer's practice. Tricho-cards were cut into strips and were stapled uniformly to the underside of the leaves in biocontrol treatment. The data were recorded on dead hearts due to stem borer and leaf damage due to leaf folder at vegetative stage (45 and 60 DAT). Grain yield was recorded on plot basis.

Based on the mean of all locations (Table 46), mean dead heart incidence in biocontrol fields was 8.25 and 3.04 per cent at 45 and 60 DAT, respectively. In farmer's practice these corresponding figures were 15.54 and 11.68 per cent. Similarly, leaf folder damage in release field was significantly lower in biocontrol fields as compared to untreated control at 60 DAT (F=135.70, P<0.0001). The damage due to leaf folder was 8.60 and 2.96 per cent at 45 and 60 DAT, respectively as compared to 11.17 and 15.99 per cent in farmer's practice field. Grain yield in biocontrol field (39.00 q/ha) was significantly higher compared to 28.72 q/ha in farmer's practice, respectively (Table 46).It can be concluded that 6 releases of *T. japonicum* each @ 1, 00,000/ha resulted in lower incidence of stem borer and leaf folder and higher grain yield in rice.

Table 46. Large scale demonstration of biocontrol of stem borer and leaf folder in rice during 2017

Treatments	Dead hearts (%)		Leaffolder damaged leaves (%)		Yield (q/ha)
	45 DAT	60 DAT	45 DAT	60 DAT	
Biocontrol*	8.25	3.04	8.60	2.96	39.00
Farmer's practice	15.54	11.68	11.17	15.99	28.72
P value	*P*=0.004	*P*=0.009	NS	*P*<0.0001	*P*=0.007

DAT – days after transplanting; *6 releases of *T. japonicum* each @ 1,00,000/ha at weekly interval starting from 25 DAT

1.5 Evaluation of fungal and bacterial isolates for disease management in Rice (GBPUAT, PAU)

1.5.1 GBPUAT, Pantnagar

A field experiment was conducted at Crop Research Centre, Pantnagar, on rice variety Pant Dhan-4 to test efficacy of 11 potential bio-agents and one fungicide, carbendazim (standard check) for disease management and yield improvement. The bio-agents were given as soil application (10 g formulation with 1kg vermicompost), seed bio-priming (10g /kg seed), seedling root dip treatment (10g /lit) and as two foliar sprays (10g /lit), 1st at 50 and 2nd at 80 DAT. The experiment was laid in a randomized block design in three replications with a plot size of 2 m x 3m.

Occurrence of Foliar diseases:

Three diseases, *viz*., Sheath blight, Brown spot and False smut were observed in the experimental field during the cropping season. Minimum Sheath blight (*Rhizoctonia solani*) disease severity was recorded with carbendazim (36.12%) followed by Psf-173 (36.33%), Psf-2 (36.37%), PBAT-3 (37.48%), TCMS-36 (40.23%) and Th-14 (40.59%) and was at par with each other but significantly better than control (52.69%). Minimum Brown spot (*Drechslera oryzae*) disease severity was recorded with NBAIR-2 (47.46%) which was at par with Psf-2 (50.94%) and NBAIR-1 (50.94%) but significantly better than other treatments and control (60.46%). Minimum percentage of False smut (*Ustilaginoidea virens*) infected panicle/hill was observed with Th-19 (16.47%) which was statistically at par with TCMS-36(16.71%), NBAIR-2 (19.64%), carbendazim (19.97%), PBAT-3(19.98%), and Psf-2 (20.34%) but significantly better than control (23.59%). Minimum percentage of false smut infected spikelet/panicle was recorded with TCMS-36 (25.60%) which was statically at par with PBAT-3 (29.69%), Th-19 (33.23%), Th-39 (31.96%), Psf-2 (30.85%), NBAIR-1 (29.84%) and Carbendazim (27.65%) but significantly better than control (41.73%)

Yield:

Maximum yield was obtained with carbendazim (56.66 q/ha) followed by Psf-2 (53.16 q/ha), Th-14 (52.83 q/ha) and PBAT-3 (52.66 q/ha) and were at par with each other but significantly better than control (45.00 q/ha). Maximum 1000 grain weight was observed with

carbendazim (27.00g) followed by PBAT-3 (26.90g) as compared to control (25.00g) but no significant differences were observed among the treatments (Table 47).

Table 47. Efficacy of promising bio-agents on plant growth and yield of rice (*var*. Pant Dhan-4)

Treatment	Plant Vigour		Yield			Test wt (g)
	Plant height (cm)	Tillers/hill (90 DAT) (no.)	Yield / plot (6 m^2) (kg)	Yield (q/ha)	Increase in yield (%)	
TCMS-36	109.49	7.59	3.08	51.33	14.07	26.70
PBAT-3	112.86	8.38	3.16	52.66	17.03	26.90
Th-14	113.40	8.36	3.17	52.83	17.40	26.80
Th-17	109.20	7.81	2.56	42.66	-5.18	25.40
Th-39	107.95	7.74	3.08	51.33	14.07	22.90
Th-19	107.96	6.88	3.04	50.66	12.59	23.50
Psf-173	110.68	7.20	3.07	51.66	13.70	26.30
Psf-2	112.26	7.47	3.19	53.16	18.14	27.30
NBAIR-1	107.84	6.67	3.08	51.33	14.07	28.30
NBAIR-2	108.40	7.89	2.58	43.00	-4.44	24.80
Sanjeevni	108.96	7.78	3.03	50.50	12.22	26.50
Carbendazim	113.40	8.34	3.40	56.66	25.92	27.00
Control	107.06	6.33	2.70	45.00	-	25.00
CD (0.05%)	1.63	0.27	0.38	-	-	N/A
CV (%)	0.87	2.12	6.37	-	-	7.92

1.5.2 PAU, Ludhiana

Evaluation of *Pseudomonas* (PANTNAGAR STRAIN) against sheath blight in rice

The experiment was conducted on variety PR 121 at PAU, Ludhiana with two treatments, *viz*., T1: Seed treatment @ 10 g/kg seed, Seedling dip @ 10 g/ litre water and two foliar sprays at 45 & 60 DAT (@ 10 g/ litre water), and T2: Untreated control

Disease incidence and severity (based of SES 0-9 scale; IRRI) were recorded from 30 plants selected at random from each plot. The incidence of sheath blight was 83.33 and 86.67 per cent in treated and untreated plots, respectively (Table 48). The corresponding figures for disease severity were 44.44 and 48.52 per cent indicating no significant differences in treated and untreated plots.

Table 48. Incidence of sheath blight in treated and untreated plots of rice

Parameters	Treated Plot	Untreated plot
Incidence (%)	83.33	86.67
Per cent Disease severity (PDS)*	44.44	48.52

*SES scale 0 – 9 scale (IRRI)

2. MAIZE

2.1 Evaluation of entomopathogenic fungi and Bt against maize stem borer (Rabi 2017-18 or as per season) (PJTSAU, PAU)

2.1.1 PJTSAU, Hyderabad

Observations:

- Dead heart count at weekly interval starting from 20 randomly selected plants at 30 and 45 DAS.
- Leaf damage at weekly interval starting from initial incidence of stem borer.
- Number of exit holes/plant.
- Grain Yield at harvest

Status of the trial

The harvesting was done during March, 2018 and outcome of the experiment will be submitted shortly after processing and analyzing of data recorded.

2.1.2 PAU, Ludhiana

The experiment was carried out during *Kharif*, 2017 on variety J 1006 with the following treatments, i) Bb-5a isolate @ 10 ml/litre water; ii) Bb-23 isolate @ 10 ml/litre water; iii) Bb-45 isolate @ 10 ml/litre water; iv) Ma-35 isolate @ 10 ml/litre water, and v) chemical control (chlorantraniliprole 18.5 SC (Coragen) @ 100 ml/ha) and vi) untreated control. Two sprays were given at 10 and 20 days days after germination.

All the fungal isolates were at par with each other in reducing the dead heart incidence (2.40 to 3.45 %). Chemical control was significantly better than other treatments in reducing the leaf injury (2.26%) and dead hearts (0.62 %) by maize borer (Table 49). Fodder yield in all the fungal isolates (142 to 150 q/ha) was significantly better than untreated control (121 q/ha).Higher green fodder yield (159 q/ha) was recorded in chemical control.

Table 49. Field evaluation of NBAIR entomopathogenic strains against stem borer *Chilo partellus* (Swinhoe) in fodder maize during 2017

Treatments	Mean leaf injury (%)	Mean dead hearts (%)	Stem length (m)	Tunnel length (cm)	Green fodder yield q/ha
Bb-5a isolate of *B. bassiana*	4.71 (12.16)	2.40 (8.62)	1.72	3.00	150
Bb-23 isolate of *B. bassiana*	5.39 (13.26)	2.76 (9.31)	1.87	4.50	142
Bb-45 isolate of *B .bassiana*	4.14 (11.53)	2.78 (9.41)	1.79	4.20	150
Ma-35 isolate of *M. anisopliae*	5.24 (13.04)	3.45 (10.27)	1.72	4.00	145
Coragen 18.5 SC@ 100 ml/ha	2.26 (8.59)	0.62 (3.66)	1.90	1.80	159

Untreated Control	9.27 (16.88)	6.72 (14.80)	1.70	5.90	121
CD (*p*=0.05)	(3.18)	(2.75)	-	-	7.7

Figures in parentheses are arc sine transformed values; Mean of 3 observations - 5, 10 and 15 days after spray

Evaluation of *Bt* formulations and bioagent against stem borer in *kharif* maize

The evaluation was carried out during *Kharif*, 2017 on variety PMH 1 and the treatments comprised of T_1 -Two sprays of *Bt* formulation Delfin WG @ 1250 ml/ha on 10 and 20 days old crop,T_2 - Two sprays of *Bt* formulation Dipel 8 L @ 1250 ml/ha on 10 and 20 days old crop, T_3 - Two releases of *Trichogramma chilonis* @ 1,00,000 /ha on 10 and 17 days old crop, T_4 - Chemical control (chlorantraniliprole 18.5 SC (Coragen) @ 75 ml/ha) and T_5– Untreated control.

The dead heart incidence in both Bt formulations (Delfin WG and Dipel 8 L) were at par with each other, followed by treatment with *Trichogramma* releases. Chemical control was significantly better than other treatments in reducing dead hearts recorded after 7 (2.00 %) and 14 (2.33 %) days of application (Table 50). Significantly higher yield (49.10 q/ha) was recorded in chemical control followed by treatments with Bt sprays, compared to 40.80 q/ha in untreated control.

Table 50. Evaluation of *Bt* formulations and bioagent against stem borer stem borer *Chilo partellus* in *kharif* maize during 2017

Treatments	**Mean dead hearts (%)**		**Yield (q/ha)**
	7 DAA	**14 DAA**	
Two sprays of *Bt* formulation Delfin WG @ 1250 ml/ha on 10 and 20 days old crop	4.00 (11.53)	5.33 (13.29)	47.10
Two sprays of *Bt* formulation Dipel 8 L @ 1250 ml/ha on 10 and 20 days old crop	4.33 (11.99)	6.00 (14.14)	47.00
Two releases of *Trichogramma chilonis* @ 1,00,000 /ha on 10 and 17 days old crop	6.00 (14.17)	8.33 (16.75)	45.00
Chlorantraniliprole 18.5 SC (Coragen) @ 75 ml/ha)	2.00 (7.94)	2.33 (8.74)	49.10
Untreated control	12.33 (20.55)	16.67 (24.08)	40.80
CD (*p*=0.05)	(2.03)	(2.32)	1.71

Figures in parentheses are arc sine transformed values; DAA – days after application

2.2 Biological control of maize stem borer, *Chilo partellus* using *Trichogramma chilonis* [ANGRAU (5 ha); PAU (120 ha); MPUAT (0.4 ha)]

2.2.1 ANGRAU, Anakapalle

The experiment was conducted at three villages in Vizianagaram and Vishakapatnam districts. The treatments comprised of T1: Releases of *Trichogramma chilonis* @ 100,000/ha/release at 15, 22 and 29 days after seedling emergence at 7-10 day interval, and T2:

Farmers' practice (Carbofuran 3 G @ 3 kg/ acre whorl application at 25-30 days after seedling emergence)

Maize stem borer, *Chilo partellus* damage was recorded low in in treatments with *Trichogramma chilonis* releases (1.87% DH) and chloraniliprole spraying (1.67%DH) followed by whorl application of carbofuran granules (3.32%DH) and high in monocrotophos sprayed plot (13.19% DH) at Singavaram village, Denkada mandal, Vizianagaram district. . The results followed a similar trend at Padmanabham village, Padmanabham mandal, Visakhapatnam district Stem borer damage was low in *T. chilonis* release (1.67% DH) and chloraniliprole spraying (2.67%DH) followed by whorl application of carbofuran granules (3.85%DH). However, the borer damage was nil in *T. chilonis* release plot compared to monocrotophos spray (2.1% DH) and untreated control (13.97% DH) at Chollangipeta village, Denkada mandal, Vizianagaram district.

2.2.2 PAU, Ludhiana

The demonstrations on the releases of *Trichogramma chilonis* were conducted at farmer's fields in an area of 404 acres in Hoshiarpur, Nawanshahr and Roop Nagar districts of Punjab in collaboration with Maize Section, Department of Plant Breeding and Genetics, FASS Hoshiarpur, KVK Hoshiarpur and KVK Ropar. Each demonstration area was divided into three blocks representing three treatments, *viz*., two releases of *T. chilonis* @ 1,00,000 parasitoids/ha, chemical control (farmers' practice) and untreated control. In chemical control, deltamethrin 2.8 EC @ 200 ml/ha was sprayed using 150 litres of water per ha.

The dead heart incidence in fields with the releases of *T. chilonis* was 6.47 per cent and in chemical control, it was 4.06 per cent (Table 51). The reduction in incidence over control was 57.35 and 74.76 per cent in biocontrol and chemical control, respectively. The yield in biocontrol (44.83 q/ha) and chemical control (46.54 q/ha) fields were significantly more than in untreated control (40.10 q/ha). The net returns over control in biocontrol package were Rs. 6240.25/- as compared to Rs.8817.25/- in chemical control.

Table 51. Effect of *T. chilonis* releases on incidence of *C. partellus* and yield in *Kharif* maize during 2017

Treatments	Dead hearts (%)	% reduction in incidence over control	Yield (q/ha)	% yield increase over control
T. chilonis @ 100,000 per ha*	6.47[b]	57.35	44.83[b]	12.58
Deltamethrin 2.8 EC @ 200 ml/ha	4.06[a]	74.76	46.54[a]	17.07
Untreated control	15.07[c]	-	40.10[c]	-

2.2.3 MPUAT, Udaipur

The IPM module was evaluated on variety "Pratap Makka-3" and comprised of T1: Two sprays of NSKE @ 5%; T2: Release of *Trichogramma chilonis* @ 100,000/ha. (2 release at weekly interval), and T3: Application of spinosad 45 SC @ 1.0ml/ 3 lit. water.

The IPM module was found most effective against *Chilo partellus* and recorded minimum leaf injury rating (LIR) and dead heart per cent 1.83 and 2.00 respectively, as compared to farmers practice (4.2 and 8.11, respectively). Comparatively higher yield was recorded in IPM module (21.50 q/ha) than farmers practice (18.50 q/ha) (Table 52)

Table 52. Biological suppression of maize borer *Chilo partellus*

Treatments	LIR	Dead heart	Yield (q/ha)	Yield (Per cent increase over control)
IPM Modules *	1.83	2.40	21.50	40.52
Farmers practices *	4.2	8.11	18.50	20.92
Control	6.50	14.20	15.30	-

* Mean of 10 farmers

PULSES

3. PIGEONPEA

3.1 Evaluation of NBAIR Bt formulation on pigeonpea against pod borer complex [PAU (2 ha); MPKV (2 ha); ANGRAU (2 ha); TNAU (0.4 ha as intercrop in groundnut ecosystem); UAS-R (2 ha)]

3.1.1 PAU, Ludhiana

Large scale evaluation of NBAIR Bt formulation against pod borer complex in pigeonpea was conducted at farmer's field in collaboration with KVK Nurmahal, at Ramewal village, Tehsil Nurmahal, District Jalandhar in 1 ha area during 2017. The experiment was conducted on pigeonpea variety AL 201 sown in May 2017. There were three treatments *viz.* NBAII BT G4 (2%), chemical control (Spinosad 45% SC@ 150 ml/ ha) and untreated control. The experiment was conducted in exploded block design where six equal sized units were considered as replications. There were three sprays at pre flowering, post flowering and pod formation. Percent pod damage and grain yield was recorded.

The number of webbed pods per plant was lowest in chemical control (1.10), followed by NBAIR Bt (1.59) and both these treatments were significantly better than untreated control. Lowest number of *H. armigera* larvae were recorded in chemical control (0.30) and NBAIR Bt (0.55), which were at par with each other and were significantly better than untreated control (2.56).The per cent pod damage was minimum (6.97%) in chemical control followed by NBAIR Bt (10.76%) and was significantly better than untreated control(19.11%).The NBAIR Bt recorded 10.32q/ha grain yield which was significantly better than untreated control(8.94q/ha) However, maximum yield (11.10 q/ha) was in chemical control (Table 53). So it was concluded that per cent pod damage and grain yield in NBAIR Bt and chemical control were significantly better than untreated control.

Table 53. Large scale evaluation of NBAIR Bt formulation against pod borer complex on pigeonpea during 2017

Treatments	Number webbed pods/ plant*	No. of *H. armigera* larvae / plant*	Per cent pod damage*	Pod yield (q/ha)
NBAIR Bt G4 @ 2%)	1.59 [b] (1.60)	0.55 [a] (0.21)	10.76 [b] (18.98)	10.32 [b]
Spinosad 45 SC@ 150ml/ha	1.10 [a] (1.32)	0.30 [a] (0.10)	6.95 [a] (14.91)	11.10 [a]
Untreated control	3.37 [c] (2.08)	2.56 [b] (1.87)	19.11 [c] (25.89)	8.94 [c]

*Pooled Mean of three readings

3.1.2 MPKV, Pune

A field experiment was conducted on the Research Farm of Agril. Entomology Section, College of Agriculture, Pune. The pigeon pea seeds var. ICPL-87 were sown at 30 x 10 cm spacing in 8 x 5 m plots on 25/7/2017. The trial was laid out in RBD with three treatments and eight replications. Three sprays were given at pre flowering, post flowering and pod formation stage. The larval population of *Helicoverpa armigera* and *Maruca testulalis* were recorded a day before treatment application as pre-count and post counts at 3 and 7 days after each spray. The data on larval population were transformed into √x+0.5 values, per cent pod and seed damage transformed to arc sin values and yield data converted into quintal per ha. The data were then subjected to analysis variance.

The results in Tables 54, 55 and 56 indicated that three sprays of chlorpyriphos (0.05%) at fortnightly interval was significantly superior over other treatments in suppressing the larval population of *H. armigera* (av. 1.14 larvae/plant) and *M. testulalis* (av. 4.20 larvae/plant) on pigeon pea and recorded minimum pod (7.84 %) and seed (5.57%) damage with maximum 16.93 q/ha yield. It was however, at par with the NBAII-BT G4 @ 2% in respect of pod damage (8.87%), grain damage (6.32%) and yield (15.92 q/ha).

Table 54. Evaluation of NBAIR Bt formulation against legume pod borer *M. testulalis* on pigeonpea

No. of *M. testulalis* larvae/25 inflorescence on pigeon pea								
Treatment	**Pre-count**	**I Spray**		**II Spray**		**III Spray**		**Cumul. Average**
		3rd DAS	**7th DAS**	**3rd DAS**	**7th DAS**	**3rd DAS**	**7th DAS**	
T1: NBAII Bt G4 2%@ 2 ml/lit	3.67[a]	2.92[a]	2.24[b]	8.99[a]	6.83[a]	6.33[a]	4.58[b]	5.32[a]
T2: Chlorpyriphos 0.05%	3.60[a]	2.82[a]	1.87[a]	7.72[a]	5.47[a]	4.75[a]	2.58[a]	4.20[a]
T3: Untreated Control	3.65[a]	7.33[b]	11.51[c]	24.75[b]	29.87[b]	22.02[b]	17.75[c]	18.87[b]
SE ±	0.03	0.02	0.03	0.08	0.13	0.12	0.15	0.08
CD at 5%	NS	0.06	0.09	0.24	0.39	0.36	0.44	0.24
CV (%)	7.84	8.15	11.27	8.34	10.73	9.52	12.35	11.24

Table 55. Evaluation of NBAIR Bt formulation against pod borer, *H. armigera* on pigeonpea

Treatments	**No. of *H. armigera* larvae/plant on pigeonpea**					
	Pre-count before 2nd spray	**2nd Spray**		**3rd spray**		**Cumulative effect of two sprays**
		3 DAS	**7 DAS**	**3 DAS**	**7 DAS**	
T1: NBAII BtG4 2%@ 2 ml/lit	4.57[a]	3.72[b]	1.72[a]	0.95[b]	0.53[a]	1.73[b]
T2: Chlorpyriphos 0.05%	4.54[a]	2.31[a]	1.36[a]	0.59[a]	0.30[a]	1.14[a]
T3: Untreated Control	4.52[a]	5.66[c]	8.00[b]	9.47[c]	11.34[b]	8.62[c]
SE ±	0.06	0.07	0.05	0.04	0.06	0.05
CD at 5%	NS	0.21	0.15	0.12	0.18	0.15
CV (%)	8.92	7.23	6.58	9.42	11.26	10.38

Table 56. Effect of NBAIR Bt formulation on pod damage and yield of pigeonpea

Treatments	Pod damage (%)	Grain damage (%)	Yield (q/ha)
T1: NBAII Bt G4 2%@ 2 ml/lit	8.87[a]	6.32[a]	15.92[a]
T2: Chlorpyriphos 0.05%	7.84[a]	5.57[a]	16.93[a]
T3: Untreated Control	28.74[b]	24.77[b]	8.12[b]
SE ±	0.38	0.32	0.43
CD at 5%	1.14	0.96	1.29
CV (%)	9.48	11.52	13.27

3.1.3 ANGRAU, Anakapalle

Treatments: Three

T1: NBAII BtG4 2% @ 2.0 ml/lt-3 sprays at pre flowering, post Flowering and pod formation stage.
T2: Chemical control (2 sprayings with chlorpyriphos 2.5 ml/lt at flowering followed by acephate @1.5 g/lt at pod formation)
T3: Control

Leaf damage due to *Maruca vitrata* leaf webber was low in Bt treatment plot. Pod damage due to *M. vitrata* recorded low at in Bt treatment plot (24.41%) followed by chemical treatment plot (26.48%) compared to untreated control plot (30.91%). High pod yield was recorded in NBAIR Bt treatment (512.01 kg/ha) compared to chemical sprays (497.56 kg/ha) and control (399.25 kg/ha). NBAIR Bt treatment was effective against *Maruca* with 42% reduction in leaf damage, 32.67% reduction in pod damage and 22.34% increase in grain yield compared to untreated control (Table 57).

Table 57. Evaluation of NBAIR Bt formulation on pigeonpea against pod borer complex

Treatment	Number of leaf webs (*Maruca*) per plant		Percent reduction in Leaf webber damage	Pod damage (%)	Percent reduction in pod damage	Pod yield kg/ha	Percent increase in yield
	Before spraying	After spraying					
NBAIR BtG4 2% @ 2.0 ml/lt - 3 sprays at pre flowering, post Flowering and pod formation stage.	0.3	0.575	42.0	21.08	32.67	512.01	22.34
Chemical control (3 sprayings with chlorpyriphos 2.5 ml/lt at pre-flowering, acephate @1.5 g/lt at	0.288	0.75	25.0	28.09	10.28	498.38	19.08

post flowering and chrantraniliprole 0.3 ml/lt at pod formation)							
Untreated control	0.35	1.0		31.31		418.52	
CD (0.05)	NS	0.254		5.79		63.52	
CV%	32.28	30.26		19.94		12.32	

Pod damage due to *M. vitrata* recorded low at in Bt treatment plot with high pod yield compared to farmers practice of two chemical sprays. This trial helps the farmers to reduce expenditure on pesticides and to adopt biological control for the management of *Maruca* borer in pigeonpea.

3.1.4 TNAU, Coimbatore

The details of the experiment are as follows.

Name of the farm: Agricultural Research Station farm
Location: Virinjipuram, Vellore Dt, Tamil Nadu
Red gram Variety: BSR 1 (First ratoon)
Date of planting: 22.7.2017

Treatments:
T_1 : NBAII BtG4 2% @ 2.0 ml/lt - 3 sprays at pre flowering, post Flowering and pod formation stage.
T2: Chemical control (Flubendiamide @ 0.3 ml/lt)
T3: Control
Replications: Eight
Plot size: 100 m^2
Spacing: 5 x 2 m
No. of Sprays/ insecticide treatments: Three
Observations:
1. No. of gram and legume/pod borer complex (spotted pod borer, plume moth, slug caterpillar, etc) / plant; Per cent pod damage; Grain yield (kg/ha)

Evaluation of NBAII BtG4 liquid formulations in comparison with the chemical flubendiamide @ 0.3 ml/lt showed that NBAII-BTG4 @ 2% spray was effective in reducing the larval population of *M. vitrata* and *Exelastis atomosa* in all stages, *viz.*, pre flowering, post flowering and pod emergence with lesser pod and seed damage. It was also effective in controlling *H. armigera* after three sprays. But in comparative terms of pest reduction and yield, this BT G4 formulation was found to be on par with flubendiamide (Table 58). Both the Bt formulation and the chemical sprays gave higher grain yield of 517.5 and 486.25 Kg/ha, respectively than control (375 Kg/ha).

Table 58. Evaluation of NBAII liquid formulations (PDBC-BT1 and NBAII-BTG4) *Bt* against pigeonpea pod borer (*Helicoverpa armigera*) and legume pod borer (*Maruca vitrata*)

Treatments	Pre flowering -Damage (%)			Post flowering-Damage (%)			Pod emergence-Damage (%)			% Pod damage	Yield Kg/ha	CB ratio
	M.v	H.a	E.a	M.v	H.a	E.a	M.v	H.a	E.a			
NBAIR –BTG 4 @ 2% spray	7.00 (14.95)[a]	1.63 (6.71)	3.63 (10.80)[a]	11.50 (19.75)[a]	2.13 (8.00)	3.13 (18.98)[a]	15.75 (23.27)[a]	2.88 (9.49)[a]	10.63 (19.56)[a]	15.16 (22.88)[a]	517.5 (2.71)[a]	2.14
Flubendiamide spray @ 0.3 ml/lt	7.75 (16.02)[a]	1.50 (6.53)	3.38 (10.17)[a]	13.63 (21.61)[a]	1.63 (6.90)	2.88 (18.60)[a]	17.38 (24.58)[a]	4.38 (11.97)[a]	10.25 (19.89)[a]	19.06 (25.83)[b]	486.25 (2.69)[a]	1.73
Control	14.63 (22.40)[b]	2.00 (7.79)	10.63 (18.61)[b]	21.63 (27.68)[b]	2.88 (9.49)	10.13 (26.98)[b]	27.63 (31.65)[b]	4.88 (12.61)[b]	20.63 (28.36)[b]	30.21 (33.32)[c]	375 (2.57)[b]	
SEd	1.47		1.13	0.99		0.83	0.87	1.22	0.58	0.83	0.01	
CD	3.05	NS	2.43	2.12	NS	1.77	1.88	2.61	1.61	1.79	0.02	
CV	16.51		16.99	8.60		7.69	6.61	21.44	3.13	6.13	1.03	

Helicoverpa armigera - H. a , Maruca vitrata – M. v, Exelastis atomosa – E. a; Means followed by a common letter in a column are not significantly different by DMRT; Figures in parentheses are arcsine transformed values (Damage), Figures in parentheses are logarithmic transformed values (Yield); Values are mean of eight replications

3.1.4 UAS, Raichur

Variety: TS3 R
Date of sowing: 27-07-2017
Area: 2 ha
Treatments

Four sprays of NBAIR *Bt* G 4 on 10-11-2017, 21-11-2017, 02- 12-2017 and 13-12-2017

Three sprays of insecticides in farmers' field
1. Profenofos 50 EC @ 2 ml/l
2. Emamectin benzoate 5 WG @ 0.2 gm/l
3. Chlorantriniliprole 18.5 SC @ 0.25 ml/l

Observations

In each acre eight quadrants were made and observations were recorded on per cent pod damage and grain yield and analyzed statistically.

One day before spray, larval population ranged from 3.78 to 3.84 per plant. On seven days after spray, NBAIR *Bt* G 4 recorded 1.64 larvae per plant while in farmer practice it was 0.98 larva per plant and on ten days after spray, NBAIR *Bt* G 4 recorded 1.26 larvae per plant and in farmers practice it was 0.82 larva per plant. NBAIR *Bt* G 4 recorded 10.18 per cent pod damage with grain yield of 8.75q/ha while in farmers practice the per cent pod damage was 8.38 with a grain yield of 9.50 q/ha (Table 59).

Table 59. Evaluation of NBAIR *Bt* G 4 in comparison with farmers practice at Gonal village of Raichur taluk

Sl.	Particulars	Larval count (No/plant)			Pod damage (%)	Grain Yield (q/ha)
		1 DBS	7 DAS	10 DAS		
1.	NBAIR *Bt* G 4	3.84 (2.08)	1.64 (1.46)	1.26 (1.33)	10.18 (18.61)	8.75
2.	Farmers Practice	3.78 (2.07)	0.98 (1.22)	0.82 (1.15)	8.38 (16.83)	9.50
S Em $\pm$		0.12	0.05	0.03	0.43	0.15
CD (*P*=0.05)		0.37	0.16	0.11	1.30	0.46

4. MUNGBEAN

4.1 Integration of botanical/microbials and insecticide spray schedule for the management of pod borer complex in mungbean (PAU)

The experiment was conducted at Entomological Research Farm, Punjab Agricultural University, Ludhiana, on mungbean variety ML 2056. The experiment was conducted in RBD plot size of 20 m^2. The detail of the treatment is given in table 60. The time schedule of first and second sprays in each treatment was at pod formation and after fifteen days interval, respectively. The observations on pod damage and grain yield were recorded.

All the treatments were significantly better than untreated control in reducing the pod damage (Table 60). Minimum percent pod damage (11.25%) was recorded in treatment (T9) with two sprays of spinosad 45 SC @ 150 ml/ha each. It was at par with treatment (T3)(First spray of Dipel Bt@ 1.25litre/ha and second of spinosad 45 SC @ 150 ml/ha each (11.65 %), treatment (T6)(first spray of Azadirachtin1 % @1.25litre/ha and second of spinosad45 SC @ 150 ml/) (11.91 %) and treatment (T2) two sprays of Dipel Bt@ 1.25litre/ha (12.71 %). Significantly higher incidence was recorded in untreated control (25.33 %). Significant increase in yield was also recorded in all treatments over control. Maximum yield was 10.91q/ha in treatment (T9) and it was at par with T3 (10.68 q/ha) However, lowest yield was in untreated control (7.65 q/ha). It was concluded that treatment T3), T6), T2 and T9 can be used for the management of pod borer complex in mungbean (Table 23).

Table 60. Integration of botanical/microbials and insecticide spray schedule for the management of pod borer complex in mungbean

T. No.	Treatments		Percent pod damage*	Yield (q/ha)
	First spray	Second spray		
T1	Bt (Dipel 8L) @1.25l/ha	Azadirachtin 1 % (Econeem plus) @1.25l/ha	16.90^{c} (24.26)	9.32^{d}
T2	Bt (Dipel 8L) @ 1.25l/ha	Bt (Dipel 8L) @1.25l/ha	12.71^{a} (20.86)	10.37^{ab}
T3	Bt (Dipel 8L) @1.25l/ha	Spinosad45 SC@150 ml/ha	11.65^{a} (19.95)	10.68^{a}
T4	Azadirachtin 1 % (Econeem plus) @1.25l/ha	Azadirachtin 1 % (Econeem plus) @1.25l/ha	16.36^{c} (23.84)	9.43^{cd}
T5	Azadirachtin 1 % (Econeem plus) @1.25l/ha	Bt (Dipel 8L) @1.25litre/ha	16.11^{c} (23.65)	9.44^{cd}
T6	Azadirachtin 1 % (Econeem plus) @1.25lha	Spinosad45 SC@150 ml/ha	11.91^{a} (20.18)	10.42^{ab}
T7	Spinosad45 SC@150 ml/ha	Azadirachtin 1 % (Econeemplus) @1.25l/ha	15.39^{bc} (23.05)	9.44^{cd}
T8	Spinosad45 SC@150 ml/ha	Bt (Dipel 8L) @1.25l/ha	13.43^{ab} (21.43)	10.01^{bc}
T9	Spinosad45 SC@150ml/ha	Spinosad45 SC@150ml/ha	11.25^{a} (19.58)	10.91^{a}
T10	Untreated control		25.33^{d} (26.02)	7.65^{e}

*Pooled Mean of three readings

5. COWPEA

5.1 Evaluation of entomopathogenic fungi against pod bug *Riptortus pedestris* on cowpea *Vigna unguiculata* (KAU, Thrissur)

The experiment is in progress at farmers field in Kuruvai, Vadekkenchery.

5.2 Screening of promising fungal and bacterial isolates for management of anthracnose disease in cowpea (KAU, Thrissur)

Promising fungal and bacterial isolates namely, *Pichia guilliermondi*, *Trichoderma harzianum* and *Pseudomonas flourescens* were evaluated for management of anthracnose disease in cowpea at College of Horticulture, Vellanikkara during June-September, 2017. The results are presented in Table 61.

Table 61. Effect of microbial isolates on anthracnose disease in cowpea

Treatments	Mean incidence of anthracnose (%)		Mean yield (Kg/plot)
	Pre count	Flowering	
Pichia guilliermondi (10 ml/l)	0.5	5.75	0.55
Trichoderma harzianum(10g/l)	0	8.75	0.76
Pseudomonas flourescens ($1x10^8$cfu/ml)	0	7.75	0.61
Carbendazim 2g/kg	0.2	6.25	0.56
Untreated control	1.25	7.0	0.67

There was no significant difference between the treatments in terms of disease incidence or yield. It has been proposed to repeat the trial in an area where cowpea anthracnose is endemic.

5.3 Evaluation of potential isolates of *Pseudomonas, Trichoderma, Bacillus* and microbial consortia against major diseases of cowpea (KAU, Kumarakom)

The experiment was laid out at RARS, Kumarakom with 6 treatments and 4 replications in RBD and treatments were imposed during November/December 2017. The disease incidence was very mild and non-uniform even after inoculation of the pathogen and hence the experiment could not be performed. New proposal for management of the disease in open field conditions will be proposed for 2018-19.

6. CHICKPEA

6.1 Integration of botanicals/microbials and insecticide spray schedule for the management of *Helicoverpa armigera* on chickpea (PAU)

No report

6.2 Management of *Helicoverpa armigera* by Hear NPV in chickpea ecosystem (NBAIR) in collaboration with UAS-R)

Chick Pea (Irrigated) (JJ-11)
Sowing Date: 08-11-2017
T_1: 0.5 ac HearNPV NBAIR Strain
T_2: 0.5 ac HearNPV UAS, Gulbarga Strain
T_3: 0.2 ac farmer's practice (1.Application of Emamectin benzoate 5 WG, 2.Chlorantriniliprole 18.5 SC)

Observations

In each block eight quadrants were made to record the incidence of pod borer, per cent pod damage and grain yield and each quadrant was considered as a replication.

Before treatment imposition, the larval population ranged from 3.92 to 4.18 larvae per plant which was statistically non significant. Hear NPV NBAIR @ 2 ml/l recorded 1.84 larvae per plant and it was at par with Hear NPV UASR @ 2 ml/l which recorded 1.92 larvae per plant at seven days after spray. While the farmer practice recorded lowest larval population of 1.06 larvae per plant which was statistically superior over the Hear NPV treatments and similar trend was noticed at 10 days after spray. Minimum damage of 10.62 per cent was noticed in Hear NPV NBAIR @ 2 ml/l and it was at par with Hear NPV UASR @ 2 ml/l which recorded 11.38 per cent pod damage. Farmers practice block recorded minimum of 8.62 per cent pod damage which was statistically superior over Hear NPV treatments. Hear NPV NBAIR @ 2 ml/l recorded 16.46 q/ ha grain yielded and it was at par with Hear NPV UASR @ 2 ml/l (15.38 q/ha) while in farmer practice highest grain yielded was 18.24 q/ha was noticed (Table 62).

Table 62. Management of *Helicoverpa armigera* by Hear NPV in chickpea ecosystem (NBAIR in collaboration with UAS-R)

Sl. No.	Particulars	Larval count (No/plant)			Pod damage (%) *	Grain Yield (q/ha)
		1 DBS	7 DAS	10 DAS		
T_1	Hear NPV NBAIR (1.5X 10^{12} POBs/ha)	4.18 (2.16)	1.84 (1.53)	1.18 (1.36)	10.62 (19.02)	16.46
T_2	Hear NPV UASR (1.5 x 10^{12} POBs/ha)	3.92 (2.10)	1.92 (1.56)	1.26 (1.33)	11.38 (19.72)	15.38
T_3	Farmers Practice	4.06 (2,14)	1.06 (1.06)	0.82 (1.15)	8.62 (17.07)	18.24
S Em $\pm$		0.08	0.05	0.03	0.33	0.46
CD (*P*=0.05)		NS	0.16	0.11	1.02	1.39

Figures in parentheses are square root transformed values; *Figures in parentheses are arcsine transformed values; NS-Non Significant

6.3 Biological suppression of pod borer *Helicoverpa armigera* infesting chickpea (MPUAT)

No report

6.4 Evaluation of fungal and bacterial isolates for chickpea disease management (GBPUAT)

Chickpea (variety PG-186)
Sowing time: Dec. 05, 2017
Spacing: 45x15 cm
Harvesting: would be done at the end of April

A field experiment was conducted at Crop Research Centre, GBPUA&T, Pantnagar, during Rabi 2017-18 to test the efficacy of bio-agents against wilt complex and yield of chickpea. The experiment was laid out in a randomized block design in three replications with a plot size of 3x2 m^2.

Methods of application: Bio-agents were applied as seed treatment (10g /kg seed), and as two foliar sprays (10 g /lit; 1st at 45, 2nd at 75 DAS), seed treatment with carbendazim (1g/kg seed) and foliar spray (1g/lit.) served as standard control while without any treatment served as control.

Plant mortality and mature plant wilt: Maximum percentage of seed germination was observed in NBAIR-1-Th and carbendazim (69.8%), which was at par with Th-39 (68.8%), PBAT-3 (68.7%),Th-17 (67.9%), Psf-2 (67.7%) and with some other treatments but significantly different from control (65.0%) and some other treatments. Significantly minimum plant mortality (30-120 DAS) was observed with BARC-Th (11.1%), followed by PBAT-3 (15.5.0%), Th-14 (16.4%), TCMS-36 (17.67%) and Th-17 (17.4%) as compared to carbendazim (31.6%) and control (34.2%). Minimum mature plant wilt (120 DAS) was observed with BARC and PBAT-3 (4.7%) followed by Th-39 (4.8%), Th-14 (6.0%), Psf-173 (5.1%) and Psf-2 (5.2%) while maximum in control (13.9%) and NBAIR-2 (10.1%) **(**Table 63 & Plate 6).

Table 63. Efficacy of promising bio-agents against seed and plant mortality and mature wilt of chickpea in field

Treatment	Plant Stand (30 DAS)	Germination (30 DAS)	Healthy Plant (30-120 DAS)	Mature plant wilt (120 DAS)	Total plant stand (120 DAS)	Wilted plant	Plant mortality including wilted plants (30-120DAS)
	(No.)	(%)	(No.)	(No.)	(No.)	(%)	(%)
TCMS- 36	157.0	65.4	130.0	14.3	144.3	9.9	17.1
PBAT-3	165.0	68.7	139.3	7.0	146.3	4.7	15.5
Th-14	155.3	64.7	138.6	9.0	147.6	6.0	16.4
Th-17	163.0	67.9	134.6	9.3	143.9	6.4	17.4
Th-39	165.3	68.8	129.0	6.6	135.6	4.8	21.9
Th-19	150.6	62.7	114.6	11.6	126.2	9.1	23.9

Psf-173	155.6	64.8	121.6	6.6	128.2	5.1	21.8
Psf-2	162.6	67.7	131.0	7.3	138.3	5.2	19.4
NBAIR1-Th	167.6	69.8	129.6	12.6	142.2	8.8	22.6
NBAIR2- Ta	153.6	64.0	112.0	12.6	124.6	10.1	27.0
BARC	158.3	65.9	140.3	7.0	147.3	4.7	11.3
Sanjeevni TV	158.0	65.8	121.3	9.6	130.9	7.3	23.2
Carbendazim	167.6	69.8	114.6	10.6	125.2	8.4	31.6
Control	156.0	65.0	102.6	16.0	114.6	13.9	34.2
CD (0.05)	11.1		12.98	2.3			
CV (%)	4.1	-	6.144	14.4	-	-	-

*240 counted seeds were sown in each plot

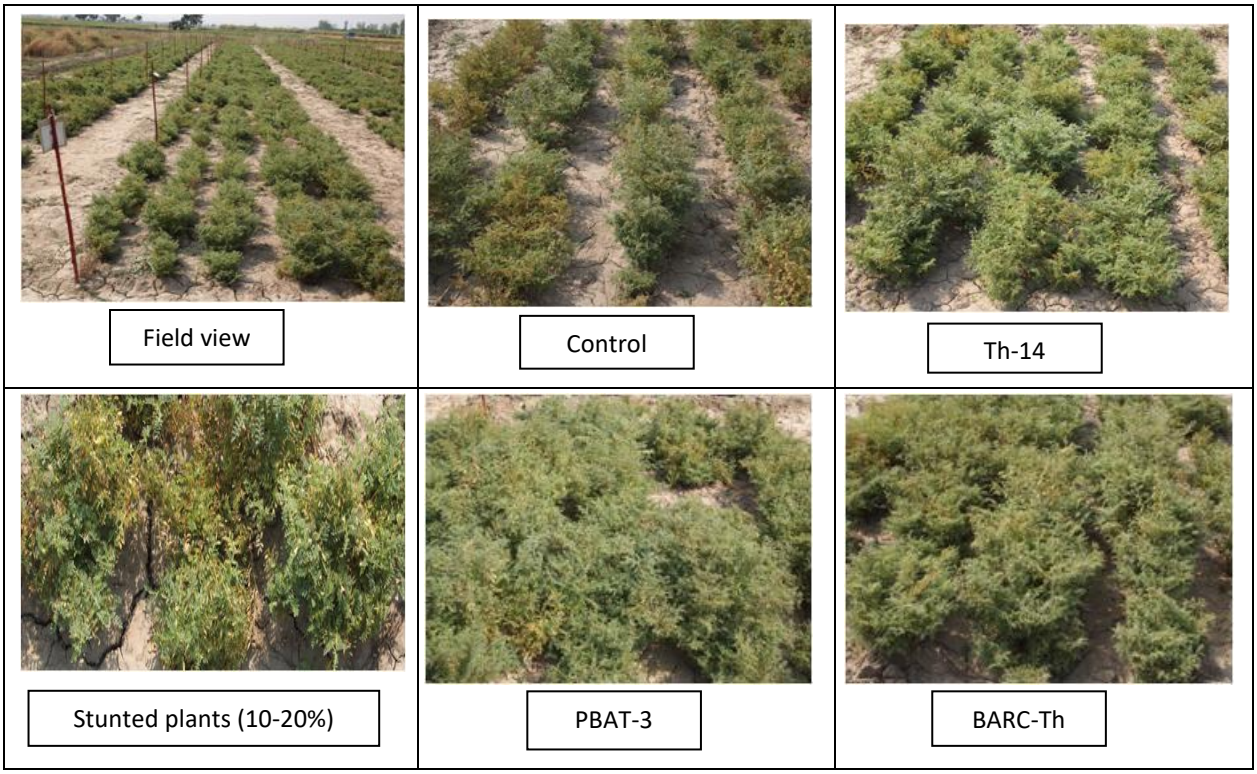


Plate 6. Efficacy of bioagents for the management of chickpea wilt complex

7. SOYBEAN

7.1. Demonstration on biological suppression of *Spodoptera litura* with *Nomuraea rileyi* in soybean (MPKV, Pune – 100 acres)

The large scale demonstration was conducted on the research farm of College of Agriculture, Pune, during *Kharif* 2017. The seeds of soybean *var*. JS- 9305 were sown at 45 x 10 cm distance in 5 x 4 m plots on 6/7/2017 on 5 ha area. The treatments comprised with need based 1-2 applications of *N. rileyi* and farmers' practice- two sprays of chlorpyriphos (0.05%) and untreated control. Two sprays were given at fortnightly interval starting from 12/8/2017. The larval population of *Spodoptera litura* was recorded in 1 m row at 5 spots per plot a day before treatment application as pre-count and post counts, a week after each spray. The data on larval population were transformed into $\sqrt{x+0.5}$ values for statistical analysis. At harvest, grain yield per plot were recorded and then converted into quintal per ha.

The results indicated from Table 64 & Fig. 14, revealed that two sprays of *N. rileyi* (2.0 x 10^8 cfu/ g) was significantly superior in suppressing the larval population of *S. litura* (2.80 larvae/m row) due to fungal infection with 16.27 q/ha yield.

Table 64. Efficacy of *N. rileyi* against *Spodoptera litura* on soybean

Treatment	Larval population/m row				Yield (MT/ha)
	Pre-count	First spray 7 DAS	Second spray 7 DAS	Average	
T1: *N. rileyi* @ 2.0 x 10^8 cfu/ g) -2.5kg/ha	5.00	3.40	2.20	2.80	16.27
T2: Farmers practice- chlorpyriphos 0.05%	4.60	3.80	3.40	3.60	15.48
T3: Untreated control	4.80	6.60	11.60	9.10	11.16
CD (p = 0.05)	NS	0.12	0.37	0.23	0.92

Fig. 14. Field photo of soybean crop treated with *Nomuraea rileyi* for biological suppression of *Spodoptera litura*

COMMERCIAL CROPS

8. COTTON

8.1 Management of pink bollworm by using *Trichogrammatoidea bactrae* in *Bt* cotton (UAS-R with NBAIR; PJTSAU)

8.1.1 UAS-R with NBAIR

Crop: Cotton
Soil: Deep Cotton soil
FYM: 10 t/ha
Variety: Laxmi Gold (PCH 5678 BG11)
Spacing: 90x60 cm
Plot size: T1: 1 Acre; T2: 1 Acre; T3: 0.25 acre

Treatments

T_1: Erection of Pheromone Traps (Funnel type) @ 10/acre; Release of *T. bactrae* @ 100000/ ha 6-8 releases from 55 DAS; Application of azadiractin 1500 ppm @ ETL
T_2: Spray of insecticides as per label claim for PBW
T_3: Control

In each treatment sucking pests were managed by recommended insecticides till 55 DAS.

T_1: Erected eight sleeve traps to monitor moth activity; Release of *T. bactrae* at weekly interval on 04.10.2017, 12.10.2017, 19.10.2017, 26.10.2017, 02.11.2017, 09.11.2017, 16.11.2017, 23.11.2017, 30.11.2017, 07.12.2017, 14.12.2017 and 21.12.2017 @ 40000/ acre. Each trichocard were made into 12 bits and they were stapled. On last release of trichocard per cent recovery studies were made by release of sentinel cards. Two rows of maize as a border crop; Application of commercial neem @ 5 ml/lt.
T_2: Profenophos 50 EC @ 2.0 ml/lt at 70 DAS; Thiodicarb 75 wp @ 1.0 gm/lt at 90 DAS; Lamda cyhalothrin 5 EC @ 0.5 ml/lt @ 110 DAS
T_3: Control

Observations

In each block eight quadrants of size 500 sq mt were made in T_1 and T_2 while in T_3 a quadrant of size 125 sq mt was considered to record the observations. To record the larval incidence of pink bollworm 10 bolls were randomly selected and dissected to record the number of PBW larvae in each block. Per cent rosette flower were counted in each quadrant and expressed as per rosette flower. At harvest per cent locule damage was worked out in each quadrant and expressed as per cent locule damage.

The results indicated that the number of PBW larvae in T_1 and T_2 was 23.25 and 11.60 larvae per 10 bolls, respectively while in T_3 maximum of 32.85 larvae per 10 bolls were noticed. Rosette flower in T_1 (7.82 %) and T_2 (3.26 %), which differed statistically. In T_3 the per cent rosette flower was 13.64. Highest locule damage of 60.18 per cent was noticed in T_3 which was followed by T_1 and T_3 which recorded 46.38 and 20.48 per cent locule damage (Table 65).

Table 65. Management of Pink bollworm by using *Trichogrammatoidea bactrae* in *Bt* cotton ecosystem

Sl. No	Particulars	Rosette flower (%)	PBW larvae per 10 bolls	Locule damage (%)
1.	**T_1**: 1. Erection of Pheromone Traps (Funnel type) @ 10/acre 2. Release of *T. bactrae* @ 10000/ ha 6-8 releases from 55 DAS 3. Application of azadiractin 1500 ppm @ ETL	7.82 (16.24)	23.25 (4.87)	46.38 (42.92)
2.	**T_2**: 1. Profenophos 50 EC @ 2.0 ml/lt at 70 DAS 2. Thiodicarb 75 wp @ 1.0 gm/lt at 90 DAS 3. Lamda cyhalothrin 5 EC @ 0.5 ml/lt @ 110 DAS	3.26 (10.40)	11.60 (3.48)	20.48 (26.91)
3.	**T_3**: Control	13.64 (21.67)	32.85 (5.77)	60.18 (50.87)
S Em $\pm$		0.43	0.11	1.32
CD (P=0.05)		1.29	0.34	3.96

Figures in parentheses are square root transformed values; *Figures in parentheses are arcsine transformed values

8.1.2 PJTSAU, Hyderabad

Observations:

- No. of healthy open bolls and infested open bolls (at least 100 balls were observed @ five observations/plot) along with number of pink bollworm larvae.
- About 20 green bolls from 20 random plants were dissected once a week from mid-October to mid-December at economic threshold level of 10% damage with live pink bollworm larvae and/or 8 pink bollworm moths per pheromone trap per 3 consecutive nights in at least 2 traps per field.
- No. of eggs were recorded & no. of parasitized eggs (around 20-50 eggs were collected in each observation) were observed.
- Yield at harvest was recorded.

Outcome of the collected data:

The package with erection of pheromone traps (Funnel type) @ 10 per acre followed by Application of Azadirachtin 1500 ppm @ 5ml/l at ETL was better than Insecticidal usage.

8.2 Evaluation of entomofungal agents and botanicals for the management of sucking pests in cotton [PAU – 2nd year (whitefly); PJTSAU & MPKV (for all sucking pests)]

8.2.1 PAU, Ludhiana

Field experiment was conducted during *Kharif*, 2017 at farmer's field in village Khuban (Block Abohar), district Fazilka, Punjab to test the efficacy of different biopesticides against cotton whitefly. A randomized block design was used in the experiments, with a plot size of 25 m^2. The cotton variety RCH 650 BG II was sown with inter and intra row spacing of 67.5 x 75 cm. There were 15 treatments in total, each with three replications. The treatments included application of Myco-Jaal (*Beauveria bassiana*) @ 2000, 2500 and 3000 ml/ha, Varunastra (*Lecanicillium lecanii*) @ 2000, 2500 and 3000 ml/ha, Kalichakra (*Metarhizium anisopliae*) @ 2000, 2500 and 3000 g/ha, Econeem plus 1% (Azadirachtin 10000 ppm) @ 1000, 1250 and 1500 ml/ha, Oberon 240 SC (spiromesifen) @ 500 ml/ha, Polo 50 WP (diafenthiuron) @ 500 g/ha and untreated control. Two sprays of biopesticides were applied using standard 250 litres of water per ha. Water spray was used for the untreated control. The observations on population of whitefly adults from 3 leaves (top, middle and lower canopy) of 5 randomly selected plants in each plot were recorded before spray, 7 and 10 days after spray. The seed cotton yield was recorded on whole plot basis.

All the treatments were significantly better than untreated control in reducing the incidence of whitefly in cotton (Table 66). After 1st spray, significantly lower incidence was recorded in diafenthiuron 50 WP (4.67 and 6.55 adults/ 3 leaves at 7 and 10 DAS, respectively). It was at par with spiromesifen 240 SC, wherein incidence was 5.22 and 6.45 adults/ 3 leaves at 7 and 10 DAS, respectively. Among biopesticides/botanicals, Econeem plus 1% (azadirachtin 10000 ppm) @ 1500 ml/ha recorded significantly lower incidence and it was at par with Econeem plus 1% (azadirachtin 10000 ppm) @ 1250 ml/ha and 1000 ml/ha. Higher doses of *L. lecanii* @ 2500 ml/ha and 3000 ml/ha were at par with each other in reducting the whitefly population. Maximum incidence (22.78 and 24.00 adults/ 3 leaves at 7 and 10 DAS, respectively) was recorded in untreated control.

Similar trend was observed after 2nd spray. Among biopesticides/botanicals, Econeem plus 1% (azadirachtin 10000 ppm) 1000, 1250 and 1500 ml/ha (10.60 to 11.45 adults/ 3 leaves at 7 and 10 DAS) was significantly better than other treatments. *L. lecanii* @ 2500 and 3000 ml/ha (12.22 to 12.67 adults/ 3 leaves) were also effective in reducing whitefly. Highest incidence of 21.67 and 18.33 adults/ 3 leaves was recorded in control plots at 7 and 10 DAS, respectively. Significantly higher yield was recorded in diafenthiuron 50 WP (24.70 q/ha) which was at par with spiromesifen 240 SC (24.34 q/ha). Among biopesticides/botanicals, Econeem plus 1% (22.71-22.92 q/ha) and *L. lecanii* (19.37-21.48 q/ha) were resulted in higher yields. Lowest seed cotton yield was recorded in untreated control (18.48 q/ha).

Table 66. Field evaluation of biopesticides against cotton whitefly at village *Khuban* during 2017

Treatment	Dose (g or ml/ha)	Whitefly population/ 3 leaves					Seed cotton yield (q/ha)
		Before spray	After 1st spray		After 2nd spray		
			7 DAS	10 DAS	7 DAS	10 DAS	
Beauveria bassiana	2000	22.03	19.81 (4.56)	21.73 (4.77)	19.75 (4.55)	17.23 (4.27)	19.02
	2500	22.36	19.67 (4.54)	21.44 (4.73)	19.37 (4.51)	17.10 (4.25)	19.18
	3000	22.97	19.32 (4.50)	20.81 (4.66)	19.26 (4.50)	16.69 (4.20)	19.22
Lecanicillium lecanii	2000	22.56	19.00 (4.47)	20.55 (4.64)	17.67 (4.32)	15.67 (4.08)	19.37
	2500	21.67	15.33 (4.04)	17.22 (4.27)	14.33 (3.91)	12.67 (3.69)	21.11
	3000	22.44	14.78 (3.97)	16.44 (4.17)	13.67 (3.83)	12.22 (3.63)	21.48
Metarhizium anisopliae	2000	22.18	19.75 (4.55)	21.38 (4.73)	19.01 (4.47)	17.08 (4.25)	9.14
	2500	21.75	19.42 (4.52)	20.76 (4.66)	17.74 (4.33)	16.77 (4.21)	19.31
	3000	22.79	19.09 (4.48)	20.41 (4.62)	17.52 (4.30)	16.61 (4.19)	19.44
Econeem plus 1% (Azadirachtin 10000 ppm)	1000	23.89	13.33 (3.78)	14.78 (3.97)	11.45 (3.53)	11.11 (3.48)	22.71
	1250	22.13	13.67 (3.82)	14.43 (3.93)	11.20 (3.49)	10.72 (3.42)	22.80
	1500	22.51	13.51 (3.80)	14.30 (3.91)	11.09 (3.48)	10.60 (3.40)	22.92
Spiromesifen 240 SC	500	21.78	5.22 (2.47)	6.45 (2.72)	3.55 (2.12)	4.22 (2.27)	24.34
Diafenthiuron 50 WP	500	23.44	4.67 (2.36)	6.55 (2.74)	3.22 (2.04)	3.89 (2.20)	24.70
Untreated Control	-	20.89	22.78 (4.87)	24.00 (5.00)	21.67 (4.76)	18.33 (4.39)	18.48
CD (p=0.05)		NS	(0.12)	(0.10)	(0.09)	(0.08)	0.49

8.2.2 MPKV, Pune

The *Bt* cotton var. Ajab, Bollgard II was raised separately on the Research Farm of Agril. Entomology Section, College of Agriculture, Pune, 90 x 60 cm, 48 x 30 m, RBD, 6/4, 13/07/2017. Three sprays of biopesticides and chemical insecticide were given at fortnightly interval on 11/09/2017, 25/09/2017 and 10/10/2017.The sucking pests were recorded on 5 plants per plot from each treatment per plot in three replicates before treatment as pre-count and post counts were taken 10 days after each spray. Seed cotton yield per plot will be recorded and converted into q/ha.

It is revealed from Table 67 & Plate 7 that amongst the biopesticides with *Lecanicillum lecanii* (1 x 10^8conidia /g) @ 5 g/litre recorded lowest population of sucking pests, *viz.*, aphids (6.68), jassids (2.48), thrips (2.82), and white flies (1.81) on 3 leaves per plant compared to the untreated control which recorded aphids (40.38) , jassids (12.21),

thrips (32.68), and white flies (10.67) on 3 leaves per plant. The *Lecanicillum lecanii* (1 x 10^8conidia /g) @ 5 g/litre recorded seed cotton yield 17.85 q/ha which is at par with dimethoate 0.05 per cent (18.56 q/ha).

Table 67. Incidence of sucking pests in *Bt* cotton

Treatment	Av. population / 3 leaves / plant								Yield q/ha
	Aphids		Jassids		Thrips		White flies		
	Pre-count	Post count	Pre-count	Post count	Pre-count	Post count	Pre-count	Post count	
T1: *M. anisopliae* (1x 10^8conidia /g) @ 5 g/lit.	25.64[a]	8.77[b]	6.85[a]	2.93[b]	15.16[a]	3.51[b]	4.20[a]	2.21[b]	15.92[b]
T2: *L. lecanii* (1 x 10^8conidia /g) @ 5 g/lit.	25.19[a]	6.68[b]	6.96[a]	2.48[b]	14.84[a]	2.82[b]	4.24[a]	1.81[b]	17.85[a]
T3: *B. bassiana* (1 x 10^8conidia /g) @ 5 g/lit.	26.53[a]	12.82[c]	7.27[a]	4.59[c]	14.78[a]	5.36[c]	4.35[a]	3.48[d]	14.28[c]
T4:Azadirachtin 1500 ppm @ 2 ml/lit	25.67[a]	10.20[c]	7.42[a]	3.95[c]	15.10[a]	4.65[c]	3.94[a]	2.33[c]	15.42[b]
T5: Dimethoate 0.05%	25.31[a]	4.46[a]	7.36[a]	1.43[a]	14.59[a]	2.01[a]	4.49[a]	1.19[a]	18.56[a]
T6: Untreated control	22.52[a]	40.38[d]	7.13[a]	12.21[d]	13.87[a]	32.68[d]	4.46[a]	10.67[e]	7.44[d]
SE ±	0.10	0.14	0.04	0.10	0.10	0.07	0.07	0.06	0.36
CD at 5%	NS	0.43	NS	0.30	NS	0.21	NS	0.19	1.09
CV (%)	13.86	18.11	11.04	9.16	15.07	15.58	16.05	10.42	14.86

Plate 7. Biological suppression of sap sucking pests on *Bt* cotton

8.3 Biointensive Pest Management in *Bt* cotton ecosystem (AAU-A; UAS-R)

8.3.1 AAU, Anand

Objectives: To demonstrate BIPM module in *Bt* cotton
Year of commencement: 2017-18
Location: Farmer field, Karena, Karjan Taluk, Vadodara Dist.
Area: 2 ha

Methodology and treatments:

Variety	:	*Bt* cotton Variety- NAWAB PCH-4599 (BG-II) (**Prabhat Agribiotech Limited, Hyderabad**)
Plot size	:	2 ha
Treatments	:	T1: BIPM package • Seed bio-priming with *Trichoderma harzianum* @ 10g/kg of seeds. • Maize as border crop • Pheromone traps @ 10/ha for bollworms. • Release of *Trichogrammatoidea bactrae* @ 100,000/ha (6-8 releases starting from 55th DAS or with appearance of PBW). • Application of Azadirachtin 1500 ppm @ 5 ml/ lit for sucking pests. • Spray of *Lecanicillium lecanii* (1x10^{8}) @ 5g/lit. • Spray of *Pseudomonas fluorescence* 2% solution against foliar diseases. T2: Farmers' Practice
Replications	:	Totally 8 quadrants were made of plot. Each quadrant served as one replication
Observations	:	• No. of good open bolls and bad open bolls • Number of pink bollworm larvae. • Average number of sucking pest population / 3 leaves, *viz.*, Aphids, Jassids, whiteflies and thrips were counted and recorded before spray, 3 and 7 days after spray. • Disease incidence was recorded. • Yield (q/ha) was recorded.

No significant difference was observed between BIPM package and farmers practice with regard to number of damage bolls and larvae. More number of PBW damaged bolls were recorded in the month of November 2017, *i. e*., 28.88 % infested bolls in BIPM package and 26.23% infested bolls in farmers practice block. While in case of no. of larvae, more no. of larvae were recorded from damaged bolls 10.59 and 8.68 in farmer's practices and BIPM module, respectively in the month of December.

In case of sucking pests, there was an incidence of thrips and aphid only. No whitefly and jassid infestation noticed. There was a significant difference in bioefficacy of different modules on aphid population. Farmers practice package recorded less number of

Table 68a. Effect of different modules on pink bollworm infestation in *Bt* cotton

Treatments	PBW infested bolls/100 bolls					
	September 2017	**October 2017**	**November 2017**	**December 2017**	**January 2018**	**Mean**
BIPM Package	2.39 (5.21)	4.49 (19.66)	5.92 (28.88)	4.93 (23.80)	3.60 (12.46)	4.17 (16.89)
Farmers Practice	2.15 (4.12)	4.01 (15.58)	5.17 (26.23)	4.68 (21.40)	3.25 (10.06)	3.85 (14.32)
S. Em. ±	0.14	0.14	0.15	0.11	0.17	0.061
CD at 5%	NS	0.46	NS	NS	NS	0.175
CV (%)	17.62	9.14	7.87	6.12	14.13	10.02

Note: Figures in parentheses are retransformed values; those outside are square root transformed values

Table 68b. Effect of different modules on pink bollworm infestation in *Bt* cotton

Treatments	PBW larvae in bolls/100 bolls					
	September 2017	**October 2017**	**November 2017**	**December 2017**	**January 2018**	**Mean**
BIPM Package	1.68 (2.32)	2.82 (7.45)	2.80 (7.34)	3.03 (8.68)	1.81 (2.78)	2.42 (5.36)
Farmers Practice	1.65 (2.22)	2.52 (5.85)	2.60 (6.26)	3.33 (10.59)	1.65 (2.22)	2.35 (2.02)
S. Em. ±	0.08	0.09	0.13	0.09	0.08	0.07
CD at 5%	NS	0.29	NS	0.30	NS	NS
CV (%)	13.57	9.22	13.27	7.85	12.43	11.06

Note: Figures in parentheses are retransformed values; those outside are square root transformed values

Table 69. Efficacy of different modules on aphid population in *Bt* cotton

Treatments		Aphid (No/leaf)							Pooled over sprays
		1st spray				2nd spray			
		Before spray	3rd day	7th day	Pooled	3rd day	7th day	Pooled	
T1:	BIPM package	3.41 (11.63)	3.18 (10.11)	1.65 (2.72)	2.41 (5.81)	2.87 (8.24)	1.99 (3.96)	2.43 (5.90)	2.42 (5.86)
T2:	Farmer's practice	3.51 (12.32)	2.70 (7.29)	1.98 (3.92)	2.34 (5.48)	2.49 (6.20)	1.69 (2.86)	2.09 (4.37)	2.21 (4.88)
S. Em. ± Treatment (T)		0.10	0.13	0.08	0.28	0.11	0.09	0.07	0.05
Spray (S)		-	-	-	-	-	-		0.05
Period (P)		-	-	-	0.08	-	-	0.07	0.05
T x S		-	-	-	-	-	-	-	0.18
T x P		-	-	-	0.11	-	-	0.10	0.72
S x P		-	-	-	-	-	-	-	0.72
T x S x P		-	-	-	-	-	-	-	0.10
C. D. at 5% T		NS	0.44	0.26	0.33	0.36	0.29	0.20	0.15
S		-	-	-	-	-	-	-	0.15
P		-	-	-	-	-	-	-	NS
T x S		-	-	-	-	-	-	-	NS
T x P		-	-	-	-	-	-	-	NS
S x P		-	-	-	-	-	-	-	NS
T x S x P		-	-	-	-	-	-	-	0.00
C. V. (%)		8.503	12.73	11.94	12.86	11.38	13.31	12.24	12.43

Note: Figures in parentheses are retransformed values; those outside are square root transformed values

Table 70. Efficacy of different modules on thrips population in *Bt* cotton

Treatments		Thrips (No/leaf)							Pooled over sprays
		1st spray				2nd spray			
		Before spray	3rd day	7th day	Pooled	3rd day	7th day	Pooled	
T1:	**BIPM package**	2.87 (8.24)	2.65 (7.02)	1.50 (2.25)	2.08 (4.33)	2.75 (7.56)	1.52 (2.31)	2.14 (4.58)	2.11 (4.45)
T2:	**Farmer's practice**	2.77 (4.88)	2.29 (7.67)	1.71 (5.24)	2.00 (4.00)	2.44 (5.95)	1.87 (3.50)	2.15 (4.62)	2.08 (4.33)
S. Em. ± Treatment (T)		0.11	0.11	0.05	0.20	0.09	0.08	0.24	0.04
Spray (S)		-	-	-	-	-	-	0.07	0.04
Period (P)		-	-	-	0.06	-	-	-	0.04
T x S		-	-	-	-	-	-	-	0.06
T x P		-	-	-	0.09	-	-	0.09	0.06
S x P		-	-	-	-	-	-	-	0.06
T x S x P		-	-	-	-	-	-	-	0.08
C. D. at 5% T		NS	0.36	0.20	0.26	0.31	0.28	0.27	NS
S		-	-	-	-	-	-	-	0.11
P		-	-	-	-	-	-	-	NS
T x S		-	-	-	-	-	-	-	0.00
T x P		-	-	-	-	-	-	-	NS
S x P		-	-	-	-	-	-	-	NS
T x S x P		-	-	-	-	-	-	-	NS
C. V. (%)		11.23	12.21	10.36	11.95	10.23	13.98	11.73	10.67

Note: Figures in parentheses are retransformed values; those outside are square root transformed values

aphid (4.88/leaf) compared to BIPM package (5.86 /leaf). With regard to thrips population BIPM package found equally effective as compared to farmers practice. Similar trend was observed in cotton seed yield. BIPM package recorded 22.03 q/ha cotton seed which was on par with the yield recorded in farmers practice (23.12 q/ha) (Table 68a&b, 69 to 71).

Disease incidence: Very low incidence (1-2%) of leaf reddening disease was recorded in both the modules.

Table 71. Efficacy of different modules on cotton seed yield

Treatments		**cotton seed yield (q/ha)**
T1:	BIPM package	22.03
T2:	Farmer's practice	23.12
S. Em. ±		0.80
C. D. at 5%		NS
C. V. (%)		10.05

8.3.2 UAS, Raichur

Crop: Cotton
Soil: Deep cotton soil
FYM: 10 t/ha
Variety: Laxmi Gold (PCH 5678 BG11)
Fertilizers: 150: 75: 75 NPK kg/ha
Plot size: T1: 1 Acre; T2: 0.25 Acre

Treatments

T_1: 1. Seed treatment with *T. harazinium* @ 10 gm/kg of seed; 2. Maize as a border crop; 3. Pheromone traps @ 10/ha; 4. Release of *T. bactrae* @ 1.0 lakh/ha 6-8 releases 55 DAG; 5. Application of Azadirachtin 1500 ppm @ 5 ml/lit; 6. Lecancillium leccani @ 1x 10^8 spores/gm @ 5 g/lit; 7. Pseudomonas fluorescenes @ 2 per cent

T_2: Famers Practice

Observations

Sucking Pests

To record the inciedence of sucking pests *Viz;* thrips, lerafhoppers, aphids and whiteflies both nymphs and adults were recorded on top three leaves and expressed as number of thrips, leafhoppers, aphids and whitefly per leaf, respectively.

Pink bollworm

Per cent rosette flower was worked out by considering number of rosette flower in five randomly selected plants in each quadrant. To record the larval population of pink bollworm 10 bolls were randomly collected, dissected and counted the number of larvae per 10 bolls. At the time of picking locule damage, good open bolls (GOB) bad open bolls (BOB) and seed cotton yield was recorded in each treatment quadrant.

Methodology

T_1: Biointensive

Erected eight sleeve traps to monitor moth activity; Release of *T. bactrae* at weekly interval on 04.10.2017, 12.10.2017, 19.10.2017, 02.11.2017, 09.11.2017, 16.11.2017 and 21.12.2017 @ 40000/ acre; Each trichocard were made into 12 bits and they were stapled; On last release of trichocard per cent recovery studies were made by release of sentinel cards; Two rows of maize as a border crop; Application of commercial neem @ 5 ml/lt.

T_2: Farmers Practice

1. Imidacloprid 17.8 SL @ 0.3 ml /l at 35 DAS; 2. Fipronil 5 SC @ 1 ml /l at 50 DAS; 3. Profenophos 50 EC @ 2.0 ml/lt at 70 DAS; 4. Thiodicarb 75 wp @ 1.0 gm/lt at 90 DAS; 5. Lamda cyhalothrin 5 EC @ 0.5 ml/lt @ 110 DAS.

Sucking pest population, *viz*., thrips, leafhoppers, aphids and whiteflies population was highest in biointensive practice which recorded (4.18, 8.84, 5.26 and 1.18/leaf). Farmer practice recorded 1.42, 2.36, 1.62 and 0.46 thrips, leafhoppers, aphids and whiteflies per leaf, respectively. Biointensive practice recorded 15.24, 26.32 and 22.86 PBW larvae, GOB and BOB, respectively. While in farmers practice it was 12.28, 31.46, and 18.64 PBW larvae, GOB and BOB, respectively. Maximum locule damage of 50.25 per cent was noticed in biointensive practice, while in farmer practice it was 30.50 per cent. Seed cotton yield was 13.75 q/ha in biointensive practice, while in farmer practice it was 16.50 q/ha (Table 72).

8.4 Habitat manipulation for the management of *Bemisia tabaci* (Gennadius) on cotton (PAU, Ludhiana)

Location : Village Khuban (Fazilka)

Treatments – 3

T_1: Bio-intensive integrated pest management (BIPM)

- Cultivation of recommended Bt cotton hybrid (RCH 650 BG II)
- Recommended time of sowing (14.5.17)
- Clean cultivation
- Growing rows of sorghum as a barrier crop around cotton fields.
- Application of recommended fertilizers
- Yellow sticky traps @ 100 per ha
- Two Augmentative releases of *Chrysoperla* sp. @ 10000/ha during last week of June and 2nd week of July
- Spray of botanicals/ microbials

➢ Azadirachtin 10000 ppm @ 1250 ml/ha

➢ *Lecanicillium lecanii* (1×10^8) @ 2500 ml/ha

➢ Azadirachtin 10000 ppm @ 1250 ml/ha

➢ *Lecanicillium lecanii* (1×10^8) @ 2500 ml/ha

A. Farmer's practice (Chemical control) – 4 sprays

Table 72. Biointensive Pest Management in *Bt* cotton during 2017-18 at Raichur

Sl. No.	Particulars	Thrips/ leaf	Leaf hoppers/ leaf	Aphids/ leaf	Whiteflies/ leaf	PBW larvae per 10 bolls	GOB /plant	BOB /plant	Locule damage (%)	Seed cotton yield (q/ha)
1.	**T_1**: 1. Seed treatment with *T. harazinium* @ 10 gm/kg of seed 2. Maize as a border crop 3. Pheromone traps @ 10/ha 4. Release of *T. bactrae* @ 1.0 lakh/ha 6-8 releases 55 DAG 5. Application of Azadirachtin 1500 ppm @ 5 ml/lit 6. Lecancillium leccani @ 1x 10^8 spores/gm @ 5 g/lit 7. Pseudomonas fluorescenes @ 2 per cent	4.18	8.84	5.26	1.18	15.24	26.32	22.86	50.25	13.75
2.	**T_2**: 1. Imidacloprid 17.8 SL @ 0.3 ml /l at 35 DAS 2. Fipronil 5 SC @ 1 ml /l at 50 DAS 3. Profenophos 50 EC @ 2.0 ml/lt at 70 DAS 4. Thiodicarb 75 wp @ 1.0 gm/lt at 90 DAS 5. Lamda cyhalothrin 5 EC @ 0.5 ml/lt @ 110 DAS	1.42	2.36	1.62	0.46	12.28	31.46	18.64	30.50	16.50
S Em $\pm$		0.18	0.31	0.26	0.04	0.13	0.15	0.21	0.43	0.36
CD (P=0.05)		0.55	0.94	0.79	0.13	0.40	0.46	0.63	1.30	1.08

Figures in parentheses are square root transformed values; *Figures in parentheses are arcsine transformed value

- Flonicamid 50 WG @ 80 g/acre
- Triazophos 40 EC @ 600 ml/acre
- Monocrotophos 36 SL @ 500 ml/acre
- Diafenthiuron 50 WP @ 200 g/acre

C. Untreated control

Plot size: BIPM - one acre; FP- one acre; Control- 100 m^2

Observations: Each plot was divided into three equal blocks representing replications
- Number of whitefly adults per 3 leaves throughout the cropping seasonat 10 days interval
- Population of predators on whole plant basis at 10 days interval
- Seed cotton yield

The seasonal abundance of whitefly population in BIPM, chemical control and untreated control has been presented in Fig. 15. Based on the mean of all observations (Table 73), the population of whitefly was 2.67 per 3 leaves in chemical control and 7.57 per 3 leaves in BIPM practices. However, both the treatments were significantly lower than untreated control (12.27/ 3 leaves). The reduction in whitefly incidence was 38.30 and 78.24 per cent in BIPM and chemical control, respectively. The predator population was more in BIPM (1.02/ plant) as compared to chemical control (0.50/ plant) and untreated control (0.84/ plant). The seed cotton yield in BIPM (23.40 q/ha) was at par with chemical control (24.60 q/ha). These yields were significantly better as compared to untreated control (22.0 q/ha). The yield increase in BIPM and chemical control was 6.36 and 11.82 per cent over untreated control, respectively.

Table 73. Effect of BIPM practices on the incidence of whitefly on cotton at village Khuban (Fazilka) during *Kharif*, 2017

Treatments	*Number of whitefly adults/ 3 leaves	Per cent reduction over control	*Number of predators / plant	Seed cotton yield (q/ha)	Per cent increase over control
BIPM	7.57^{b}	38.30	1.02^{a}	23.40^{a}	6.36
Chemical Control	2.67^{a}	78.24	0.50^{c}	24.60^{a}	11.82
Untreated control	12.27^{c}	-	0.84^{a}	22.00^{b}	-

* Mean of 9 observations recorded at 10 days interval; Predators include chrysopids, spiders and coccinellids

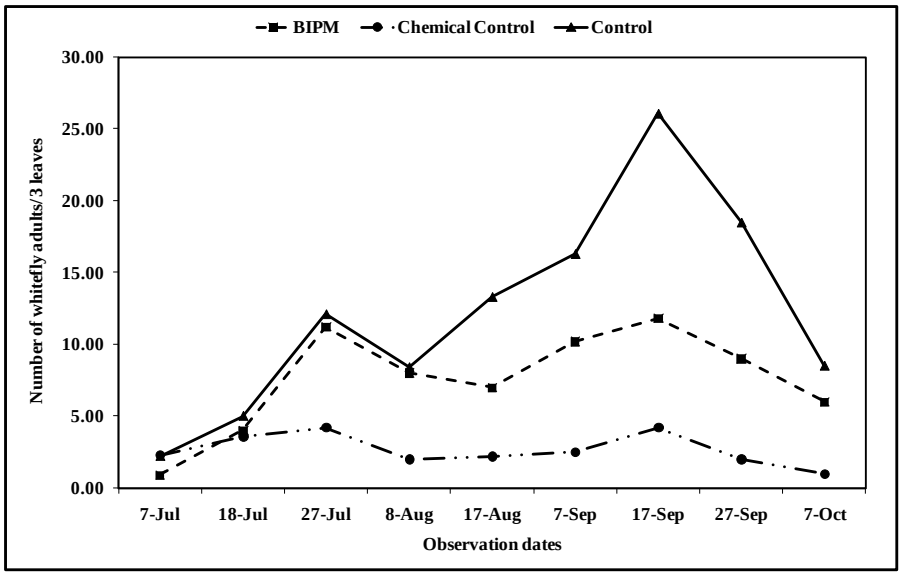


Fig. 15. Seasonal abundance of whitefly in different treatments at village Khuban (Fazilka) during *Kharif*, 2017

Pooled mean (2016 and 2017)

Based on the pooled mean of two years (2016 and 2017), the population of whitefly was 3.75 per 3 leaves in chemical control and 8.50 per 3 leaves in BIPM practices. However, both the treatments were significantly lower than untreated control (14.18/ 3 leaves). The reduction in whitefly incidence was 40.06 and 73.55 per cent in BIPM and chemical control, respectively. The predator population was more in BIPM (1.19/ plant) as compared to chemical control (0.45/ plant) and untreated control (0.91/ plant). The seed cotton yield in BIPM (23.10 q/ha) was at par with chemical control (24.15 q/ha). These yields were significantly better as compared to untreated control (21.65 q/ha). The yield increase in BIPM and chemical control was 6.70 and 11.55 per cent over untreated control, respectively (Table 74).

Table 74. Effect of BIPM practices on whitefly incidence, predators and seed cotton yield (pooled mean of 2016 and 2017)

Treatments	*Number of whitefly adults/ 3 leaves	Per cent reduction over control	*Number of predators / plant	Seed cotton yield (q/ha)	Per cent increase over control
BIPM	8.50[b]	40.06	1.19[a]	23.10[a]	6.70
Chemical Control	3.75[a]	73.55	0.45[c]	24.15[a]	11.55
Untreated control	14.18[c]	-	0.91[a]	21.65[b]	-

* Predators include chrysopids, spiders and coccinellids

9. SUGARCANE

9.1 Efficacy of entomopathogenic nematodes and entomofungus for the management of white grub in sugarcane ecosystem [ANGRAU (5 ha); UAS-R (2 ha)]

9.1.1 AUGRAU, Anakapalle

Treatments: four
T1: *Heterorhabditis indica* WP @12 kg/ha in 250 kg FYM per ha.
T2: *Metarhizium anisopliae* (NBAIR) @2.5 kg/ ha in 250 kg FYM per ha.
T3: Chemical control (Chlorantraniliprole 18.5SC @ 0.3 ml / lit)
T4: Untreated control
Time of Application: Treatments applied in furrows after the onset of monsoon

Entomopathogenic nematode, *Heterorhabditis indica* was found significantly effective in reducing white grub damage compared to entomofungus, *Metarhizium anisopliae*. Per cent reduction in plant damage due to white grub recorded high in *Heterorhabditis indica* (79.86%), *Metarhizium anisopliae* (67.74%) and chlorantraniliprole (72.91%) over untreated control. Higher yield increase was recorded in *Heterorhabditis indica* (39.1%) compared to *Metarhizium anisopliae* (35.24%) and chlorantraniliprole (36.02%) over untreated control (Table 75).

Table 75. Efficacy of entomopathogenic nematodes and entomofungus for the management of white grub in sugarcane ecosystem

Treatment	White grub damage Before Treatment (%)	White grub damage at 45 days after treatment (%)	White grub damage at 3 months after treatment (%)	White grub damage at Harvest (%)	Percent reduction in white grub damage over control	Yield t/ha	Yield increase (t/ha) over control	Sucrose %
Heterorhabditis indica WP @12 kg/ha in 150 kg sand per ha.	0.83 (1.29)	0.48 (1.18)	0.48 (1.18)	7.44 (2.55)	79.86	52.75	39.1	20.42
Metarhizium anisopliae @ 5 kg/ ha in 250 kg FYM per ha.	10.88 (3.43)	10.75 (3.41)	10.75 (3.41)	11.92 (3.56)	67.74	48.89	35.24	19.45
Chemical control (chlorantraniliprole 18.5SC @ 0.3 ml / lit)	4.14 (2.25)	4.05 (2.24)	4.05 (2.24)	10.01 (3.23)	72.91	49.67	36.02	19.43
Untreated control	12.15 (3.61)	14.33 (3.9)	26.14 (5.07)	36.95 (6.08)		13.65		16.19
CD (0.05)	0.36	0.36	0.79	1.05		5.20		1.09
CV%	13.07	12.72	25.48	26.05		12.05		5.53

Values in parentheses are angular transformed values

Entomopathogenic nematode, *Heterorhabditis indica* was found significantly effective in reducing white grub damage compared to entomofungus, *Metarhizium anisopliae* resulted in higher cane yield. Use of entomopathogenic fungi and entomopathogenic nematodes reduces the use of pesticides in turn reduces the cost of plant protection and in turn increases the economic yields.

9.1.2 UAS, Raichur

To implement the trial an area of 5 ha has been identified in Sakralli village of Hampasgar Hobli, which is prone to root grub infestation.

9.2 Large Scale Demonstration of *Trichogramma chilonis* against sugarcane borers [PAU (4000 ha); OUAT (5 ha); ANGRAU (5 ha); MPKV (5 ha); UAS-R (5 ha); PJTSAU (5 ha)]

9.2.1 PAU, Ludhiana

9.2.1.1 Large scale demonstration of proven biocontrol technologies against sugarcane stalk borer, *Chilo auricilius*

A) INCOLLABORATION WITH SUGARMILLS

Large scale demonstrations on the effectiveness of *T. chilonis* against stalk borer, *Chilo auricilius* were carried out on an area of 8260 acres in collaboration with six sugar mills of the state, *i.e*., Nawashahr Co-operative Sugar Mills Ltd. Nawanshahr (SBS Nagar), Morinda Co-operative Sugar Mills Ltd. Morinda (Roop Nagar), Nahar Sugar Mills Pvt. Ltd. Amloh (Fatehgarh Sahib), Rana Sugar Mills Ltd. Buttar Seviyan (Amritsar), Gurdaspur Cooperative Sugar Mills, Paniar (Gurdaspur) and Fazilka Cooperative Sugar Mills (Fazilka). The egg parasitoid, *T. chilonis* was released from July to October in the mill areas at 10 days interval @ 50,000/ha. The mean incidence of *C. auricilius* in IPM fields was 2.88 per cent. The corresponding figure in control (non-adopted) fields was 6.78 per cent. It can be concluded that in large-scale demonstrations, 12 releases of *T. chilonis* @ 50,000 per ha at 10 days internal during July to October reduced the incidence of stalk borer by 57.5 per cent (Table 76).

Table 76. Large-scale demonstrations of biocontrol based IPM on sugarcane in collaboration with six sugarcane mills of Punjab during 2017

Area covered (acres)	Incidence of *Chilo auricilius*		
	IPM*	Non- Adopted	Per cent reduction over control
8260	2.88	6.78	57.5

***** Twelve releases of *T. chilonis* @ 50,000 per ha at 10 days interval during July to October.

B) PAU, LUDHIANA

Large-scale demonstrations on the effectiveness of *T. chilonis* against stalk borer, *C. auricilius* were carried out on an area of 628 acres at villages Paddi Khalsa (Jalandhar), Haripur (Jalandhar), Rawalpindi (Hoshiarpur), Karni Khera (Fazilka), Khuban (Fazilka), Chachrali

(Kapurthala) and Gunike (Patiala). The parasitoid, *T. chilonis* was released 12 times at 10 days interval from July to October @ 50,000 per ha and was compared with untreated control. The incidence of stalk borer in released fields (3.3 %) was significantly lower than untreated control (8.1 %). The reduction in incidence over control was 59.3 per cent. The mean parasitism of eggs of *C. auricilius* in released fields was 48.7 per cent as compared to 4.5 percent in control (Table 77). It can be concluded that twelve releases of *T. chilonis* at 10 days interval during July to October @ 50,000 per ha were better than untreated control against stalk borer.

Table 77. Demonstrations of *T. chilonis* against *C. auricilius* by PAU, Ludhiana during 2017

Treatments	Incidence (%)	Per cent reduction over control	Per cent parasitism
T. chilonis @ 50,000 per ha*	3.3[a]	59.3	48.7[a]
Control	8.1[b]	-	4.5[b]

* 12 releases at 10 days interval

9.2.1.2 Large scale demonstrations of proven biocontrol technologies against sugarcane early shoot borer, *Chilo infuscatellus*

A) IN COLLABORATION WITH SUGAR MILLS

Large scale demonstrations on the effectiveness of *T. chilonis* against early shoot borer, *Chilo infuscatellus* were carried out on an area of 1562 acres in collaboration with three sugar mills of the state i.e. Nawashahr Co-operative Sugar Mills Ltd. Nawanshahr (SBS Nagar), Morinda Co-operative Sugar Mills Ltd. Morinda (Roop Nagar) and Nahar Sugar Mills Pvt. Ltd. Amloh (Fatehgarh Sahib). The egg parasitoid, *T. chilonis* was released during mid-April to end-June, at 10 days interval @ 50,000 per ha. The mean incidence of *C. infuscatellus* in released fields was 1.73 per cent as compared tp 3.83 per centin control (non-adopted) fields. It can be concluded that in large-scale demonstrations, eight releases of *T. chilonis* @ 50,000 per ha at 10 days interval during mid-April to end-June reduced the incidence of early shoot borer by 54.7 per cent (Table 78).

Table 78. Demonstration of *T. chilonis* against *Chilo infuscatellus* in collaboration with three sugar mills of Punjab during 2017

Area covered (acres)	Incidence of *Chilo infuscatellus*		
	IPM*	Non- Adopted	Per cent reduction over control
1562	1.73	3.83	54.7

*****Eight releases of *T. chilonis* were made @ 50,000/ha at 10 days interval during mid-April to end June.

B) PAU, LUDHIANA

Large-scale demonstrations on the effectiveness of *T. chilonis* against early shoot borer, *C. infuscatellus* were carried out on an area of 402 acres at villages Paddi Khalsa (Jalandhar), Haripur (Jalandhar), Rawalpindi (Hoshiarpur), Karni Khera (Fazilka), Khuban (Fazilka), Chachrali (Kapurthala) and Gunike (Patiala). The parasitoid, *T. chilonis* was released 8 times at 10 days interval from mid-April to mid-June @ 50,000 per ha and was compared with chemical

control, *i.e*., chlorantraniliprole (Coragen 18.5 SC) @ 375 ml/ha applied 45 days after planting and untreated control. The incidence of early shoot borer in released fields (2.81 %) and chemical control (1.02 %) was significantly better than untreated control (6.30 %). The reduction in incidence over control was 55.40 and 83.65 per cent in released fields and chemical control, respectively. The mean parasitism of eggs of *C. infuscatellus* in released fields was 42.0 per cent as compared to 4.40 percent in chemical control and 7.20 per cent in control (Table 79). The yield in control (639.5 q/ha) was significantly lower than released fields (706.2 q/ha) and chemical control (823.7 q/ha). It can be concluded that eight releases of *T. chilonis* at 10 days interval during mid-April to mid-June @ 50,000 per ha were better than untreated control, however, these were inferior to chemical control against early shoot borer. However, the cost: benefit ratio (1: 19.01) was high in biocontrol as compared to chemical control (1: 9.28) (Table 80).

Table 79. Demonstration of *T. chilonis* against *C. infuscatellus* by PAU, Ludhiana during 2017

Treatments	Incidence (%)	Per cent reduction over control	Per cent parasitism	Yield (q/ha)
T. chilonis @ 50,000 per ha*	2.81^{b}	55.40	42.0^{a}	706.2^{b}
Coragen 18.5 SC @ 375 ml/ ha	1.02^{a}	83.65	4.40^{b}	823.7^{a}
Control	6.30^{c}	-	7.20^{b}	639.5^{c}

* 8 releases at 10 days interval

Table 80. Cost Benefit analysis (2017)

Treatments	Yield (q/ha)	Additional yield over control (kg/ha)	Gross returns over control (Rs)	Cost of treatment* (Rs/ha)	Net return over control (Rs/ha)	Cost benefit ratio
T. chilonis @ 50,000 per ha	706.2	66.7	20010.00	1000.00	19010.00	1: 19.01
Coragen 18.5 SC @ 375 ml/ ha	823.7	184.2	55260.00	5375.00	49885.00	1: 9.28
Control	639.5	-	-	-	-	-

Price of sugarcane: Rs. 300/- per quintal during 2017; * includes trichocard/insecticide + labour cost; Price of Coragen 18.5 SC @ Rs. 1750/- per 150 ml

9.2.1.3 Large scale demonstration of proven biocontrol technologies against sugarcane top borer, *Scirpophaga excerptalis*

A) PAU, LUDHIANA

Large-scale demonstrations on the effectiveness of *T. japonicum* against top borer, *S. excerptalis* were carried over an area of 222 acres at villages Paddi Khalsa (Jalandhar), Haripur (Jalandhar), Rawalpindi (Hoshiarpur), Karni Khera (Fazilka), Khuban (Fazilka), Chachrali (Kapurthala) and Gunike (Patiala). The parasitoid, *T. japonicum* was released 8 times at 10 days

interval from mid-April to mid-June @ 50,000 per ha and was compared with chemical control, i.e. chlorantraniliprole (Ferterra 0.4 GR @ 25 kg/ha applied during last week of June). The egg masses of *S. excerptalis* were collected to record per cent parasitization. The incidence of top borer in release and chemical control fields was 4.70 and 2.00 per cent, respectively. However, both the treatments were significantly better than untreated control (10.20 %). The reduction in incidence over control was 53.92 and 80.39 per cent in released fields and chemical control, respectively. The mean parasitism of eggs of *S. excerptalis* in released field was 32.0 per cent as compared to 2.20 per cent in chemical control and 5.20 per cent in control (Table 81). The yield in control (619.0 q/ha) was significantly lower than release fields (687.5 q/ha) and chemical control (811.3 q/ha). It can be concluded that eight releases of *T. japonicum* at 10 days interval during mid-April to mid-June @ 50,000 per ha proved as effective as chemical control for the control of top borer. The cost benefit ratio (Table 82) was high in biocontrol (1: 19.55) as against chemical control (1: 10.96).

Table 81. Large scale demonstrations of *T. japonicum* against *Scirpophaga excerptalis* during 2017

Treatments	Incidence (%)	Per cent reduction over control	Per cent parasitism	Yield (q/ha
T. japonicum @ 50,000 per ha	4.70[b]	53.92	32.0[a]	687.5[b]
Ferterra 0.4 GR @ 25 kg/ha	2.00[a]	80.39	2.20[b]	811.3[a]
Control	10.20[c]	-	5.20[b]	619.0[c]

*8 releases at 10 days interval

Table 82. Cost Benefit analysis (2017)

Treatments	Yield (q/ha)	Additional yield over control (kg/ha)	Gross returns over control (Rs)	Cost of treatment* (Rs/ha)	Net return over control (Rs/ha)	Cost benefit ratio
T. japonicum @ 50,000 per ha	687.5	68.5	20550.00	1000.00	19550.00	1: 19.55
Ferterra 0.4 GR @ 25 kg/ha	811.3	192.3	57690.00	4825.00	52865.00	1:10.96
Control	619.0	-	-	-	-	-

Price of sugarcane: Rs. 300/- per quintal during 2017; * include trichocard/insecticide + labour cost; Price of Ferterra 0.4 GR @ Rs 185/ kg

9.2.2 OUAT, Bhubaneswar

Area covered: 5ha of sugarcane (87A-298)
Location: Gogal village of Dharmasala block in Jajpur District.
No. of beneficiaries: 7

Treatments

T1: Release of *Trichogramma chilonis* (temperature tolerant strain)@ 50,000/ha at 10 days interval starting from 45 days after sowing against early shoot borer (ESB). Release of *T. Japonicum* will be made against top shoot borer (TSB) at 10 days interval soon after its appearance.

T2: Farmers practice (spraying of mixed insecticides like profenophos 40% + cypermethrin 4%, chlorpyriphos 50% + cypermethrin 5% and Triazophos 35 + Delta methrin 1% each at 3ml/l)

T3: Untreated control

Replications: 8

Plot size: 10mx10m

The crop was sown in first week of December 2017. First release of *T. chilonis* was done in the month of February 2018 @ 50,000/ha at 10 days interval against ESB and compared with chemical spay and untreated control. Control of early shoot borer (6.14 -8.17% DH) due to parasitoid release was comparable to chemical spray (5.47-6.89% DH), but significantly higher infestation (16.33-27.34%) was recorded in untreated control (Table 83).

Table 83. Effect of *Trichogramma* sp. on ESB in sugarcane

Treatments	DH (%)	
	February 2018	March 2018
Release of *Trichogramma chilonis* @ 50,000/ ha at 10 days interval	6.14	8.17
Farmers practice (Pesticide application)	5.47	6.89
Untreated control	16.33	27.34

9.2.3 ANGRAU, Anakapalle

Treatments: Two

T1: Releases of *T. chilonis* (temperature tolerant strain of *T. chilonis* should be released) @50,000/ha at weekly intervals 8-10 releases from 30 days after planting/ rationing for early shoot borer and at node formation against internode borer.

T2: Farmers' practice (Four insecticide sprays with chlorpyriphos @ 2.5 ml/lt from 30 days after planting at 7-10 day interval).

Large scale demonstration using temperature tolerant strain *T. chilonis* was conducted in 10 acre area of 6 plots (six farmers) in 4 villages, *i.e.*, Govindapuram, Ramavaram, G. Rangampeta, Virava, Jaggampeta mandal, East Godavari district, Navbharath ventures (Sugar division) operational area, Samalkota. Conducted field releases of temperature tolerant strain of *T. chilonis* @ 50,000/ha at weekly interval from 30 days after planting against early shoot borer, 8 releases (5 releases in may and 3 releases in june) and 4 releases from node formation during july,august against internode borer. Farmer's fields: Cumulative incidence of early shoot borer incidence was low (4.51 to 12.65 % DH) in temperature tolerant strain *T. chilonis* release – 8 +4 times compared to farmer's practice of Chlorpyriphos sprays four times (21.66 % DH) in farmers fields (Table 84) .Yield data in demonstrations plots of farmers fields will be recorded at

harvest during april, 2018. Early shoot borer incidence upto 120 days (3.42 % DH) and internode borer incidence (3.02%) and internode borer intensity (20.73 %) recorded low in temperature tolerant strain *T. chilonis* release (8+4 times) in march ratoon crop resulted in high cane yield (84.47t/ha) and sucrose (20.01%) (Table 85). Temperature tolerant strain *T. chilonis* release (8+4 times) in may plant crop showed low incidence of early shoot borer incidence upto 120 days (9.99 %DH compared to Chlorpyriphos- 4 sprays (21.12%DH). Internode borer incidence (22.92%) and internode borer intensity (1.88%) recorded low in temperature tolerant strain *T. chilonis* release with higher cane yield (47.9 t /ha) compared to farmers' practice (39.8 % INB incidence & 2.66% INB internsity) with cane yield of 42.02 t/ha (Table 86).

Promotion of temparature tolerant strain of *Trichogramma chilonis* through large scale frontline demonstrations against early shoot borer and internode borer in sugarcane improve the efficiency of biocontol technology in high temperature conditions and reduce the cost on plant protection. This trial helps in effective management of early shoot borer (*Chilo infuscatellus*) and internode borer (*Chilo infuscatellus*; *Chilo sacchariphagus indicus*) utilizing for the benefit of farming community temparature tolerant strain of *Trichogramma chilonis*.

Table 84. Efficacy of temperature tolerant *Trichogramma chilonis* against Sugarcane borers in farmers fields

Treatment	Location	Cumulative ESB %DH
T1	*G.Rangampeta,* Jaggampeta mandal	11.4
T2	*G.Rangampeta, Jaggampeta mandal*	21.66
T1	Govindapauram, Jaggampeta mandal	1.44
T2	Govindapauram, Jaggampeta mandal	8.93
T1	Govindapauram, Jaggampeta mandal	1.95
T1	Ramavaram, Jaggampeta mandal	12.65
T1	Virava, Jaggampeta mandal	4.51
T1	Ramavaram, Jaggampeta mandal	6.94

Table 85. Efficacy of temperature tolerant *Trichogramma chilonis* against Sugarcane borers in March ratoon crop

Treatment	Cumulative ESB %DH	INB incidence %	INB intensity %	INB index	Cane yield t/ha	Sucrose %
Temperature tolerant *Trichogramma chilonis* (8+4 releases) in March ratoon crop 2000A56	3.42	3.02	20.73	0.63	84.47	20.01

Table 86. Efficacy of temperature tolerant *Trichogramma chilonis* against Sugarcane borers in May plant crop

Treatments	ESB % DH 35 DAP	ESB % DH 60 DAP	ESB % DH 90 DAP	ESB % DH 120 DAP	Cumulative ESB % DH	INB incidence %	INB intensity %	INB index	Cane yield t/ha	Sucrose %	Incremental benefit cost ratio
Temperature tolerant *Trichogramma chilonis* (8+4 releases) in May plant crop 2009A107	5.17	4.04	0.75	0.023 (1.01)	9.99	22.92	1.88	0.43	47.9	16.1	57.49
Farmers' practice- Four insecticide sprays with chlorpyriphos @ 2.5 ml/lt	8.31	9.72	2.5	0.086 (1.04)	21.12	39.58	2.66	1.05	42.02	16.07	2.13
t-test	*	*	*		*	*	*			NS	
t cal	-5.12	-8.94	-6.66	-1.84	-11.69	-1.923	-1.312			0.12	
t table (0.05)	2.03	2.03	2.11	2.11	2.11	2.074	2.074			2.03	

ESB- Early shoot borer; INB – Internode borer ; DH – Dead heart

9.2.4 MPKV, Pune

The large scale demonstration on biological suppression of borer complex in sugarcane was carried out. The effectiveness of *T. chilonis* TTS against ESB in sugarcane was conducted on the farm of Agronomy, College of Agriculture, Pune. Planting of sugarcane cv. Co 265 @ 25,000 setts/ha was done on 21/01/2017 over 5.0 ha with at 90 x 30 cm plant spacing. Nucleus culture of the parasitoid was obtained from the NBAIR, Bangalore and mass cultured in the Biocontrol laboratory. The treatments comprised eight releases of *T. chilonis* TTS @ 50,000 adults/ha at weekly interval, farmers' practice- three sprays of chlorpyriphos 0.05% and untreated control. A control plot maintained at 200 m distance from parasitoid released plot. Each treatment plot divided into 10 subplots as replicates. Release of parasitoids started from 05/3/2017. The pre-release observations on infestation of ESB (% dead hearts) and number of tillers per clump were recorded at 15 spots in each subplot. Similarly, post counts of dead hearts and number of tillers at each spot were recorded at 15 days interval from initiation of parasitoids' release up to 4 months old crop. Yield was recorded on per plot basis and converted into MT per ha. Data on per cent dead hearts and number of tillers per clump transformed to arcsin and $\sqrt{x+0.5}$ values respectively, before statistical analysis.

The results in Table 87 indicated that eight releases of *T. chilonis* TTS @ 50,000 parasitoids/ha at weekly interval starting from 45 days after emergence of shoots found significantly superior to untreated control in reducing the ESB infestation (from 14.00 to 5.90 % dead hearts) and increased number of tillers (10.9 tillers/clump) as well as cane yield (139.25 MT/ha). It was, however, statistically comparable with chemical control.

Table 87. Efficacy of *T. chilonis* TTS against ESB on sugarcane

Treatment	Dead hearts (%)		No. of tillers/clump		Yield
	Pre-count	Post count	Pre-count	Post count	(MT/ha)
T1: *T. chilonis* @ 50,000 parasitoids/ha	13.96	5.89	8.48	10.91	139.25
T2: Farmers practice- chlorpyriphos 0.05%	14.13	6.26	7.96	9.38	137.84
T3: Untreated control	13.78	21.83	7.61	5.76	123.42
CD (p = 0.05)	NS	1.27	NS	0.29	2.32

*****In Maharashtra among the borer complex only early shoot borer is a pre-dominant pest in sugarcane ecosystem.

9.2.5 UAS, Raichur

The trial is implemented in two location namely Hagaribommanhalli taluk of Bellari district (Area: 25 acre) and Mudhol taluk of Vijaypur district (Area: 10 acre). Totally 4 release were made and observation is in progress.

9.2.6 PJTSAU, Hyderabad

T1: Six releases of *T. chilonis* (temperature tolerant strain of *T. chilonis* was released) @ 50,000/ha at weekly intervals.

T2: Farmers' practice (as per sprays recommended insecticide)

Replications:
Divide Each block was divided into 5 equal sized units (each unit was considered as one replication)

Methodology and observations:

- Pre-release infestation, *i.e.*, per cent dead hearts / water shoots due to ESB and other borers
- Post-release count of percent dead hearts at monthly interval from initiation of parasitoid release up to 4 months
- Cane yield data
- Number of millable canes, juice quality
- Incremental benefit cost ratio recorded at harvest

.

Status of the trial:

The trial is in field. The outcome of the experiment will be submitted within week after processing and analyzing of data recorded.

OILSEEDS

10. MUSTARD

10.1 Bio-efficacy of entomopathogenic fungus against mustard aphid (AAU-J; OUAT; AAU-A; PAU)

10.1.1 AAU, Jorhat

Location:	ICR Farm, AAU, Jorhat
Target pests:	*Lipaphis erysimi*
Plot Size:	5m x 5.5 m
Variety:	TS-36
Replication:	4 RBD
Treatment:	6
Date of planting:	06.11.2017
Fertilizer dose:	120:60:60 kg N: P: K/ ha

Treatments:

T1:*Beauveria bassiana* (AAU-J Culture) @1X10^8 conidia/g – 5 g/lit
T2: *Metarhizium anisopliae* (AAU-J Culture) @1X10^8 conidia/g – 5 g/lit
T3*: Lecanicillium lecanii* (AAU – J Culture) @1X10^8 conidia/g – 5 g/lit
T4: *Lecanicillium lecanii* (NBAIR Culture) @1X10^8 conidia/g – 5 g/lit
T5: Azadirechtin 1500 ppm @ 2 ml/l
T6: Dimethoate 30 EC @ 0.06% (Standard check)
T7: Untreated control

The field experiment was conducted during *rabi*, 2017-18, to evaluate the efficacy of entomopathogenic fungus against mustard aphid. Four sprays of entomopathogenic fungus, neem based pesticides (Azadirechtin 1500 ppm) and chemical insecticides (dimethoate 30 EC) as standard check were made at 15 days interval starting from 25 DAS. Observations on aphid population on 10 cm apical shoots per plant from 10 randomly selected plants of each plot were recorded 1 (one) day before and at 3, 7 and 10 days after each treatment application. The harvesting was done on 8.02.2018. Yield data was recorded per plot basis and converted into quintal/ha.

The results in the table 88 & Plate 8 showed that significantly less incidence of aphid was registered in all the treated plots over untreated control. While comparing the significance of differences among the treatment means, it was observed that three spraying of dimethoate 30 EC @ 2ml/lit at 15 days interval found significantly superior in suppressing the aphid population (4.41 per 10 cm apical shoot) over other treatments with highest yield of 8.09q/ha. Amongst the entomopathogenic fungus, *Beauveria bassiana* (AAU-J culture) @ 5g/lit was the next best treatment (8.72 per 10 cm apical shoot) with next higher yield of 7.85 q/ha. It was, however at par with *Lecanicillium lecanii*(AAU-J culture) @ 5g/lit in their efficacy in respect of mean population of aphid (10.05 per 10 cm of apical shoot) and yield (7.83 q/ha) The treatment with Azadirachtin 1500 ppm @ 2 ml/lit was also statistically at par in respect of mean aphid population(12.40 per 10 cm apical shoot) with different entomopathogenic fungus.

However, the insecticidal check treatment, dimethoate 30 EC @ 2ml/lit brought about maximum mean percent reduction of aphid population (84.70) followed by *Beauveria bassiana* (AAU-J culture) @ 5g/lit with 69.75 per cent over untreated control.

Table 88. Evaluation of different entomopathogenic fungi against mustard aphid, *Lipaphis erysimi*

Treatments	Pre treatment count	Post treatment count *			Mean of 3 sprays	Reduction over control (%)	Yield (q/ha)
		Ist spray	IInd spray	IIIrd spray			
T1: *Beauveria bassiana* (AAU-J Culture) 10^8 @ 5g/l	25.75	12.40^{b}	8.55^{b}	5.20^{b}	8.72^{b}	69.75	7.85^{d}
T2: *Metarhizium anisopliae* (AAU-J Culture)10^8 @ 5g/l	25.85	12.65^{b}	12.30^{b}	8.20^{d}	11.05^{b}	61.67	6.68^{b}
T3: *Lecanicillium lecanii* (AAU – J Culture)10^8 @ 5g/l	24.75	14.20^{c}	10.35^{bcd}	6.35^{c}	10.30^{b}	64.27	7.65^{cd}
T4: *Lecanicillium lecanii* (NBAIR Culture)10^8 @ 5g/l	23.95	13.85^{bc}	10.10^{bc}	6.20^{bc}	10.05^{b}	65.14	7.83^{d}
T5: Azadirechtin 1500 ppm @ 2 ml/l	24.35	15.00^{c}	12.20^{cd}	10.0^{e}	12.40^{b}	56.98	7.28^{c}
T6: Dimethoate 30 EC @ 2 ml/l	24.95	8.30^{a}	5.80^{a}	3.55^{a}	4.41^{a}	84.70	8.09^{d}
T7: Untreated control	24.85	25.70^{d}	31.60^{e}	29.20^{f}	28.83^{c}	-	5.13^{a}
CD =0.05	NS	1.51	2.15	1.58	3.88		0.52
CV %		6.96	11.14	10.83	17.52		4.82

Mean of three observations; means followed by the same letter in a column are not significantly different

Plate 8. View of Expeimental Plot of mustard

10.1.2 OUAT, Bhubaneswar

Variety: NRCHB-101
Design: RBD
Plot size: 8m x 5m

Treatments
T1: *Beauveria bassiana* (Agrizone, Tamil Nadu) @1x10⁸ spores/g – 5ml/l
T2: *Metarrhizium anisopliae* (Agrizone, Tamil Nadu) @ $1x10^8$ spores/g - 5ml /l
T3: *Lecanicillium lecanii* (Agrizone, Tamil Nadu) @ $1x10^8$ spores/g- 5g/l
T4: *Lecanicillium lecanii* (NBAIR) @ $1x10^8$ spores/g- 5g/l
T5: Azadirachtin 1500ppm @ 2ml/l
T6: Imidacloprid 17.8 SL @ 3ml /10l
T7: Untreated control

No of replications: 4
Date of sowing: 07.11.2017
Spacing: 30cmx10cm
Fertilizer dose: N.P.K: 65:30:30 kg/ha
Manuring: 10 tonnes/ha

Spraying dates:
First: 12.12 2017
Second: 03.01.2018
Third: 20.01.2018

Date of harvesting: 19.2.2018

Aphid populations were recorded on 5cm apical twig per plant from 5 randomly selected plants per plot from each treatment one day before and 7 days after spraying. Seed yield was recorded from each plot after harvest of the crop. The data obtained were transferred wherever necessary and analysed statistically. Finally, the B:C ratio was determined.

It is evident from Table 3 that, all the biopesticides including the chemical check significantly reduced the aphid population as compared to the untreated check. Highest reduction in aphid population was noticed in imidacloprid followed by azadirachtin 1500 ppm. Among the tested fungal biopesticides, *Lecanicillium Lecanii* both Tamil Nadu and NBAIR cultures significantly reduced the aphid population as compared to other two cultures. Significantly highest yield was recorded in imidacloprid treated plots followed by azadirachtin. The yield in *L. lecanii* treated plots remained at par with azadirachtin. Similar trend in B: C ratio was also noted in different treatments (Table 89).

10.1.3 AAU, Anand

Location: Agronomy farm, BACA, AAU, Anand
Year of commencement: 2016-17
Experiment year: 2017-18; **Date of sowing:** 12-11-2017; **NPK**: 100-50-0

Table 89. Effect of biopesticides on aphid population and yield of mustard during *rabi* 2017-18 in Bhubaneswar

Treatments	Dose	Aphid population/ 5cm twig						Yield (q/ha)	B:C ratio
		1DBFS	7DAFS	1DBSS	7DASS	1DBTS	7DATS		
T_1: *Beauveria bassiana* $1x10^8$ spores/g (Tamil Nadu culture)	5ml/l	12.90 (3.66)	6.90 (2.72)	27.30 (5.27)	16.23 (4.09)	33.40 (5.82)	14.30 (3.85)	5.83	1.30
T_2: *Metarrhizium anisopliae* $1x10^8$ spores/g (Tamil Nadu culture)	5ml/l	12.80 (3.64)	3.20 (1.91)	22.81 (4.83)	10.81 (3.36)	30.41 (5.56)	12.03 (3.53)	6.76	1.38
T_3: *Lecanicillium lecanii* $2X10^8$ spores/g (Tamil Nadu culture)	5ml/l	11.30 (3.43)	2.43 (1.72)	17.21 (4.20)	10.20 (3.27)	26.61 (5.20)	10.60 (3.32)	7.40	1.47
T_4: *L. lecanii* $1X10^8$ spores/g (NBAIR culture)	5g/l	12.87 (3.66)	1.20 (1.30)	20.01 (4.53)	9.21 (3.11)	24.30 (4.98)	8.67 (3.03)	7.45	1.59
T_5: Azadirachtin 1500 ppm	2ml/l	11.50 (3.46)	1.57 (1.44)	9.62 (3.18)	2.01 (1.58)	13.30 (3.71)	2.17 (1.63)	7.47	1.64
T_6: Imidacloprid 17.8 SL	3ml/10l	12.67 (3.58)	0.87 (1.16)	5.01 (2.34)	0.07 (0.75)	8.30 (2.96)	0.30 (0.89)	8.66	1.75
T_7: Untreated control	-	11.97 (3.53)	15.03 (13.94)	29.93 (5.52)	34.30 (5.90)	46.41 (6.85)	58.70 (7.69)	5.54	1.12
S.E. (m) ±	-	- (0.09)	- (0.07)	- (0.07)	- (0.06)	- (0.06)	- (0.10)	0.11	
C.D. (0.05)	-	- (0.28)	- (0.20)	- (0.22)	- (0.19)	- (0.19)	- (0.30)	0.34	
C.V. (%)	-	4.66	5.93	2.92	3.51	2.11	5.02		

Experimental details:

1. Treatments : 8
2. Replication : 3
3. Design : Randomized Block Design (RBD)
4. Crop / variety : GM 1
5. Plot size : 5 X 6 m
6. Spacing : 45 x 15 cm

Details of treatments

T_1 : *Metarhizium anisopliae*@ 5 g/ liter ($2x10^8$cfu g^{-1})

T_2 : *Lecancillium lecanii*@ 5 g/ liter ($2x10^8$cfu g^{-1})

T_3 : *Beauveria bassiana*@ 5g/ liter ($2x10^8$cfu g^{-1})

T_4 : NSKE @ 5% suspension

T_5 : *L.lecanii* + *M.anisopliae*@5g/ liter ($2x10^8$cfu g^{-1})

T_6 : *B.bassiana* + *L.lecanii*@ 5g/ liter ($2x10^8$cfu g^{-1})

T_7 : Dimethoate 30 EC @ 0.06% chemical control

T_8 : Control (water spray)

Methodology:

Treatments application was started at initiation of aphid infestation. All the three sprays were given at fortnightly interval in the evening hours.

Observations:

1. Aphid Index Count

The aphid population was recorded on 5 randomly selected plants by following 0-5 index method as per the methodology described by Patel *et al.*, (1995).

0: Plant free from aphid infestation
1: Only few aphids with very little injury
2: Small colonies on few twigs, no curling or yellowing of leaves
3: Aphid colonies on almost all the twigs, stunted growth, curling and yellowing of leaves
4: Very heavy population of aphids on inflorescence, leaves, stem and siliqua.
5: Very heavy population of aphids on inflorescence, leaves, stem and siliqua.

$$\text{Average aphid index} = \frac{0N+ 1N +2N+ 3N + 4N + 5N}{\text{Total number of plants observed}}$$

Where, 0, 1, 2, 3, 4, 5 were the aphid index

N= Number of plants showing respective aphid index.

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2. Seed yield per plot (q/ha)

The results obtained in the year 2017-18 are presented in Table 7 & 8. However, the treatment *Beauveria bassiana* + *Lecanicillium lecanii* recorded low aphid index (1.51) among the biocontrol treatments and with regard to seed yield consistent results were not recorded as compared to previous year. Low seed yield was recorded in the current year. Among the biocontrol treatments *Beauveria bassiana* + *Lecanicillium lecanii* recorded the highest seed yield (4.77q/ha) (Table 90 & 91).

Table 90. Bio-efficacy of different biological control agents against mustard aphid, *Lipaphis erysimi* Kaltenbach (2017-18)

Treatments		Aphid Index Count										Pooled over periods over sprays
		BS	1st spray			2nd spray			3rd spray			
			3 DAS	7 DAS	Pooled	3 DAS	7 DAS	Pooled	3 DAS	7 DAS	Pooled	
T1	*Metarhizium anisopliae* @ 5 g /liter (2 X 10^8cfu g^{-1})	1.92 (3.19)	1.90 (3.11)	1.85 (2.92)	1.88 (3.03)	1.96 (3.34)	1.92 (3.19)	1.94 (3.26)	1.88 (3.03)	1.78 (2.67)	1.83 (2.85)	1.88 (3.03)
T2	*Lecanicillium lecanii* @ 5 g / liter(2 X 10^8cfu g^{-1})	1.92 (3.19)	1.86 (2.96)	1.78 (2.67)	1.82 (2.81)	1.94 (3.26)	1.85 (2.92)	1.89 (3.07)	1.83 (2.85)	1.72 (2.46)	1.78 (2.67)	1.83 (2.85)
T3	*Beauveria bassiana* @ 5 g/liter (2 X 10^8cfu g^{-1})	1.97 (3.38)	1.83 (2.85)	1.72 (2.46)	1.77 (2.63)	1.79 (2.70)	1.56 (1.93)	1.68 (2.32)	1.49 (1.72)	1.40 (1.46)	1.44 (1.57)	1.63 (2.16)
T4	NSKE @ 5 % suspension	1.89 (3.07)	1.82 (2.81)	1.61 (2.09)	1.71 (2.42)	1.70 (2.39)	1.55 (1.90)	1.63 (2.16)	1.44 (1.57)	1.37 (1.38)	1.40 (1.46)	1.58 (2.00)
T5	*L. lecanii + M. anisopliae* @ 5g/liter (2 X 10^8cfu g^{-1})	1.90 (3.11)	1.87 (3.00)	1.76 (2.60)	1.81 (2.78)	1.90 (3.11)	1.70 (2.39)	1.80 (2.74)	1.71 (2.42)	1.44 (1.57)	1.58 (2.00)	1.73 (2.49)
T6	*B. bassiana + L. lecanii* 5g/liter (2 X 10^8cfu g^{-1})	1.96 (3.34)	1.80 (2.74)	1.50 (1.75)	1.65 (2.22)	1.66 (2.26)	1.47 (1.66)	1.56 (1.93)	1.34 (1.30)	1.30 (1.19)	1.32 (1.24)	1.51 (1.78)
T7	Dimethoate 30 EC @ 0.06%	1.99 (3.46)	1.69 (2.36)	1.22 (0.99)	1.41 (1.49)	1.39 (1.43)	1.14 (0.80)	1.26 (1.09)	1.01 (0.52)	1.01 (0.52)	1.01 (0.52)	1.23 (1.01)
T8	Control (water spray)	1.86 (2.96)	2.18 (4.25)	2.26 (4.61)	2.22 (4.43)	2.24 (4.52)	2.23 (4.47)	2.24 (4.52)	2.27 (4.65)	2.30 (4.79)	2.29 (4.74)	2.25 (4.56)
S. Em. ±	Treatment(T)	0.08	0.08	0.09	0.06	0.08	0.09	0.06	0.11	0.08	0.06	0.05
	Period (P)	-	-	-	0.03	-	-	0.03	-	-	0.03	0.02
	Spray (S)	-	-	-	-	-	-	-	-	-	-	0.02
	T x P	-	-	-	0.08	-	-	0.08	-	-	0.10	0.05
	T x S	-	-	-	-	-	-	-	-	-	-	0.06
	S x P	-	-	-	-	-	-	-	-	-	-	0.03
	T x S x P	-	-	-	-	-	-	-	-	-	-	0.09
C. D. at 5%	T	NS	0.24	0.27	0.18	0.24	0.26	0.16	0.33	0.25	0.18	0.15
	P	-	-	-	-	-	-	-	-	-	-	0.05
	S	-	-	-	-	-	-	-	-	-	-	0.06
	T x P	-	-	-	NS	-	-	NS	-	-	NS	NS
	T x S	-	-	-	-	-	-	-	-	-	-	0.00
	S x P	-	-	-	-	-	-	-	-	-	-	NS
	T x S x P	-	-	-	-	-	-	-	-	-	-	NS
C. V. (%)		6.98	7.44	8.87	8.14	7.59	8.80	8.18	11.46	9.37	10.53	9.29

Note: Figures in parentheses are retransformed values; those outside are square root transformed values; BS: Before Spray

Table 91. Impact of biological control agents on seed yield of mustard (2017-18)

Treatments		Seed yield (q/ha)
T_1	*Metarhiziumanisopliae* @ 5 g /liter (2 X 10^8cfu g^{-1})	3.66
T_2	*Lecanicilliumlecanii* @ 5 g / liter(2 X 10^8cfu g^{-1})	3.83
T_3	*Beauveriabassiana* @ 5 g/liter (2 X 10^8cfu g^{-1})	4.17
T_4	NSKE @ 5 % suspension	4.50
T_5	*L.lecani + M.anisopliae* @ 5g/liter (2 X 10^8cfu g^{-1})	3.95
T_6	*B.bassiana + L.lecanii* @ 5g/liter (2 X 10^8cfu g^{-1})	4.77
T_7	Dimethoate 30 EC @ 0.06%	6.96
T_8	Control (water spray)	2.96
S. Em. ±		0.43
C. D. at 5%		1.32
C.V. (%)		17.32

10.1.4 PAU, Ludhiana

The field experiment to evaluate different biopesticides against *Brevicorynae brassicae* / *Lipaphis erysimi* in mustard was conducted at Entomological Research Farm PAU, Ludhiana. The seeds of the mustard (Variety- RLC - 3) were sown on November 21-22, 2017 in three blocks. Each block was further divided into sub-plots as replicates. The crop was grown as per PAU recommendations. The following biopesticides along with farmer's practice and untreated control were evaluated and the experiment is in progress.

Treatments:

T_1 - T_3: Commercial formulation of *Beauveria bassiana* (1 x 10^8) @ 8, 10 & 12 ml/litre
T_4 - T_6: Commercial formulation of *Metarhizium anisopliae* (1 x 10^8) @ 8, 10 & 12 gm/litre
T_7- T_9: Commercial formulation of *Lecanicillium lecanii* (1 x 10^8) @ 8, 10 & 12 ml/litre
T_{10}: *Beauveria bassiana* (AAU-J Culture) @1x10^8 spore/g-5g/lit
T_{11}: *Metarhizium anisopliae* (AAU-J Culture) @1X10^8 spore /g-5g/lit
T_{12}: *Lecanicillium lecanii* (AAU-J Culture) @1X10^8 spore/g -5g/lit
T_{13}: *Lecanicillium lecanii* (NBAIR) @1X10^8spore/g-5g/lit
T_{14}- T_{16}: Azadirachtin 10000ppm @ 6, 7 & 8 ml/lit
T_{17}: Azadirachtin 1500ppm @ 2ml/lit
T_{18}: Chemical control – Rogor 30EC (Dimethoate) @ 4 ml/lit
T_{19}: Untreated control (Water spray)

FRUIT CROPS

11. BANANA

11.1 Bio-efficacy of entomopathogens against banana fruit and leaf scaring beetle, *Nodostoma subcostatum* (AAU, Jorhat)

Location: Farmers' field, Dergaon, Golaghat
Target pests: Banana fruit and leaf scaring beetles, *Nodostoma subcostatum*
Plot size: 1500 m^2
Variety: Cavendis (CV- Jahaji)
Replication: 4 RBD
Plot size: 8m x7 m
Date of planting: First year ratoon crop
Fertilizer dose: 110:33:330 g N: P: K/ plant

Treatments

T1: Four spray of Neem product (Azadiractin, 1500 ppm) @ 5ml/lt at 15 days interval.
T2: Fourtime filling of Leaf axil with *Beauveria bassiana* (AAU Culture) @ 10^8 spore /5 ml at 15 days interval.
T3: Four spray of *Beauveria bassiana* (AAU Culture) @ 10^8 spore / 5 ml at 15 days interval.
T4: Bunch covering with plastic bags.
T5: Sprays Cholropyrifos20Ec @ 2.5 ml/l at 15 days interval
T6: Untreated control

Observations on mean number of scarring beetle per plant was recorded at 3 and 7 and 10 days after application of treatments by counting them on leaves including those hidden inside the crown from randomly selected 5 plants of each plot. Number of leaf scars on leaf surface was also recorded from different areas of the youngest leaves at 3, 7 and 10 days after each spray. Observations pertaining to number of infested fingers per bunch were also recorded for computing the mean per cent finger infestation. Four rounds of entomopathogenic fungi and chemical insecticides (chlorpyriphios 20EC) at their respective dosages were applied at 15 days interval.

The data on mean number of beetles per plant (Table 92) indicated that evaluation of entomopathogens (filling of leaf axil with *Beauveria bassiana* (AAU Culture) and spray of *Beauveria bassiana* (AAU Culture)), neem product (Azadirachtin 1500ppm), Chemical insecticides (chlorpyrifos 20 EC) and bunch covering with plastic bags were equally effective in reducing the leaf scarring beetle per plant in comparison to untreated control plots after 4^{th} spray. Amongst the entomopathogens, filling of leaf axil with *Beauveria bassiana* (AAU culture) @ 5ml/lit was the best treatment in reducing the population of fruit and leaf scarring beetle, *Nodostoma subcostatum* (9.10 /plant) with highest per cent reduction (47.24) over untreated control plots. The chemical insecticides, cholropyrifos 20 EC @ 2.5ml/lit was significantly at par with the plots treated with filling of leaf axil with *Beauveria bassiana* (AAU Culture)10^8 @ 5 ml/lit registering same level of beetle population (9.11/plant) and per cent reduction (47.24), respectively. However, plots treated with different treatments exhibited more or less same level of incidence to that of recommended insecticides (Cholropyrifos 20EC @ 2.5 ml/lit) (Plate 92).

More or less similar trends were followed in case of incidence of beetle on leaves also. cholopyrifos 20 EC @ 2.5 ml/l caused lowest leaf scars per 5 cm^2 leaf surfaces (9.81), which was at par with spraying of *Beauveria bassiana* (AAU culture) @ 5ml/lit and neem product (Azadirachtin 1500 ppm) @ 5ml/lit, respectively while comparing the mean number of leaf scars in different treatments after 4^{th} spray. The highest leaf scar of 14.14 per 5 cm 2 was recorded in untreated control plots (Table 93).

The mean fruit infestation by scarring beetle (Table 94) varied significantly in different treatments and recorded lower level of fruit infestation (7.94%) treated with Cholropyrifos 20EC @ 2.5 ml/l and bunch covering with plastic bag (9.98%), which were statistically at par. Maximum number of fruit infestation 37.93% was recorded at untreated check.

Table 92. Bioefficacy of entomopathogen against *Nodostoma subcostatum* (Beetles/plant)

Treatments	**Pre treatment count**	**Post treatment count***				**Mean of 3 sprays**	**Reduction over control (%)**
		Ist spray	**IInd spray**	**IIIrd spray**	**IV th spray**		
T1: Neem product (Azadiractin) @ 5ml/lt	16.85	13.77[b]	12.92 [b]	9.67 [b]	3.50 [b]	9.97 [b]	42.26
T2:Leaf axil with *Beauveria bassiana* (AAU Culture) @ 10^8 spore / ml	16.67	13.34 [b]	11.42 [a]	8.58 [a]	3.09 [b]	9.10 [b]	47.24
T3:*Beauveria bassiana* (AAU Culture) @ 10^8 spore / ml	17.34	13.83[b]	12.83 [b]	9.42 [b]	3.42 [b]	9.88 [b]	42.80
T4:Bunch covering with plastic bags	17.08	13.34 [b]	14.0 [b]	12.0 [c]	4.42 [b]	10.94 [b]	36.65
T5:Cholropyrifos20Ec @ 2.5 ml/l	16.25	12.5 [b]	11.42 [a]	9.0 [ab]	3.42 [b]	9.11 [b]	47.24
T6:Untreated control	16.42	18.24 [a]	17.0 [c]	17.83 [d]	16.0 [a]	17.27 [a]	
CD =0.05	NS	1.39	1.33	1.01	1.62	2.42	
CV %		6.52	6.64	6.06	19.04	14.55	

- Mean of three observations; means followed by the same letter in a column are not significantly different

Table 93. Bioefficacy of entomopathogen against *Nodostoma subcostatum* (nos. of scars/5m^2)

Treatments	Pre treatment count	Post treatment count *				Mean of 3 sprays	Reduction over control (%)
		Ist spray	IInd spray	IIIrd spray	IV th spray		
T1: Neem product (Azadiractin) @ 5ml/lt	8.25	11.5 [a]	13.33 [cd]	12.7[b]	9.67 [b]	11.67 [bc]	14.94
T2: Leaf axil with *Beauveria bassiana* (AAU Culture) @ 10^8 spore / ml	8.83	14.25 [b]	13.09 [cd]	13.33 [bc]	10.57 [bc]	12.71 [cd]	7.36
T3: *Beauveria bassiana* (AAU Culture) @ 10^8 spore / ml	8.42	10.92 [a]	11.67 [ab]	10.84 [a]	9.75 [b]	10.8 [ab]	21.35
T4: Bunch covering with plastic bags	8.50	11.0 [a]	12.50 [bc]	14.50 [c]	12.08 [c]	12.52 [bcd]	8.74
T5:Cholropyrifos20Ec @ 2.5 ml/l	8.25	11.25 [a]	10.75 [a]	9.75 [a]	7.50 [a]	9.81 [a]	28.50
T6: Untreated control	9.17	13.67 [b]	14.0[d]	16.50 [d]	12.42 [c]	14.14 [e]	-
CD =0.05	NS	1.73	1.20	1.72	2.06	1.78	
CV %		9.84	6.36	8.88	13.32	9.95	

- Mean of three observations; means followed by the same letter in a column are not significantly different

Table 94. Bioefficacy of entomopathogen against *Nodostoma subcostatum* (% fruit infestation)

Treatments	Mean fruit infestation (%)
T1: Neem product (Azadiractin) @ 5ml/lt	23.37 [c]
T2: Leaf axil with *Beauveria bassiana* (AAU Culture) @ 10^8 spore / ml	15.15 [b]
T3: *Beauveria bassiana* (AAU Culture) @ 10^8 spore / ml	17.42 [b]
T4: Bunch covering with plastic bags	9.98 [a]
T5: Cholropyrifos20Ec @ 2.5 ml/l	7.94 [a]
T6: Untreated control	37.93 [d]
CD =0.05	4.48
CV %	15.95

- Mean of three observations; Means followed by the same letter in a column are not significantly different

a b C

Plate 9. a) Adult of *Nodostoma subcostatum*, b) Fruit infested by the insect and c) leaf infested symptom caused by *N. subcostatum*

11.2 Field evaluation of entomopathogenic fungi against banana pseudo-stem borer *Odoiporus longicollis* (KAU)

An experiment was laid out at the Banana Research Station of Kerala Agril. University at Kannara (Fig. 4 & 5) for the field evaluation of the two entomopathogenic fungi, namely, *Metarhizium anisopliae* and *Beauveria bassiana* for the management of the banana pseudostem borer *Odoiporus longicollis*. Each fungus was applied in two different methods of application such as trunk spraying and leaf axil filling. The treatments were applied at monthly intervals starting from October 2017. The results are presented in Table 95.

Design: RBD; Treatments: 6; Replication: 3 (10 plants/replication)

Table 95. Effect of entomopathogenic fungi on infestation by banana pseudostem weevil

Treatments	Total number of plants	No. Infested plants	Mean Infestation (%)	Adjusted Mean
T1: *Metarhizium anisopliae* (10^8 spores/ ml) - leaf axil fillin	9	5	54.23	4.923
T2: *M. anisopliae* (10^8 spores/ ml) – spraying	9	6	63.33	5.807
T3: *Beauveria bassiana* (10^8 spores/ ml) - leaf axil filling	10	4	46.66	4.025
T4: *B. bassiana* (10^8 spores/ ml) – spraying	8	4	27.38	2.484
T5: Chlorpyriphos leaf axil filling	10	0	0.00	- 0.417
T6: Chlorpyriphos spraying @ 2.5 ml/l	10	0	0.00	- 0.642
T7: Untreated control	7	3	35.45	4.156
CD Value (10%)				3.904

Chloryriphos applied at 2.5 ml/l applied either as spray or leaf axil filling were the most effective treatment in controlling pseudostem weevil infestation in banana. They were significantly superior to the remaining treatments, which were on par with each other.

12. PAPAYA

12.1 Biological control of Papaya/mulberry mealybug/ complex with *Acerophagus papayae* and *Cryptolaemus montrouzieri* (TNAU; NBAIR; AAU-A)

12.1 TNAU, Coimbatore

Name of the Farmer	: Th.Manikandan
Location	: Sathyamangalam, Erode Dt.
Papaya variety	: Red Lady
Date of planting	: 15.7.2017

Treatments

T1. Releases of *Acerophagus papayae* if incidence of PMB is observed.
T2: Releases of *Cryptolaemus montrouzieri* grubs in 2nd instar @ 20 grubs / tree if incidence of other mealybugs is observed.
T3: Natural control

No. of replication- 8
Plot size: 5×8 m

Observations:
i. The incidence of various species of mealybug.
ii. Natural enemies of mealybug complex on papaya at fortnightly interval and weather factors to work out correlation**.**
Mealybug incidence as per cent incidence based on random selection of 25 plants from each orchard visited.
Pest intensity rating (1-5 scale) will be recorded from 5 plants/ orchard.
Natural enemies species-wise from two leaves/ plant and 5 plants/ orchard

Field experiment to manage papaya mealybug in papaya was carried out at farmers' field in Sathyamangalam. Release of *Acerophagus papayae* (100 No's) was done when the incidence of PMB was noticed during Dec, 2018. Initially, 1.3 to 1.4 per cent incidence was noticed. With the release of *A. papayae,* the pest incidence became nil within three months whereas in the unreleased field, the PMB incidence increased and by March, 2018, the per cent incidence was 9.3 (Table 96). Natural enemies like *A. papayae, Spalgis epius*, Spiders and *Crytoplaemus* were also recorded (Plate 10). The association of *A. papayae* and *Cryptolaemus* with papaya mealybug was more significant and these natural enemies were more prevalent during the months of December – February, where the population of mealybug was also high. The spatial and temporal distribution of parasitoids *A. papayae,* and predators like *Cryptolaemus* and *Spalgis* coincided with the population of mealybug. This might be reason for effective containment of the mealybug without severe outbreaks even in control plots.

Table 96. Biological control of papaya/mulberry mealybug/ complex with *Acerophagus papayae* & *Cryptolaemus montrouzieri*

Treatments	Number of plants affected by mealy bug out of 25 plants							
	Observation recorded	Dec 15, 2017	Dec 30, 2017	Jan 15, 2018	Jan 30, 2018	Feb 15, 2018	Feb 28, 2018	Mar 15, 2018
T1	Per cent incidence	1.4	2.2	1.2	2.8	1.6	0.5	0
	Pest intensity rating	2.0	2.0	2.0	2.0	2.0	2.0	0.0
	Natural enemy population / 10 leaves	4	7	12	10	18	18	24
T2	Per cent incidence	1.3	3.6	2.3	1.6	4.8	5.6	9.3
	Pest intensity rating	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	Natural enemy population / 10 leaves	4	4	4	8	6	10	8

Plate 10. *Cryptolaemus montruzieri* feeding on papaya and cotton mealybug in mulberry and papaya plants

12.2 NBAIR, Bangalore

Papaya mealybug on mulberry

Infestation in mulberry was surveyed in the districts of Chamarajnagar, Maddur, Ramanagar, Kollegal, Hassan, Tumkur, Mandya, Kolar and Chikballapur area. The occurrence of papaya mealybug was very low to nil in the surveyed areas. The incidence of papaya mealybug in mulberry was less than 10 percent in Ramnagar, Kollegal, and Maddur areas where parasitoids were augmented.

Occurrence of papaya mealybug on papaya, weeds and other host plants in Karnataka

Survey in about 40 orchards of papaya in Nelamangala, Devanahalli, Kunigal, Mandya, Bangalore, Kollegal, Maddur, Kanakapura, Mysore, Chamarajanagar, Kolar, Tumkur road, and Hassan revealed that there was not even a single tree with incidence of papaya mealybug. Stray incidence of papaya mealybug was observed in one or two isolated plants where very low infestation was there in almost all the locations surveyed in Karnataka. Damages in the score of 1 (1- 5 Scale) and below only were observed very sporadically in homesteads.

Hibiscus and *Parthenium* were found to harbor papaya mealybug in low populations in most of the localities and was found invariably associated with *Maconellicoccus hirsutus*, *Phenacoccus solenopsis, Ferrisia virgata*, several weeds and other plants, which were previously found to harbor papaya mealybug, *viz*., *Parthenium, Sida acuta, Acalypha, Abutilon* and crotons were free from papaya mealybug in many of the localities surveyed (Table 97).

Supply of host insects and natural enemies

10 requests for *Acerophagus papayae* were received this year by papaya growers out of fear only and no orchard recorded severe incidence of papaya mealybug.

Table 97. List of Farmers involved in field experiments on papaya and mulberry mealybug pest complex

Sl.No	Name of farmer	location	Crop	Area in Acers
1	Anbalagan. V*	05, Sundaripalyam Veerapur post Dindigul district	Papaya	7.00
2	S. Shivanesan	Byadamodlu Chamarajnagar	Papaya	12.00
3	B. Shankar Rao	Vartur, Tavarekere hobli Bangalore	Papaya	5.00
4	Narasimhamurthy*	Hindupur, Ananthpur Dist	Papaya	3.00
5	Murthy V.K.	Hagalahalli Ramnagar Tq. Ramnagar	Papaya	7.50
6	S. Gopi*	Keipudupet Walaja tq. Vellore	Papaya	5.00
7	Rajesh C.	G.B.H. Layout Tatanagar	Papaya	1.00
8	Marisiddaiah	Keeranagere Ramnagar	Mulberry	6.00
9	Sateesha. E.L.	V.G. Doddi, Ramanagar.	Mulberry	10.00
10	Thimmegowda	Waderahalli, Ramnagar	Mulberry	3.00

Biological control of mealybug complex in papaya and mulberry

Three farms each of papaya and mulberry with more than a ha area were selected for the experiment for management of mealybug complex in papaya and Mulberry. Initial infestation level of mealybug, species of mealybugs, and natural enemies were recorded. Each farmer was supplied with 250 *Cryptolaemus montruzieri* and 250 *Acerophagus papayae* per acre to be released on the affected plants. The observations were recorded after 15, 30 and 45 days after release. The data was compared with control with 25 plant/ tree patch away from the release site which served as control.

In papaya orchards the incidence of papaya mealybug was very sporadic and only few fruits and leaves were found with papaya mealybug infestation. No other mealybug other than *Paracoccus marginatus* was recorded on papaya plants. The mealybug infestation was 7 per cent of the trees in Byadamodlu village and 4 percent in Vartur and Ramnagar. The observations were recorded in July 2017. Presence of *Acerophagus papayae* was seen in all the infested plants. Random collection of samples and emergence studies revealed 35-40 percent parasitization in Vartur and 50-60 per cent parasitization in Byadamodlu and 20 percent in case of Ramnagar.

In mulberry among the three farms selected, papaya mealybug was observed but the incidence of papaya mealybug was less than 5 per cent. In Waderahalli papaya mealybug was found associated with *Meconellicoccus hirsutus* and the incidence was also less than 5%. Association with cotton mealybug *Phenacoccus solenopsis* and with long tailed mealybug *Pseudococcus longispinus* was less than one per cent. Natural enemies recorded on the mealybug complex in the initial observations, revealed presence of *A. papayae* and *Aenasius arizonensi*s (Girault) on papaya mealybug and cotton mealybug, respectively. *Scymnus* sp. and *Cryptolaemus* larvae were also recorded where ever cotton mealybug and *M. hirsutus* were present. The incidence of natural enemies was less than 5 percent in the mulberry ecosystem.

Post release observations after 45 days revealed that the released parasitods enhanced the reduction of pest population and the parasitization percentage increased to 72-85 percent in the Byadamodlu. In Vartur also similar results was observed. In Ramnagar the population of mealybug was reduced drastically due to continuous rains and the parasitization in the remaining mealybug population was recorded at 35-40%. In papaya the released *Cryptolaemus* population also survived in the field but the adults could not be seen after 45 days in the papaya plants. The combination of *Cryptolaemus* with *Acerophagus papayae* did not have any additive effect on the management of papaya mealybug in papaya ecosystem as there was not much difference in reduction of mealybugs over only *A. papayae* released plots.

In case of Mulberry ecosystem the mealybug complex was efficiently managed by the combination of *Cryptolaemus* with *Acerophagus papaye* as *Cryptolaemus* survived very well on the cotton mealybug, long tailed mealybug and *M. hirsutus* and the adult activity was also seen in mulberry ecosystem after 45 days of release. The release of *A. papayae* in combination with *Cryptolaemus* was beneficial in mulberry as compared to papaya ecosystem.

In the farms where natural enemies were supplied to papaya and mulberry orchards the farmers conveyed that the *A. papayae* was very useful in checking the population of mealybug within 1-2 months of release. In case of mulberry, the mealybug complex consisting of pink mealybug and cotton mealybug along with papaya mealybug could be successfully managed using *Cryptolaemus* and *A. papaya*e combinations

12.3 AAU, Anand (Additional Experiment)

Work carried out during current year:

a) Survey for ascertaining the outbreak of papaya mealybug were carried out in farmers' fields of Anand district during the year 2017-18.
b) The samples of papaya mealybug and infested papaya fruits were brought to the laboratory and reared on sprouted potato.

Methodology:

a) Surveys were conducted in randomly selected villages of Anand district to record the infestation of papaya mealybug, *Paracoccus marginatus*.
b) Farmers' fields were visited once in a month.
c) Percentage of plants infested with mealybug was assessed by observing 25 randomly selected plants and intensity of damage (grade in the scale of 1-5) was determined.

Grade	**Population**
1	very low
2	low
3	medium
4	high
5	very high

Observations recorded:

1. Date of survey
2. Name and full address of the farmer
3. Crop plants infested.
4. Non-host crops and weeds infested
5. Chemical pesticides if any used with dose
6. Anticipated yield loss / ha (crop - wise)
7. Existing natural enemies in 25 randomly selected plants

Results:

- In the year 2017-18 the intensity of papaya mealybug infestation ranged from very low to medium (Table 98).
- The parasitoid *viz*., *Acerophagus papayae* was noticed parasitizing mealybug in field conditions.

Table 98. Survey and monitoring of papaya mealybug *Paracoccus marginatus*

Sr. No.	Date of survey	Location Detail /GPS location	Crop plants infested.	Non-host crops and weeds infested	Chemical pesticides if any used with dose	Existing natural enemies in 25 randomly selected plants	Grade
1.	13.11.'17	Near Sandeshar Ta-Anand, Dist- Anand 22 31 44.43, 72 52 45.64	Papaya	-	-	*Acerophagus papayae*	1
2.	13.11.'17	Sandeshar Ta- Anand Dist- Anand 22 30 49.45, 72 52 49.34	Papaya	-	-	*A. papayae*	1
3.	30.11.'17	Sandeshar Ta- Anand Dist- Anand 22 30 52.41, 72 52 48.20	Papaya	-	-	-	2
4.	30.11.'17	Sandeshar Ta- Borsad Dist- Anand 22 30 48.24, 72 52 50.12	Papaya	-	-	*A. papayae*	1
5.	30.11.'17	Dhundhakuva Ta- Borsad Dist- Anand 22 27 18.63, 72 52 39.96	Papaya	-	-	-	2
6.	08.12.'17	Dhundhakuva Ta- Anand Dist- Anand 22 27 10.77, 72 52 38.26	Papaya	-	-	*A. papayae*	1
7.	08.12.'17	Kavitha Ta- Petlad Dist- Anand 22 27 1.34, 72 52 32.31	Papaya	-	-	-	2
8.	08.12.'17	Sureshbhai Patel Sandesar Ta- Petlad Dist- Anand	Papaya	-	-	*A. papayae*	1

		22 27 1.29, 72 52 29.85					
9.	29.12.’17	Kavitha Ta- Petlad Dist- Anand 22 26 54.36, 72 52 28.32	Papaya	-	-	-	2
10.	29.12.’17	Kavitha Ta- Petlad Dist- Anand 22 26 53.34, 72 52 26.62	Papaya	-	-	*A. papayae*	3
11.	06.01.’18	Kavitha Ta-Petlad Dist.- Anand 22 26 35.41, 72 51 58.48	Papaya	-	-	*A. papayae*	1
12	06.01.’18	Kavitha Ta- Petlad Dist: Anand 22 26 37.86, 72 51 56.94	Papaya	-	-	-	2

13. POMEGRANATE

13.1 Biological control of pomegranate fruit borer with *Trichogramma* sp. (TNAU – Laboratory experiment)

Mass culturing of pomegranate fruit borer is in progress.

14. APPLE

14.1 Integrated pest management of apple Codling moth, *Cydia pomonella* (SKUAST)

The experiment was conducted in Kargil district at four different locations, with following treatments as mentioned below.

Treatments

Treatments	Orchards	Details of treatments
T1	Kirkichoo	Installation of mating disruption traps
T2	Mingy	Release of *T. cacoeciae* @ 2.5 lakh/ha. (4 releases/ season) + Trunk banding + Pheromone trapping + Disposal of infested fruits + Spray of *Heterorhabditis pakistanensis* (NBAIR)
T3	Shanigund	Farmers practice of the region
T4	Slikchey	Untreated Control

Treatments T1-T3 were given to randomly selected 50 plants and data was collected from ten randomly selected plants for per cent fruit damage and larval density under trunk bands used. Data on trapped adult moths was however based on four pheromone traps/ orchard. Mating disruption pheromone was procured from ATGC, Hyderabad. Approximately 25 sachet of MD pheromones were used during arrival of second generation of the Codling moth, *Cydia pomonella*. The MD pheromones could not be used during first generation of the moth, due to late receipt of the material. *T. cacoeciae* and *Heterorhabditis pakistanensis* were received from NBAII, Bangalore. Two sequential releases of *T. cacoeciae* were made at Mingy @ 4000- 5000 adult wasps/tree, coinciding with first and second generation of the moths. Trunk banding of apple trees was done during July and late August. In previous case, observation on the numerical density of overwintering larvae was done by untying them during the month of May, whereas in later case, it was done during September to October. Data on numerical density of larvae trapped/ overwintered were duly recorded and larvae killed thereafter. Dropped infested fruits during June-August were disposed off the orchard. The EPN, *Heterorhabditis pakistanensis* (NBAIR) was sprayed on 20 trees during the month of late August. The morbid/dead larvae during 24 hours were counted and per cent mortality calculated.

Data on fruit damage (on tree & dropped fruits), per cent reduction in damage over control for each treatment was determined.

Overall fruit damage during 2017 in treated orchards was found varying from 35.08 to 68.05 per cent as compared to untreated control (83.29) (Table 99 & Fig. 1). Differences among treatments in relation to fruit damage on tree (F= 62.05**; d.f.=3,27; p= 0.00), dropped fruits (F=92.71*, d.f.= 3,27; p= 0.00) as well as overall fruit damage (F= 107.82**; d.f.= 3,27; p= 0.00) were found statistically significant, when data was analyzed through one way ANOVA. Per cent reduction in damage over control ranged 15.23 to 48.21, which was also worked out to be statistically significant for treatments (F= 57.26**; d.f.= 2,18; p = 0.00). In present work, T3 (farmer's practice), which involved only one spray of Chlorpyriphos @ 1.0ml/ liter of water during the month of May did not reveal as good result as T2 (Release of *T. cacoeciae* @2.5 lakh/ha. (4 releases/ season) + Trunk banding + Pheromone trapping + disposal of infested fruits

+ spray of *Heterorhabditis pakistanensis* (NBAIR)) and T1 (Installation of mating disruption traps). An all-inclusive approach for the management of Codling moth, *Cydia pomonella*was found best in terms of reduction in pest in Kargil (Plate 11 & 12).

Overwintering larvae of Codling moth, *Cydia pomonella* sheltering in trunk bands (Plate 2) differed statistically orchard wise during the month of July (F= 30.18**; d.f.= 3,27; p= 0.0) August (F= 4.44**; d.f.= 3,27; p= 0.00) and also in their overall mean (F= 12.10**; d.f.= 3,27; p= 0.00). Difference between larval catch during the two months differed statistically when compared through Student's t- test (t= 1.72*; d.f.= 74).

Average catch of adult moths through pheromone traps ranged 11.25- 56.5 and 20.25-101.25 during May and July respectively (Plate 13).

The number of moths differed significantly during May (F= 18.87**; D.F.=3,9; p= 0.00), July (F= 19.09**; D.F.=3,9; p= 0.00) and mean of the two months (F= 47.11**; D.F.=3,9; p= 0.00) (Table 100), when analyzed through ANOVA. Difference between moth catch during May and July, when compared using Student's t-test was found statistically significant (t= 2.59* P=0.016, DF= 25).

Spray of *Heterorhabditis pakistanensis* @ 20.0 gms/lit of water caused 77.3 to 88.64 per cent mortality of overwintering larvae of Codling moth, *Cydia pomonella* (Plate 4 Fig. 3).

Table 99. Effect of different treatments on apple fruit damage by Codling moth, *Cydia pomonella* in Kargil, during 2017-18

Location	Damage on tree (%)	Dropped fruits (%)	Overall fruit damage (%)	% reduction in damage over control
(T1) Kirkichoo	21.95 (27.8)[a]	89.9 (72.08)[b]	55.96 (48.44)[b]	27.32 (31.39)[b]
(T2) Mingy	19.03 (25.34)[a]	51.13 (45.64)[a]	35.08 (36.21)[a]	48.21 (43.9)[a]
T3 Shanigund	43.5 (41.24)[b]	92.6 (74.5)[b]	68.05 (55.63)[c]	15.23 (22.49)[c]
(T4) Control Slikchey	71.06 (57.7)[c]	95.52 (78.46)[c]	83.29 (66.11)[d]	--
C.D.(0.05)	4.54	3.73	2.91	3.48
CV (%)	57.9	23.43	31.45	51.48

Values in parentheses are arc sin transformations; similar alphabets in a column indicate values statistically on par; each figure represents mean of 10 replications; Where T1=Use of mating disruption pheromone; T2= two times sequential release of *T. cacoeciae*+ trunk banding + Pheromone trapping, disposal of dropped fruits + use of *H. pakistanensis :* T3= one spray of Chlorpyriphos 20 EC @1.0 ml/lit.; T4= Untreated Control

Fig. 1 Effect of treatments on Codling moth, *Cydia pomonella* on apple in Kargil during 2017

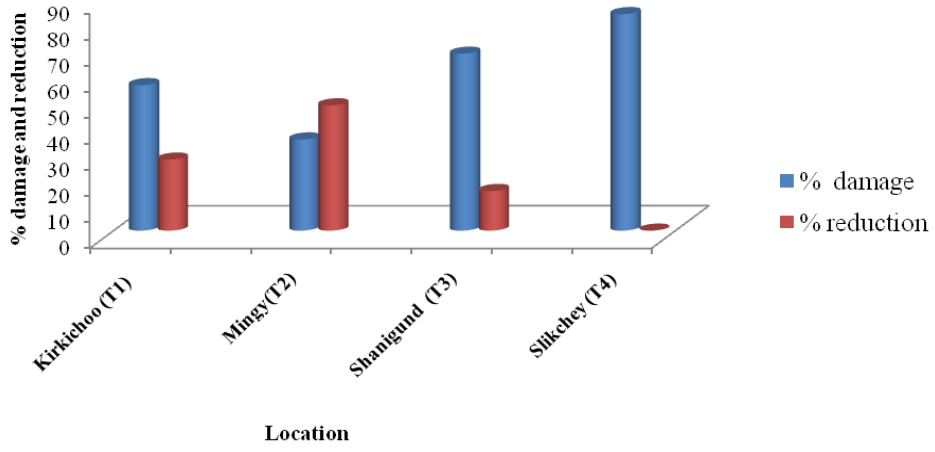


Fig. 2. Effect of trunk banding and pheromone trapping on larval and adult catches of Codling moth, *Cydia pomonella* on apple during 2017

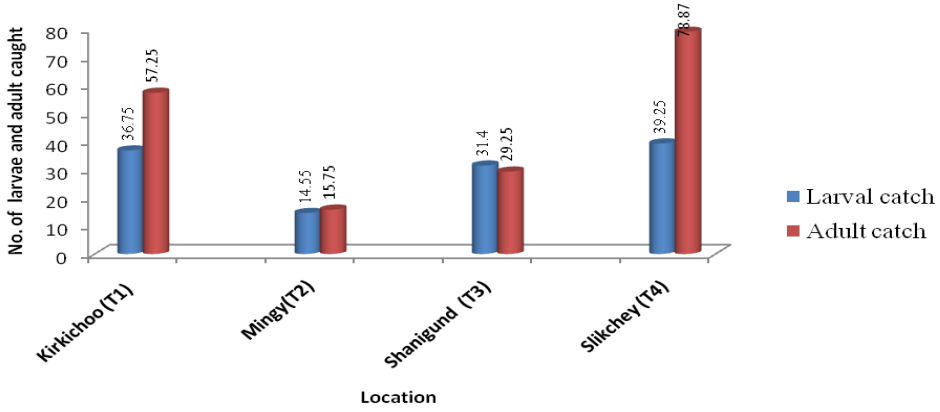


Plate 11

Plate 12

Plate 11 & 12. 1st row: Apple cut open to show larva of Codling moth (L); Overwintering larvae on tree trunk (R); **2nd row**: adult moth of Codling moth on apple (L); Damaged fruit dropped on ground (R); **3rd row**; AICRP staff using Mating Disruption (L) and training to farmer for use of pheromone trap; **4th row**: Staff demonstrating the use of *Trichogramma* (L) and training farmer to use trunk band to trap overwintering larvae (R).

Plate 13

Plate 13. (1st row): Biocontrol Scientist examining fruit damage (L) Pheromone traps showing adult moths of Codling moth trapped (R). **2nd row**: Bio control staff showing the result of pheromone trap (R); Mature apple crop as a result of treatments

Table 100. Larval catches in trunk bands and Pheromone trapping of adult moths of *Cydia pomonella* in Kargil during 2017-18

Location	Larval catches in trunk bands			Pheromone trapping of adults		
	July	August	Mean	May	July	Mean
(T1) Kirkichoo	29.2 (5.36)[b]	44.3 (6.59)[c]	36.75 (6.01)[b]	45.0 (6.56)[b]	69.5 (8.3)[c]	57.25 (7.55)[c]
(T2) Mingy	8.2 (2.82)[a]	30.3 (5.40)[b]	14.55 (3.78)[a]	11.25 (3.32)[a]	20.25 (4.46)[a]	15.75 (3.94)[a]
T3 Shanigund	32.5 (5.63)[b]	20.9 (4.51)[a]	31.4 (5.53)[b]	14.0 (3.70)[a]	44.5 (6.6)[b]	29.25 (5.39)[b]
(T4) Control Slikchey	38.5 (6.08)[ab]	40.0 (5.98)[b]	39.25 (6.08)[b]	56.5 (7.5)[b]	101.25 (9.95)[d]	78.87 (8.84)[d]
CD (0.05)	0.64	1.01	0.74	1.24	1.39	0.82
CV (%)	56.66	55.63	44.78	70.77	60.36	58.83

Values in parentheses are √n; similar alphabets in a column indicate values statistically; on par; figures in first three columns represent mean of 10 replications, whereas other three are based on mean of four replications.

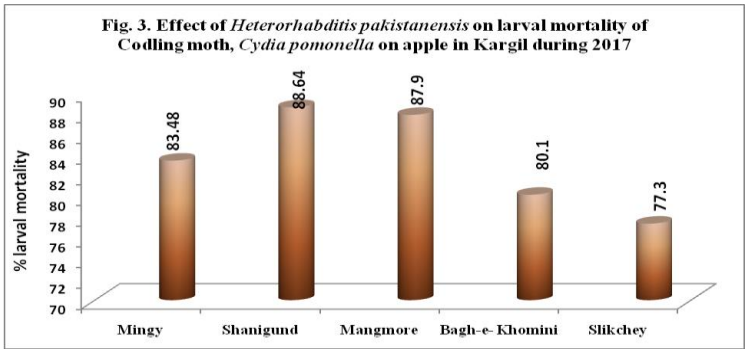


Plate 14

Plate 14. (First row): Overwintering larvae of Codling moth on apple trunk; Dead larvae collected 24 hr. after treatment with *Heterorhabditis pakistanensis*; **Second row:** Progressive change in colour of larvae in response to treatment with EPN.

14.2 Evaluation of predatory bug, *Blaptostethus pallescens* against European red mite *Panonychus ulmi* and two spotted spider mite *Tetranychus urticae* on apple (SKUAST)

On an average, number of European red mites (only the motile stages) *P. ulmi* in untreated check (T4) was 15.04 and 22.52^{-leaf} on 3 DAT and 7 DAT, respectively, with mean population of 18.78^{-leaf} (Table 4). In response to two releases of bugs @ 100 $^{-plant}$ (T1), average number of motile mites were observed as 12.31 and 14.21 at 3 DAT and 7 DAT, respectively with mean population of 13.27 mites^{-leaf}. In treatment T2 which involved release of 200 bugs/plant, the average number of mites at 3DAT, 7DAT and mean population was 9.94, 10.84 and 10.39 mites^{-leaf}, respectively. One spray of Fenazaquin 40 EC @ 0.04 ml/ lit. of water (T3), showed average number of mites at 3DAT, 7DAT and mean population as 5.33, 3.77 and 4.55 mites$^{-leaves}$, respectively (Table 101; Fig. 5).

Comparison of data indicated a significant difference in mites' population, in response to treatments, both on 3DAT (F= 174.24**, d.f.= 3(69), p = 0.000), 7DAT (F= 487.69**, d.f. = 3(69), p = 0.000) and mean of the two periods (F= 650.03**, d.f.= 3(69), p= 0.000), when compared through one way ANOVA.

Per cent reduction in mite population^{-leaf} over control for treatments T1, T2 and T3 was 26.65, 41.88 and 73.47, respectively.

Table 101. Impact of field release of anthocorid bug, *Blaptostethus pallescens* against European red mite, *Panonychus ulmi* in high density apple in Kashmir during 2017

Treatment	No. of mites/ leaf		Mean population	% reduction in pop. Over control
	3rd day after treatment	7th day after treatment		
100 bugs/plant (T1)	12.31 (3.57)^{c}	14.25 (3.83)^{c}	13.27 (3.70)^{c}	26.65
200 bugs/ plant (T2)	9.94 (3.22)^{b}	10.84 (3.36)^{b}	10.39 (3.29)^{b}	41.88
Chemical (T3)	5.33 (2.40)^{a}	3.77 (2.02)^{a}	4.55 (2.23)^{a}	73.47
Control (T4)	15.04 (3.93)^{d}	22.52 (4.79)^{d}	18.78 (4.38)^{d}	0.0
CD(0.05)	**0.11**	**0.12**	**0.08**	
CV (%)	**35.42**	**52.10**	**43.3**	

Each figure in column represents mean of 72 observations; figures in parentheses are$\sqrt{n+0.5}$; different alphabetical superscripts in column indicate values statistically significant

Two spotted spider mite *Tetranychus urticae* on apple

Average number of two spotted spider mites on 3 DAT, 7 DAT and mean of the two periods for untreated check (T4) was 8.02, 12.20 and 10.11^{-leaf} respectively. In response to treatments @ 100 bugs/ plant (T1), 200 bugs/ plant (T2) and one spray of Fenazaquin 40 EC @ 0.4 ml/lit. of water (T3), the number of two spotted spider mites after 3DAT, 7DAT and mean of

the two periods were observed as: 6.23, 8.58,7.41; 4.30, 5.87, 5.09 and 2.02, 2.68, 2.35 respectively (Table 102).

Differences in number of mites among plants in response to treatments were found statistically significant on 3DAT (F= 212.14**, d.f.= 3(69), p= 0.000) 7 DAT(F= 27.98**, d.f.= 3(69), p= 0.000) and mean of the two periods (F= 464.80**, d.f.= 3(69), p= 0.000), when analyzed through one way ANIOVA.

Per cent reduction in mite population^{-leaf} over control, for treatments T1, T2 and T3 was worked out as 24.54, 48.61 and 75.72 respectively.

Field survival ability of the predator was found as 5.33 and 7.0 per cent when released @ 100 and 200 bugs $^{-plant}$ after 24 and 48 hours, respectively. (Table 103) (Fig. 6).

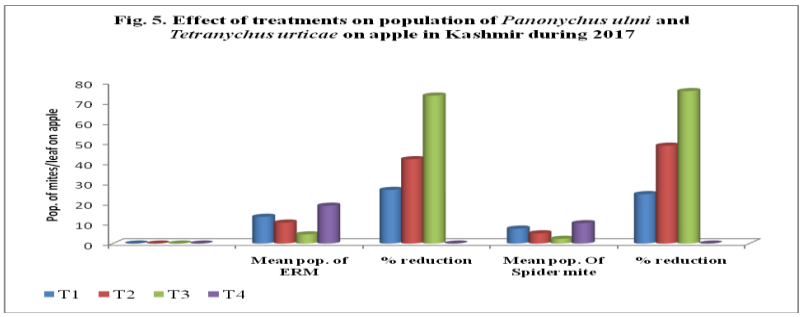
Table 102. Impact of field release of anthocorid bug, *Blaptostethus pallescens* against two spotted spider mite, *Tetranychus urticae* in High density apple in Kashmir during 2017

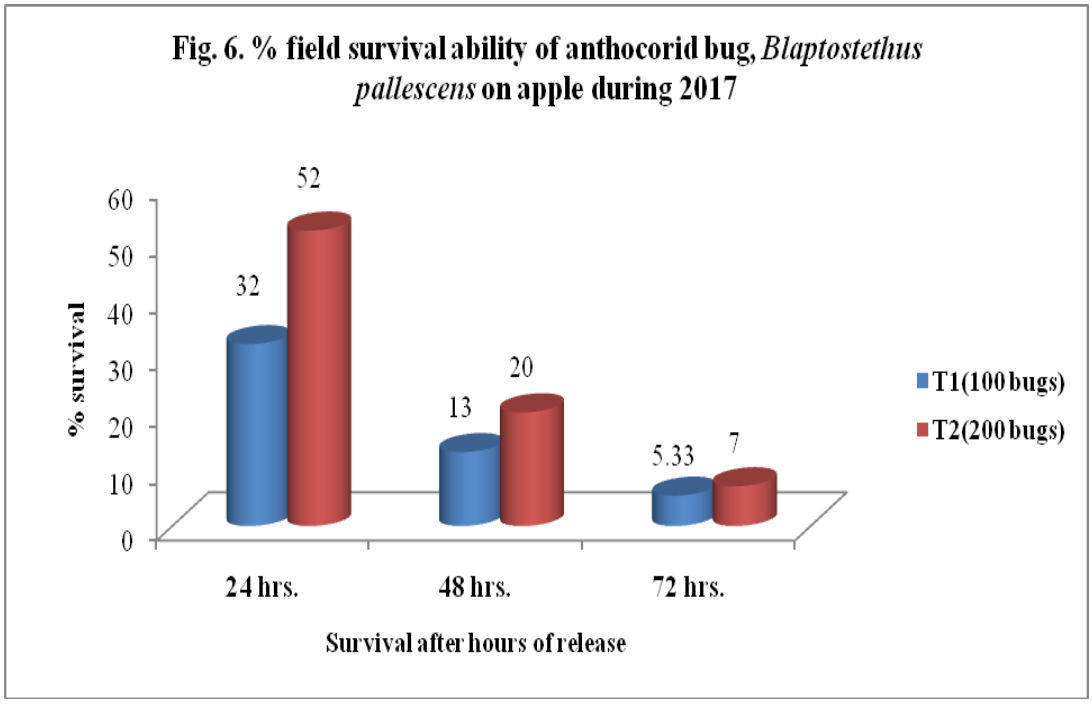
Treatment	No. of mites/ leaf		Mean population	% reduction in pop. Over control
	3rd day after treatment	7th day after treatment		
100 bugs/plant (T1)	6.23 (2.58)^{c}	8.58 (3.00)^{c}	7.41 (2.8)^{c}	24.54
200bugs/ plant (T2)	4.30 (2.18)^{b}	5.87 (2.51)^{b}	5.09 (2.35)^{b}	48.61
Chemical (T3)	2.02 (1.57)^{a}	2.68 (1.77)^{a}	2.35 (1.68)^{a}	75.72
Control (T4)	8.02 (2.91)^{d}	12.20 (3.55)^{d}	10.11 (3.25)^{d}	-
CD (0.05)	0.09	0.20	0.07	
CV (%)	47.24	51.16	47.9	

Each figure in column represents mean of 72 observations; figures in parentheses are$\sqrt{n+0.5}$; different alphabetical superscripts in column indicate values statistically significant

Table 103. Field survival ability of anthocorid bugs, *Blaptostethus pallescens* after release on apple during 2017 at Shalimar

Bugs/plant	% survival ability after		
	24 hrs.	48 hrs.	72.0 hrs.
@ 100 bugs/ plant	32.0	13.0	5.33
@ 200 bugs/ plant	52.0	20.0	7.0





14.3 Evaluation of *Trichogramma* spp. against apple fruit moth, *Argyresthia conjugella* under laboratory conditions (YSPUHF)

The experiment to evaluate *Trichogramma* spp. namely *Trichogramma achaeae*, *Trichogramma pretiosum* (thelytokous strain), *Trchogramma chilonis, Trichogramma pieridis* and *Trichogramma embryophagum* against apple fruit moth, *Argyresthia conjugella* under laboratory conditions was conducted at YSPUHF, Regional Horticultural Research Station cum KVK, Rekongpeo district Kinnaur. The adult moths of the pest were collected under light and kept in insect rearing cages for egg laying on the developing immature fruits. The eggs of the moth were exposed to each *Trichogramma* sp. separately in glass tubes at the rate of 30 eggs per *Trichogramma* female for 24h, after 24h, the eggs were transferred to another tube and observed for parasitism and emergence of the 149 parasitoid adults. Observations on per cent parasitism, per cent adult emergence, adult longevity and percentage of females emerged were recorded. The results of the experiment (Table 104) revealed that all the *Trichogramma* spp. had low efficacy against the pest. Maximum parasitisation obtained was only 16.6 per cent which was resulted by *T. embryophagum.* The parasitism resulted by *T. achaeae, T. pretiosum* and *T.chilonis* was 5.6, 8.9 and 11.1 per cent, respectively, whereas, *T. pieridis* failed to parasitize the eggs of apple fruit moth. Adult emergence from the parasitized host eggs was 80, 75, 70 and 86.6 per cent for *T. achaeae*, *T. pretiosum, T. chilonis* and *T. embryophagum*, respectively, of which 50, 100, 42.6 and 46.2 per cent were the females. The developmental period was 13.2, 12.9, 11.6 and 11.9; while, the adult longevity was 3.4, 3.6, 2.8 and 3.1 days for the respective species.

Table 104. Evaluation of *Trichogramma* spp. against apple fruit moth, *Argyresthia conjugella* under laboratory conditions

Trichogramma species	% Parasitism	% Adult emergence	Adult longevity (days)	Development period (days)	% females
T. achaeae	5.6 (13.6)c	80.0 (63.4)ab	3.4	13.2	50.0 (45.6)b
T. pretiosum	8.9 (17.4)bc	75.0 (59.9)b	3.6	12.9	100 (90.0)a
T. chilonis	11.1 (19.5)b	70.0 (56.7)b	2.8	11.6	42.9 (40.9)b
T. embryophagum	16.6 (24.1)a	86.6 (68.6)a	3.1	11.9	46.2 (42.8)b
T. pieridis	0.0 (0.0)d	-	-	-	-
CD (p = 0.05)	(4.2)	(8.1)	NS	NS	(11.2)

14.4 Management of apple root borer using *Metarhizium anisopliae* (YSPUHF)

A large scale demonstration on the management of apple root borer, *Dorysthenes hugelii* by using *Metarhizium anisopliae*was laid in apple (cv Royal Delicious) in Shimla, Sirmaur and Solan districts covering an area of 5ha and 11 orchards. *Metarhizium anisopliae* (10^8 conidia/g) was applied @ 30g/ tree basin mixed in well rotten farm yard manure (FYM) during July-August *i.e.* at the time of egg hatching and emergence of new/young grubs. Chemical treatment comprising of chlorpyriphos (0.06%) was also applied for comparison. The details of the farmers and the locations where the demonstrations were laid are given below:

SN	Location	Number of orchards
1	Rohru, district Shimla	5
2	Choupal, district Shimla	3
3	Shilai, district Sirmaur	1
4	Rajgarh, district Sirmaur	1
5	Dharokidhar, district Solan	1
	Total	11

Metarhizium anisopliae treatment resulted in 71.1 to 82.2 per cent mortality of the apple root borer grubs in different orchards, which was close to mortality obtained when chlorpyriphos (0.06%) was applied (77.4 - 86.6%). It can therefore be concluded that *Metarhizium anisopliae* can be used as a substitute for chlorpyriphos for the control of apple root borer, *Dorysthenes hugelii* in apple.

15. MANGO

15.1 Effect of biopesticides for the management of Mango hopper, *Idioscopus* spp. in field condition (KAU, Vellayani; DRYSRHU, Ambajipeta)

15.1.1 KAU, Vellayani

Experiment details:

Design : RBD
Replication : 3
Treatments : 5

Treatments:

T1 : *Beauveria bassiana* 2 % (ITCC 6063) 20g/l
T2 : *Metarizhium anisopliae* 0.5 % (NBAIR culture) 5gm/l
T3 : Azadiractin1 % SC 1ml/l
T4 : Malathion 50 % EC 2ml/l
T5 : Untreated control

Significant reduction in the damage by the hopper was observed at 3rd, 5th, 10th and 15th day of intervals, when *Metarhizium anisopliae* 0.5 % @ 5 g/l, *Beauveria bassiana* ITCC 6063 @ 20 g /l were applied. Insecticide Malathion 50% EC @ 2ml/l was also found effective against the mango hoppers (Table 105).

Table 105. Effect of different treatments on the per infestation of mango hopper, *Idioscopus* spp.

Number of hopper 10 cm/ panicle; Figures in parentheses are √X transformed values

Treatment	First spraying				Second spraying			
	3 DAS	5 DAS	10 DAS	15 DAS	3 DAS	5 DAS	10 DAS	15 DAS
Beauveria bassiana	20 (4.450)	19.66 (4.849)	16 (3.953)	14 (3.644)	19.33 (4.397)	13.66 (3.667)	11.66 (3.408)	10 (3.156)
Metarhizium anisopliae	32.33 (5.686)	19.33 (4.845)	19 (4.358)	13.33 (3.625)	20.33 (4.509)	10.33 (3.197)	9.0 (2.999)	7.33 (2.694)
Azadiractin	26 (5.077)	27.66 (5.254)	27.33 (5.173)	22 (4.681)	19.33 (4.397)	12 (3.456)	12.33 (3.501)	9.66 (3.101)
Malathion	26.33 (5.127)	24.0 (4.952)	21.0 (4.567)	18.0 (4.226)	19.33 (4.396)	12.33 (3.501)	11.33 (3.364)	11.0 (3.313)
Control	33 (5.745)	39.66 (6.290)	45.66 (6.743)	51.66 (7.170)	22.66 (4.766)	28.66 (5.356)	26 (5.076)	28 (5.255)
CD	0.806	0.790	0.749	1.091	0.219	0.657	0.645	0.707

15.1.2 DRYSRHU, Ambajipeta

Orchards having about 50- 100 trees were selected. The selected blocks were isolated from each other since hoppers are migratory

Treatment details
T1 : *Beauveria bassiana* talc formulation @ 10 g / L
T2: *Metarhizium anisopliae* talc formulation @ 10 g /L
T3: Azadirachtin 1500ppm @ 2 ml/L
T4: Malathion 0.1%
T5: Untreated Control

Frequency of spray: Weekly (a total of three/ four sprays) (with the incidence of hoppers-first generation). If hopper population was very severe the spray were done once in 5 days

Data to be recorded in the spraying experiment: The hoppers population in each treatment was recorded before and after treatment observations were made from 10 trees, from each tree from four inflorescence the number of hoppers was recorded.

The spraying experiment was carried out in mango garden (variety Banginapalli) aged 7 years in Komaragiripatnam village of Allavaram mandal in East Godavari. The first spray was done on 07/03/2018 and subsequent two sprays were given at weekly intervals. Data on surviving hopper population was transformed into $\sqrt{x+0.5}$ values before subjecting to analysis of variance.

The results in Table 106 show that the spraying of bio pesticide *Beauveria bassiana* was effective in suppressing mango hoppers and a reduction in hoppers population was observed after three sprays in this treatment. *B. bassiana* treatment was comparatively more effective than *Metarhizium anisopliaea* and Azadirachtin 1500 ppm treatments and comparable to insecticide treatment malathion. The chemical insecticide treatment malathion and bio pesticide treatment *B. bassiana* recorded a mean surviving population of 19.50, 17.50 and 10.75 and 20.38, 16.13 and 15.75 numbers of hoppers per tree, respectively. In untreated control block a high population of mango hoppers ranging from 37 .00 to 44.38 was recorded consistently.

Table 106. Field evaluation of bio pesticide formulations against mango hoppers, *Idioscopus* spp in Andhra Pradesh

Treatments	Dosage	Hopper population/ per tree (for 4 inflorescence) 7 days after spray			
		Pre count	1st spray	2nd spray	3rd spray
T1- *Beauveria bassiana*	@ 5 g / L	39.13 (6.29)	20.38 (4.56)	16.13 (4.08)	15.75 (4.03)
T2- *Metarhizium anisopliae*	@ 5 g / L	40.88 (6.43)	31.25 (5.63)	26.50 (5.19)	20.63 (4.59)
T3- Azadirachtin 1500 ppm	@ 2 ml / L	40.25 (6.39)	32.88 (5.99)	25.50 (5.09)	24.25 (4.97)
T4- Malathion	1 ml/L	39.38 (6.31)	19.50 (4.46)	17.50 (4.24)	10.75 (3.35)

T5- Untreated Control	--	43.88 (6.66)	35.50 (5.99)	37.00 (6.14)	44.38 (6.70)
SEM		--	0.14	0.13	0.09
CD (5%)		NS	0.43	0.42	0.28

Figures in parentheses are √x+0.5 transformed values

15.2 Effect of biopesticides for the management of mango leaf webber, *Orthaga* spp. in field condition (KAU, Vellayani)

Design : RBD
Replication : 3
Treatments : 5

Treatments:

T1 : *Beauveria bassiana* 2 % (ITCC 6063) 20g/l
T2 : *Metarizhium anisopliae* (NBAIR culture) 5gm/l
T3 : Azadiractin1 % SC 1ml/l
T4 : Malathion 50 % EC 2ml/l
T5 : Untreated control

Observation: Number of active webs/plant

Table 107. Effect of different treatments on the per cent infestation of mango webber, *Orthaga* spp.

Treatment	First spraying				Second spraying			
	3 DAS	5 DAS	10 DAS	15 DAS	3 DAS	5 DAS	10 DAS	15 DAS
Beauveria bassiana	66.66 (8.168)	66.66 (8.168)	66.66 (8.168)	67.57 (8.218)	55.60 (7.453)	55.60 (7.453)	54.34 (7.368)	54.00 (7.345)
Metarhizium anisopliae	63.37 (7.956)	63.37 (7.956)	63.37 (7.956)	63.37 (7.956)	61.04 (7.802)	51.04 (7.132)	45.67 (6.752)	40.71 (6.381)
Azadiractin	61.56 (7.846)	60.77 (7.789)	65.93 (8.102)	65.93 (8.102)	61.69 (7.854)	61.69 (7.854)	62.24 (7.881)	56.90 (7.536)
Malathion	56.04 (7.485)	56.04 (7.485)	56.04 (7.485)	56.04 (7.485)	53.46 (7.317)	53.46 (7.317)	53.46 (7.317)	52.40 (7.234)
Control	63.80 (7.983)	69.07 (8.308)	72.27 (8.505)	79.01 (8.882)	68.71 (8.281)	72.47 (8.516)	83.98 (9.152)	91.11 (9.543)
CD	0.294	0.523	0.581	0.620	0.494	0.476	0.549	0.560

Figures in parentheses are √X transformed values

Significant reduction in the damage by the leaf webbers was observed at 3rd, 5th, 10th and 15th day of intervals, when *Metarhizium anisopliae* 0.5 % @ 5 g/l, *Beauveria bassiana* ITCC 6063 *@ 20* g /l were applied. Insecticide malathion 50% EC @ 2ml/ l was also found effective against the mango webber.

16. PLUM

16.1 Feeding potential of *Chilocorus infernalis* against *Parthenolecanium corni* on plum in laboratory

Developmental duration of 1st to 4th instar grubs of *C. infernalis* was recorded as 2.5, 3.5, 5.5 and 7.5 days, respectively. It took 17-21 days to complete larval stage before entering pupation. Pupal stage averaged 11.5 days whereas an adult female survived an average of 30.5 days (Table 108).

Total feeding potential by grubs of *C. infernalis* against scales by 1st to 4th instar was 5.33, 15.0, 29.0 and 56.33. Total consumption of scales during larval period of the predator was 105.66. An adult female consumed a total of 283.2 scales during a period of 30.5 days. A single female of *Chilocorus infernalis* was worked out to consume a total of 388.86 scales during its life time.

Table 108. Developmental duration and fecundity potential of *Chilocorus infernalis* against *Parthenolecanium corni* on plum in Srinagar during 2017

Stage of predator	Developmental duration(days)	Fecundity/ day	Total Fecundity
1st instar	2.5 (2-3)	1.77	5.33
2nd instar	3.5 (3-4)	3.75	15.0
3rd instar	5.5 (5-6)	5.8	29.0
4th instar	7.5 (7-8)	7.04	56.33
1st- 4th instar	19.0 (17-21)	-	105.66
Pupa	11.5 (11-12)	-	-
Adult	30.5 (28-33)	9.44	283.2

Each figure in column represents mean of three replications

17. COCOA

17.1 Evaluation of microbial insecticides against bag worm, *Pteroma plagiophelps* in cocoa

Month and year**:** February, 2018
Design: RBD
Treatments: 5
Replications: 5
Target pest: Bag worm

Treatment details
T1: *Beauveria bassiana* @ 5 g/ L
T2: *Metarrhizium anisopliae* @5 g /L
T3: Azadirachtin 1500 ppm @ 3 ml/L
T4: Lamada cyhalothrin 1ml/litre (chemical check)
T5: Untreated control

Frequency of spray: At 10 days interval after initial population is observed and number of sprays will be carried out as per the need

Observations to be recorded:
i. No. of bag worms / 5 leaves before treatment
ii. No. of bagworms / 5 leaves /pods after every treatment

The experiment was carried out in HRS, Ambajipeta, in VTLCH 2 clone block on 3 years old cocoa crop inter cropped in coconut. A low bag worm population was recorded throughout the experimentation in all the treatments. The first spraying was done on 09/02/2018 and second spraying was given at 10 days interval. The results in Table 109 show that the spraying of *Beauveria bassiana*, *Metarhizium anisopliaea* and Azadirachtin 1500 ppm were on par with chemical check lamada cyhalorthrin throughout the observational period.

Table 109. Evaluation of microbial insecticides against *Pteroma plagiophleps* in Cocoa

Treatments	Dosage	Bag worm population/ per 5 leaves/ 10 days after spray		
		Pre count	1st spray	2nd spray
T1- *Beauveria bassiana*	5 g / L	5.80 (2.49)	2.60 (1.76)	0.20 (0.81)
T2- *Metarhizium anisopliae*	5 g / L	5.60 (2.46)	2.80 (1.81)	0.60 (1.01)
T3- Azadirachtin 1500 ppm	3 ml/L	5.40 (2.39)	3.00 (1.86)	0.80 (1.12)
T4- Lamada cyhalorthrin	0.5 ml/L	6.00 (2.53)	2.20 (1.61)	0.00 (0.71)
T5- Untreated Control	-	6.00 (2.53)	6.80 (2.69)	7.80 (2.87)
SEM		--	0.11	0.09
CD (5%)		NS	0.33	0.29

Figures in parentheses are √x+0.5 transformed values

PLNATATION CROPS

18. COCONUT

18.1 Surveillance of rugose whitefly (*Aleurodicus rugioperculatus*) on coconut and assessing the population of natural biocontrol agents (NBAIR, TNAU, KAU, DRYSRHU)

18.1.1 NBAIR, Bangalore

Five trips were made to Dakshina Kannada, Udupi and Uttar Kannada districts and two trips in Ramanagara, Mandya, Mysuru districts in Karnatakafor survey on incidence and infestation of rugose spiralling whitefly *Aleurodicus rugioperculatus* Martin on coconut and other host plants during 2017-18. Survey route was Mangalore to *via* Udupi and Brahmavar, Kundapura, Hemmadi, Marvanthe, Byndoor, Shiroor and Bhatkal; Bengaluru to Malavalli (via Ramanagara, Channapatna, Madduru, KM Doddi) and Malavalli to Bengaluru (via, Lakshmipura, Bannur, Mysuru, Srirangapatna and Mandya). Incidence and infestation of rugose spiralling on coconut, banana, mango, Indian Almond, Cashew and many other ornamental plants was recorded to the extent of 20-80% on different host plants. Maximum incidence on Coconut, banana, sapota, Indian almond and low to moderate on mango, cashew and few ornamental plants. The pest is spreading to a greater extent along the coastal belts and highways towards Goa. As per the natural parasitism as concern, the predominant natural enemies were *Encarsia guadeloupae* which parasitism was recorded to extent of 30-70 percent and maximum recorded on sapota, *Canna indica* and banana plants. This probably is due the lesser exposer to insecticides.

Initial incidence of RSW was noticed in Madduru, Mandya on coconut palm adjoining to state highways. However, infestation was very low, only few colonies noticed on few leaflets per palm. In case of natural enemies, natural parasitism of *Encarsia guadeloupae* was also noticed up to 42%. Further, we moved to state horticultural nursery, there was no incidence of RSW on any of the plant species though nursery consists of many host plants of RSW.

Moderate to severe infestation of RSW was noticed on coconut which was along the state highways at 10th Mile (K.M. Doddi), Mandya district. RSW damage was noticed up to 45-50% of leaflets covered with egg spiral, RSW colonies. The coconut palms were about 7-8-year-old, dwarf variety which covered with black sooty mold on upper surface of the infested palm. Similarly, natural parasitism by *E. guadeloupae* was observed about 54%. Besides, RSW infestation was noticed on Arjun tree (*Terminalia arjuna*), Indian tulip tree (*Thespesiapopulnea*), Jamun tree (*Syzygium cumini*) which was just planted both the side of the state highways as the avenue trees. The infestation of RSW was moderate to severe on *T. arjuna* where it was low to moderate on *T. populnea* and *S. cumini.* In case of natural parasitism by *E. guadeloupae* also maximum to extend of 70% on *T. arjuna* 12% on *T. populnea*and 26% in *S. cumini.*In Malavalli, RSW infestation was noticed on coconut, oil palm, sopata, garden croton, areca palm with low to moderate range (10-12%) in and around the Office of Department of Horticulture, Karnataka.

Similarly, moderate range of natural parasitism was noticed to the extent of 60-70%. Very severe infestation of RSW was noticed on coconut in Lakshmipura village, Mysuru taluk with heavy sooty mold development. RSW covered almost entire leaflets in frond with white waxy mat like appearance. In case of natural parasitism, it was noticed about 65-75%, besides RSW infestation in and around the Mysuru city. In Ramagnagara district, spiralling whitefly, *Aleurodicus dispersus* was noticed on coconut, banana, custard apple and guava.

Aleurodicus dispersus colony was noticed almost all the above survey location with sporadic and very negligible population. It was observed that, *A. dispersus* even coexist with RSW in many coconut palms. Incidence and infestation of RSW was confirmed so far in Dakshina Kannada and Udupi districts in Karnataka. The present occurrence on Mandya and Mysuru district likely due to movement of vehicles which are carrying tender coconut from infested areas to market that is located in Madduru. Presence of parasitioid *E. guadeloupae* believed that they might be moved from *A. dispersus* which were noticed from all the surveyed location. The enhancement of parasitoid population is likely due to availability of host insect (*A. rugioperculatus*) on coconut and many other host plants larger in number (Plate 15).

Plate 15. Infestation of Rugose whitefly on different host plants and mode of dispersal

18.1.2 TNAU, Coimbatore

Rugose whitefly and their natural enemies on coconut were monitored during 2017-18. The pest population escalated from July to November and declined during Dec. 2017 and Jan. 2018 and again increased during Feb. 2018 (Table 110). From, Feb, 2018, the pest was reported from new areas like Dindigul, Tanjore, Pudukottai and Thiruvarur Dt. Though reported from new areas, the incidence was less than 25 per cent. Natural enemies like the parasitoid *Encarisa* sp and predators, *viz., Chrysoperla zastrowi sillemi, Mallada* sp. and *Cryptolaemus Cryptolaemus montrouzieri* were observed in the infected leaflets. Among the naturally occurring predators, *Mallada* sp. was found actively predating on rugose whitefly.

Table 110. Incidence of rugose whitefly (*Aleurodicus rugioperculatus*) and its natural enemies in Tamil Nadu

Places surveyed	Period	*A. rugioperculatus* (No. of nymph /15 cm leaflet)	*A.rugioperculatus* (% incidence)	Natural Enemy/5 leaflet			
				Encarsia sp.	*Cryptolaemus*	*Mallada* sp.	*Chrysoperla*
Coimbatore	July 17	85	10	8	-	-	-
	Aug 17	95	12	10	-	-	-
	Sep 17	55	12	14	-	1	-
	Oct 17	110	20	11	-	-	-
	Nov17	105	22	10	1	1	-
	Dec 17	90	20	18	-	2	1
	Jan 18	65	22	16	2	-	-
	Feb18	125	18	24	-	3	-
	Mar 18	90	20	20	-	1	1
Tirupur	July 17	-	-	-	-	-	-
	Aug 17	-	-	-	-	-	-
	Sep 17	-	-	-	-	-	1
	Oct 17	50	8	-	-	-	-
	Nov17	65	15	3	-	2	2
	Dec 17	85	15	7	-	1	-
	Jan 18	150	22	7	-	-	-
	Feb18	110	18	10	-	-	-
	Mar 18	90	20	12	-	-	
Erode	Feb18	95	1	5	-	-	-
Theni	Oct 17	105	2	-	-	-	-
	Nov17	110	5	8	-	-	-
	Dec 17	65	2	3	-	-	-
	Jan 18	85	9	10	-	2	-
	Feb18	110	14	12	-	-	-
Dindigul	Mar 18	60	2	2	-	-	-
Tiruvarur	Feb 18	70	1	6	-	-	-
	Mar 18	85	2	5	-	-	-
Tanjore	Feb18	120	2	-	-	-	-
Pudukottai	Feb18	65	1	-	-	-	-

18.1.3 KAU, Thrissur

Monitoring of rugose whitefly infestation and its natural enemies on coconut

Incidence of rugose whitefly on coconut as well as the population of its natural enemies was recorded from one garden in Elavenchery in Palghat District where the infestation was first observed in September, 2017. The incidence of whitefly appeared to be localized in the Palghat District (Table 111). Observations were recorded at monthly intervals as per approved technical programme. The results are presented in Table 111. The severity of infestation ranged from high to severe during September but decreased to medium levels by December and low levels by March, 2018. Parasitism by *Encarsia guadeloupe* ranged from 10-54 per cent in September, 2017 but increased substantially to over 90 per cent by October, 2017. Mean parasitism was 87.98 during December. Higher mean parasitism of 93.31 and 92.02 were recorded during December and January respectively. The parasitism remained high on four out of five palms during March but was very low at 7.83 per cent on one palm where the leaves had fresh infestation.

18.1.4 DRYSRHU, Ambajipeta

Experimental details

Observations on the whitefly incidence were made at monthly intervals from three gardens. Five palms were selected at random in each garden as per methodology below.

Methodology:

The estimation of damage level caused by RSW was by scoring the presence of live egg spirals on each coconut leaflet. It is categorized as Low (<10 egg spirals/ leaflet), Medium (10-20 egg spirals/leaflet) and High (>20 egg spirals/ leaflet). Five such leaflets were sampled per garden and brought to laboratory for assessment of natural enemies and pest stages. Information on the management practices followed by the farmer was also collected. Information on alternate hosts if any was documented.

The incidence of rugose whitefly was observed on coconut and oil palm in the following villages in various districts and host plants in 2017-18 in Andhra Pradesh (Table 112 & 113) The host preference of rugose whitefly was also recorded by scoring the presence of live egg spirals on leaf and categorized as Low «10 egg spirals/ leaflet) Medium (10-20 egg spirals/leaflet) and High intensity (>20 egg spirals/ leaflet). An observation trail on efficacy of spraying of Azadirachtin 10,000 ppm @ 1ml on rugose whitefly was carried out in a 4 year old Godavari Ganga Hybrid coconut garden in October 2017 as detailed against Rugose white fly

Name of the Village :	Kalavacharla, West Godavari District
Number of palms sprayed	50 palms
Date of initial incidence of pest observation :	13-10-2017 (observation for 10 leaflets in five palms)
Date of Sprayings :	
Ist Spray :	10-20 Egg spirals per leaf let (Medium level of infestation)
IInd Spray :	25-10-2017 (Low level of infestation) < 10 Egg spirals per leaf let
IIIrd Spray	10-11-2017 (Nil Infestation)

Table 111. Severity of infestation and extent of parasitism of rugose whitefly at Elavenchey in Palghat District

Palms	13/09/17		12/10/17		16/11/17		14/12/17		16/01/18		15/02/18		20/03/18	
	Severity of infestation	Mean parasitism (%)	Severity of infestation	Mean parasitism (%)	Severity of infestation	Mean parasitism (%)	Severity of infestation	Mean parasitism (%)	Severity of infestation	Mean parasitism (%)	Severity of infestation	Mean parasitism (%)	Severity of infestation	Mean parasitism (%)
P1	Severe	26.1	Severe	91.0	Severe	98.15	Medium	73.46	Low	93.48	Low	98.33	Low	94.38
P2	High	21.4	Severe	95.0	High	55.55	Low	95.12	Low	92.10	Low	85.65	Low	98.62
P3	High	54.4	Severe	95.4	High	88.00	Medium	87.18	Low	93.33	Low	83.41	Low	93.33
P4	High	12.8	Severe	95.0	Severe	84.78	Medium	88.88	Low	92.31	Low	93.22	Low	95.34
P5	Severe	10.5	Severe	88.0	High	100.00	Low	95.24	Low	95.35	Low	99.5	Low	7.83
	Mean parasitism	25.04		92.88		85.30		87.98		93.31		92.02		77.9

Low (3 infested leaflets /frond); Medium (4 to 7 infested leaflets /frond) High (>10 infested leaflets/ frond); Severe (>10 infested leaflets /frond with sooty mould)

Table 112. Incidence of rugose whitefly, *A.rugioperculatus* in Andhra Pradesh

District	Villages (Up to 10.03.2018)
East Godavari	Kadiyapulanka, Pottilanla, Ubalanka, Appanapali, Ponnamanda, P.Gannavaram , Atreyapuram , Dulla
West Godavari	Kalavalapalli, Chikkala, Neeladripuram, Korumamidi, Ranmanagudem, Chagallu
Srikakulam	Ravada

Table 113. Incidence and intensity of Rugose white fly *A. rugioperculatus* on various plants in Andhra Pradesh

Common name	Scientific name	Spirals per leaflet/leaf	Intensity
Coconut	*Cocos nucifera*	>30	High
Oil palm	*Elaeis guineensis*	>30	High
Cocoa	*Theobroma cacao*	<10	Low
Banana	*Musa* sp	10 -20	Medium
Seethaphal	*Annona squamosa*	Spirals on entire leaf	High
Curry leaf	*Murraya koenigii*	Spirals on entire leaf	Medium
Jack fruit	*Artocarpus heterophyllus*	Lower no of spirals	Low
Papaya	*Carica papaya*	<10	Low
Yam	*Colacasia* sp	<10	Low
Mango	*Mangifera indica*	Lower no of spirals<10	Low
Ornamentals			
Bird of paradise	(*Strelitzia reginae*)	<10 (Low)	
Fish tail palm	*Wodyetia bifurcata*		
Spider lily	*Lycoris* sp.		
Areca palm	*Chrysalidocarpus lutescens*		
Cabbage tree	*Pisonia alba*		
Rose apple	*Syzigium malaccense*		
Heliconia	*Heliconia stricta var. Iris Red*		

The spraying of Azadirachtin 10,000 ppm @ 1ml per liter of water along with 10 gms of detergent powder, reduced whitefly adult population (Medium to nil level of infestation) when spraying was done at 20 days interval

Studies on per cent parasitisation of rugose whitefly after release of *Encarsia guadeloupae* in infested gardens of East and West Godavari districts by clipping method

Among the natural enemies the natural incidence of coconellid predator *Jauravia pallidula* was observed in Kalavalapalii village and natural incidence of *Dichochrysa* sp. nr. *astur* was observed in Kadiyapulanka nurseries. The parasitisation by *E. guadeloupae* was not observed in the white fly infested gardens and nurseries up to December 2017 in A.P.

As *E. guadeloupae* parasitoid is effective against the whitefly and was yet to establish in Andhra Pradesh, in December 2017 the parasitoids consignment were obtained from Coconut Research Station, Aliyarnagar, TNAU. The first consignment of 150 numbers of *E. guadeloupae* parasitized pupae was released in coconut gardens in Kalavalapalli village of West Godavari district on 18-12-2017. Further on 08-1-2018 a second consignment of 250 numbers of *E. guadeloupae* parasitized pupae were released in Oil palm and Coconut gardens in Kalavalapalli and Chikkala villages in West Godavari district . The third consignment of *E. guadelopae* parasitoid in higher numbers (3000 nos.) were obtained and distributed for release in Kalavalapalli, Chikkala, Neeladripuram, Korumamidi and Chagallu villages in West Godavari and Kadiyapulanka and Pottilanka villages in East Godavari on 20.01.2018. The data on parasitisation of Rugose white fly by *E. guadeloupae* was recorded to ascertain establishment of parasitoid in the released gardens. The parasitisation gradually increased and reached a maximum of 70 per cent 08.2.2018 On 17.2.18 the RSW parasitized leaf lets were cut for redistribution to neighbouring farmers and there after the parasitisation of RSW pupae recorded in this garden decreased gradually . However in oil palm garden in the same village the parasitoid effectively developed and complete reduction in spirals in lower whorl was observed. However, no leaf cuttings of parasitized pupae were carried out in the oil palm garden (Table 114).

Table 114. Per cent parasitized whitefly pupae observed after parasitoid release on oil palm and coconut in Kalavalapalli village

Date of observation	Per cent parasitized whitefly pupae observed (For 10 palms at random)	
	Coconut (Age of the garden 5 years old)	Oil Palm (Age of the garden 15 years old)
18.12.2017	Nil	Nil
8.1.2018	20	10
19.1.2018	60	40
8.2.2018	70	70
17.2.2018	70	60
	(parasitized pupae leaflets were cut for redistribution)	No spirals on lower whorl
5.3.2018	50	No spirals on lower whorl
22.3.2018	33	

Efficiency of yellow sticky traps in attracting rugose whitefly

The use of locally made yellow sticky traps (yellow colour tarpaulin sheet used for fish pond bunds purpose available and sufficient to prepare 10 traps of 1 m x 1 m size smeared with castor oil at three days interval) was promoted instead of commercially

available A4 size yellow sticky traps. The locally prepared yellow sticky were durable and cost effective and observation in two nurseries revealed that in palms where yellow sticky traps were placed on tree trunks at 5 feet height there was low adult, pupae and spirals of rugose whitefly compared to those on palms where sticky traps were absent (Table 115).

Table 115. Population of adult RSW, pupae and number of spirals in palms with and without yellow sticky trap (Average for 20 leaflets in lower whorl coconut leaf (Mean± SE)

VijayaDurga Nursery , Kadiyapulanka , East Godavari	**Adults**	**Pupae**	**Spirals**
With Yellow sticky trap	18.00 ± 1.81	37.90 ± 3.11	14.70 ± 0.91
Without Yellow sticky trap	66.50 ± 4.32	88.20 ± 6.06	26.30± 1.08
Sri Satya Deva Nursery Nursery , Kadiyapulanka , East Godavari	**Adults**	**Pupae**	**Spirals**
With Yellow sticky trap	9.90 ± 1.45	42.15± 5.54	16.05 ± 1.91
Without sticky trap	69.10 ± 3.16	97.90 ± 3.50	25.95 ± 1.05

18.1.5 CPCRI, Kayamgulam

Rugose Spiralling Whitefly (RSW) (*Aleurodicus rugioperculatus* Martian), an invasive pest on coconut reported from Pollachi (Tamil Nadu) and Palakkad (Kerala) during July-August 2016 was noticed to spread in all districts of Kerala (Palakkad, Malappuram, Thrissur, Idukki, Kozhikode, Kannur, Ernakulam, Kasaragod, Pathanamthitta, Alappuzha, Kollam and Thiruvananthapuram districts), Tamil Nadu (Pollachi, Pattukottai, Tiruppur, Thanjavur, Theni, Marthandam), Andhra Pradesh (Kadiyam, East Godavari- Damalacheruvu, Pottilanka; West Godavari-Kalavalapalli, Chikkala and Kakinada), Karnataka (Udupi, Mulki, Sulia Mangaluru, Dharwad), and Goa (Colva Beach) (Table 116). In several infested coconut gardens of these places, the pest incidence exceeded 20 adult whiteflies per palm leaflet.

Table 116. Distribution of RSW in major coconut growing areas of South India

State	**Place /district**	
	2016	2017
Kerala	Kollam, Pathanamthitta, Kottayam, Alappuzha, Ernakulam, Thrissur, Palakkad, Idukki	Thiruvananthapuram, Malappuram, Kozhikode, Kannur, Kasaragod
Tamil Nadu	Pollachi, Pattukottai	Tiruppur, Thanjavur, Krishnagiri, Kanyakumari, Theni
Andhra Pradesh	Kadiyampalanka	Damalacheruvu, Pottilanka (East Godavari) Kalavalapalli, Chikkala (West Godavari) on coconut & oil palm
Karnataka	Udupi	Mulki, Mangalore, Dharwad
Goa		Colva Beach (South Goa)

Molecular identification

Molecular characterization of mitochondrial cytochrome c-oxidase subunit I (*COI*) gene of *Aleurodicus* sp. collected from coconut in Chathenkari, Pathanamthitta (WFPT1, GenBank No. KY574536), Kozhinjampara, Palakkad (CN-WFP1a, GenBank No. KY574535), Oachira, Kollam (CN-WFKOa GenBank No. KY499623), Kumarakom, Kottayam (WFKT1, GenBank No. KY574534), Krishnapuram, Alappuzha (WFAL1, GenBank No. KY574533), Vellangallur, Thrissur (WFTb2, GenBank No. KY574537) and Pollachi, Coimbatore (WFTN2, GenBank No. KY574538) indicated 100% similarity with that of mitochondrial *COI* sequence of *A. rugioperculatus* reported from Florida, USA (GenBank No. KP032219) thus confirming the molecular taxonomic identity as *A. rugioperculatus* in confirmation with species-specific morphological characters (Rugose operculum, triangular lingula and dagger-like process on compound pores).

On the other hand, *Aleurodicus* sp. collected from guava in Krishnapuram, Alappuzha (WFG1AL1, GenBank No. KY574539) and Kumarakom, Kottayam (WFG1KT1, GenBank No. KY574540) identified as *Aleurodicus dispersus* based on morphological taxonomic keys showed 100% similarity with COI sequences of *A. dispersus* thus confirming the molecular taxonomic identity as *A. dispersus* (GenBank No. KC822647) All seven sequences of *A. rugioperculatus* obtained from Kerala and Tamil Nadu as well as two sequences of *A. dispersus* recorded from guava in Kerala were deposited in NCBI GenBank.

Host range

In the surveillance survey, various alternate plants (*Psidium guajava*, *Musa* sp., *Myristica fragrans, Colocasia sp., Garcinia sp., Annona muricata, Murraya koenigii, Spondias mombin, Annona squamosa, Mangifera indica, Heliconia stricta, Strelitzia reginae* and *Artocarpus heterophyllus Annona reticulata, Saccharum officinarum, Elaeis guineensis* and the ornamental yellow palm (*Dypsis lutescens*) have been registered as egg laying/ feeding hosts in coconut homesteads; however, the pest, was found to be relatively more confined to coconut, indicating its host preference. Despite egg laying noticed in other crops, *A. rugioperculatus* could not complete its life cycle and multiply in other crop hosts, except for banana and *H. stricta* to a small extent. It was categorically observed that certain host plants such as *Cassia siamea*, *Conocarpus erectus* and *Psidium gujava* had relative preference for *A. dispersus* indicating extreme host affinity. It is therefore of extreme importance to confirm the identity of the whitefly pest, before ascertaining the host. *A. rugioperculatus* was not observed from *C. siamea* and *C. erectus* so far. Based on the adult RSW population and feeding potential on palm leaflets, Chowghat Green Dwarf and King Coconut were found to be more susceptible than West Coast Tall inferring that the Tall cultivars are tolerant than the Dwarf genotypes (Table 117). In addition, feeding regions are mainly restricted on older leaflets than younger leaflets.

Estimation of damage level

The index followed for estimating damage level of RSW on coconut was; Low: < 10 adults/leaflet; Medium: 10-20 adults/leaflet and High: > 20 adults/leaflet.

Table 117. Incidence of RSW on dwarf coconut varieties at Kayamkulam

Variety	Palms infested (%)
Niu Lekha Dwarf	25.0
Andaman Green Dwarf	32.1
Malayan Green Dwarf	35.7
Gangabondam Green Dwarf	47.8
Gudanjali Green Dwarf	67.9
King Coconut	87.5
Chowghat Green Dwarf	89.3
West Coast Tall	9.5

Though the pest has been reported in different districts of Kerala, it has not caused any severe economic losses. Feeding was noticed to be confined mostly on the older whorl of coconut leaves. Extensive desapping of RSW would induce stress on the palms due to removal of water and nutrients, but neither colour change nor necrosis of leaves could be observed. Even though there was loss of photosynthetic efficiently due to the formation of sooty mould fungus (*Leptoxyphium* sp.) on coconut palms and understory intercrops, mortality of palms has not been observed. In case of severe attack, egg spirals could be located on leaf petiole, inflorescence as well as on tender coconuts.

A positive correlation with maximum temperature (r=0.950192) could be associated whereas the relative humidity (r=-0.85816) and rainfall (r=-0.73739) were found to be negatively correlated with the live colonies of RSW. Deficit rainfall and drop in subsequent humidity could be the main causes for the gradient outbreak of the pest in the recent times

Natural enemies

The taxonomic identity of the aphenilid parasitoid associated with most of the RSW colonies was confirmed by Dr. Mohammad Hayat, Aligarh Muslim University as *Encarsia guadeloupae* Viggiani as well as by molecular taxonomy (GenBank no. KY607910) by characterization of *COI* gene. It was observed that more than 30-50 % of the whitefly was parasitized by *Encarsia guadeloupae* in Chathenkari (Pathanamthitta district) and Kumarakom (Kottayam district) in Kerala during 2016-17 indicating the natural build of the parasitoids.

Observations from different parts of RSW prone tracts of Kerala during 2017-18, indicated that 60-80% of the RSW nymphs were parasitized by, *E. guadeloupae,* where the pest has appeared during 2016-17 confirming the natural establishment of the parasitoids. Enhancement in the level of parasitism by *E. guadeloupae* diminished the population of RSW in all regions. Conservatory biological control is therefore the key strategy to tackle this pest by resorting to pesticide holiday.

General predators *viz*., *Dichochrysa* sp. nr. *astur* (Banks) was observed during initial stages of RSW incursion, *Jauravia pallidula* (Motschulsky), a common predator was observed during active build up phase of RSW population and *Menochilus sexmaculatus* was observed during final and receding phase of RSW. In addition, lady beetles belonging to *Cybocephalus* sp. and *Sasajiscymnus* sp. and a wide array of spiders were also noticed in the

palm system. Among all the natural enemies, the most successful was the parasitism by the aphelinid parasitoid, *Encarsia guadeloupae* which could parasitize >85% RSW in a period of four to six months under field condition exemplifying conservatory biological control. Adult longevity of the aphelinid parasitoid, *Encarsia guadeloupae* was found to be 11 ± 4.8 days with honey supplementation. On an average three adult *E. guadeloupae* emerged from field collected 10 cm coconut leaflet infested by RSW . In this backdrop, 10 cm coconut leaflet containing parasitized RSW pupae was distributed to farmers in the new areas of RSW outbreak. More than 250 coconut leaflets (10 cm) containing parasitized RSW pupae were released in pest prone West Godavari region in Andhra Pradesh during January 2018.

Sooty mould feeding beetle

A novel discovery of sooty mould scavenging beetle, *Leiochrinus nilgirianus* Kaszab (Coleoptera: Tenebrionidae) was reported from coconut palms infested by RSW in Kerala, India. Scavenging action of *L. nilgirianus* and its immature stages on sooty mould deposits on coconut palms is very conspicuous and significant. Adult beetles, averaging 2.07±0.9/ leaflet, with a maximum of five beetles per leaflet, and immature stages were generally confined to the abaxial of the palm leaves during daytime, but were found feeding on sooty mould on the upper leaf surface during morning hours in damp conditions. *L. nilgirianus* was observed mainly on sooty mould covered leaves of coconut and sooty mould laden non-hosts such as custard apple (*Annona squamosa*) and *A. muricata*, indicating their preference to sooty mould, rather than the respective plants. Due to their feeding, the black sooty mould deposits were gradually and eventually completely cleansed and the leaves became bright green, reviving their photosynthetic efficiency. On an average one adult beetle could clear 1-2 mm^2 sooty mould laden area in a period of one minute. This is the first report on the bio-scavenging action of an insect in any economic crop so far.

18.2 Management of coconut black headed caterpillar using *Goniozus nephantidis* and *Bracon brevicornis* in endemic areas of Tamil Nadu / Karnataka (NBAIR)

Pre-treatment sampling was carried out in Avathavadi village in Krishnagiri district (Tamil Nadu) in July, 2017 to assess the incidence of the pest in the field and also to determine the natural enemy population if any. Trees of uniform height were selected for the study. 10% of the total number of palms was randomly selected for initial observation and pre-treatment sampling. The pre-release sampling was done for each palm by collecting and examining 20 leaflets. The larvae, pupae and adult stages of the pest from each leaflet were counted to arrive at the number of *Opisina arinosella* per leaflet.

The number of *Opisina arenosella* larvae/leaflet: Nil
Number of BHC cocoons (emerged)/leaflet: 0.46
Number of *Goniozus* pupae (emerged)/leaflet: 0.18

Even though the pest damage was observed in the field, the population of larvae of *O. arenosella*was almost nil and the collected cocoons of the pest were all emerged ones. So, the susceptible stage of the pest was not found in the field and therefore large-scale field trial was not undertaken. Nevertheless, one release of parasitoids (*Goniozus nephantidis*@ 20 female parasitoids/palmand *Bracon brevicornis*@ 30female parasitoids/palm) was undertaken for 1000 palms in Avathavadi village ofKrishnagiri district in Tamil Nadu.

Further, a farmer group meeting was convened in Krishnagiri and they were sensitized about the importance of biological control in the management of coconut black headed caterpillar. Field demonstration of the release of *Goniozus nephantidis* and *Bracon brevicornis* was also done so that the farmers will be encouraged to adopt the technique for the management of the pest in their field.

Another pre-treatment sampling was carried out in Kanakapura in Karnataka in October 2017. The sampling revealed the presence of only emerged cocoons and the population of susceptible stage of the pest, *i.e*., larvae was almost negligible.

The number of *Opisina arenosella*larvae/leaflet: Nil

Number of BHC cocoons (emerged)/leaflet: 0.38

Number of *Goniozus* pupae (emerged)/leaflet: 0.11

Since peak occurrence of the pest is normally observed from February to May, repeated surveys are being carried out for monitoring the pest incidence in Krishnagiri in Tamil Nadu and Kanakapura in Karnataka. The pest population was found to be almost nil in the pre-treatment samplings carried out in Krishnagiri and Kanakapura. When the repeated surveys being undertaken encounters the pest population in the larval stage (2nd to 7th instar), release of the parasitoids will be carried out at fortnightly intervals. Post release count will be taken on the number of larvae, pupae and larval parasitoids per 10 leaflets/ palm and monthly observations will be undertaken on the population of pest and larval parasitoids.

18.3 Screening of coleopteran specific Bt formulation (NBAIR strains) against red palm weevil (*Rhynchophorus ferrugineus*) at CPCRI, Kayamkulam

Three liquid formulations of coleopteran specific *Bacillus thuringiensis* (Bt) supplied by ICAR-NBAIR, Bengaluru, *viz.,* 4Aa1, 4AT2 and BTAN4 were tested on red palm weevil grubs under laboratory conditions (28-32°C, 80-90%RH). The stock solution was diluted ten times (10^{-1}) and tested on red palm weevil grubs having average weight of 2.2 grams by food contamination technique (by allowing the grubs to feed on incised coconut petiole of 10cm length smeared with 4 ml of the respective Bt preparation) combined with oral feeding of grubs (0.5 ml/grub) and an untreated control. The treated grubs were maintained individually along with food material (coconut petiole). Four treatments were imposed with above-mentioned formulations and control, which was replicated 5 times and observation on mortality of grubs at 24h interval till pupation and external symptoms specific to Bt infection.

There was no grub mortality up to 24h in any of the formulations tested. The formulation BTAN4 induced 8% mortality of grubs at 48h after treatment and attained maximum of 36% at 10 days after treatment. The formulation 4AT2 effected a maximum of 34% grub mortality at 10 days after treatment (Fig. 16).

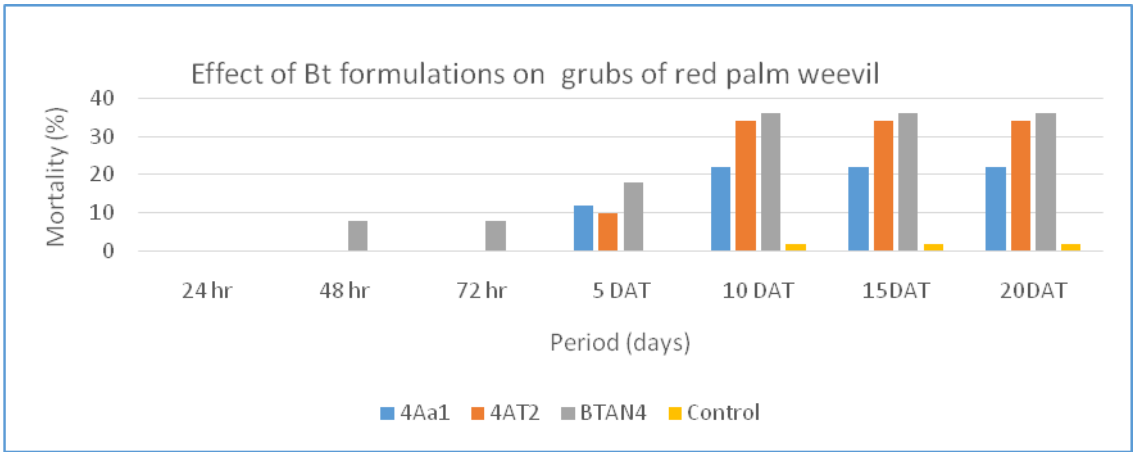


Fig. 16. Effect of Bt formulations on grubs of red palm weevil under laboratory conditions

Comparative performance of the various Bt formulations indicated relatively higher mortality of grubs with BTAN4 and 4AT2 over control at 10 days after treatment (Table 118).

Table 118. Effect of Bt formulations on grubs of red palm weevil

Treatment	Mortality (%) at 10 DAT
4Aa1	22 (4.64)[b]
4AT2	34 (5.41)[a,b]
BTAN4	36 (6.34)[a]
Control	02 (1.21)[c]
CD (0.01)	1.51

(Figures in parenthesis are square root transformed values)

Preliminary field evaluation of the formulation (BTAN4) on red palm weevil infested palms was carried out at Neendakara, Kollam district in farmer's field and could recover one palm out of 5 treated palms infested by red palm weevil.

18.4 Screening of coleopteran specific Bt formulation (NBAIR strains) against rhinoceros beetle (*Oryctes rhinoceros*) at CPCRI, Kayangulam

Three liquid formulations of *Bacillus thuringiensis* (Bt), *viz.*, 4Aa1, 4AT2 and BTAN4 were tested on grubs of rhinoceros beetle under laboratory conditions (28-32°C, 80-90%RH) at ICAR-CPCRI, Regional Station, Kayamkulam. The stock solution was diluted ten times (10^{-1}) and tested on I to III instars of grubs of rhinoceros beetle having weight ranging from 2.0 gram to 10.3 grams by food contamination combined with oral feeding of grubs. Grubs were treated orally with 0.5 ml of the test solution/grub and allowed to feed on sterilized cow dung treated with respective Bt formulations (100 gram of food treated with 4 ml of Bt formulation). Untreated control was maintained with same amount of sterilized water. The treated grubs were maintained individually along with food material in plastic containers.

Treatments: Four (4Aa1, 4AT2, BTAN4, control)
Replicates: 5 (10 grubs in each replicate)
Observation: Mortality of grubs at 24 hr interval till pupation and external symptoms specific to Bt infection

There was no mortality in first instar grubs (average weight of 2.0g) in any of the treatments at 24h after treatment. The formulation 4AT2 affected 12% mortality of grubs at 48h which showed a time depended effect up to 10 days after treatment (44%), beyond which there was no further mortality of grubs and all grubs pupated after 25 days of treatment. The formulations 4Aa1 and BTAN4 induced maximum of 30% and 14% grub mortality at 10 days of treatment. The formulations tested on 2nd instar grubs indicated maximum of 22% grub mortality with 4AT2 at 10 DAT followed by 20% mortality with 4Aa1 and BTAN4. With advanced age /weight of grubs, mortality was reduced to a maximum of 20% and 6% respectively, with grub weight of 7.4 g and 10.3 g at 20 DAT with 4AT2 (Fig. 2 to Fig. 5).

Comparative performance of Bt formulation on grubs of rhinoceros beetle indicted that all the three strains are equally efficacious inducing mortality as high as 44% of early instar grubs at 10 days after treatment. The mortality is age depended which showed reduction at advance stages of grub development (Table 119).

Table 119. Effect of Bt formulations on grubs of rhinoceros beetle

Treatments	Mortality (%)			
	1 instar grubs at 10 DAT	II instar grubs at 10 DAT	Early III instar grubs at 20 DAT	Late III instar grubs at 30 DAT
4Aa1	30 (5.46) [a]	20 (4.47)[a]	14 (3.51) [a]	04 (1.72)
4AT2	44 (6.65)[a]	22 (4.67)[a]	20 (4.38)[a]	06 (2.23)
BTAN4	14 (3.75)[b]	20 (4.47)[a]	16 (3.71)[a]	02 (1.21)
Control	04 (1.72)[c]	00 (0.70) [b]	00 (0.70)[b]	00 (0.70)
CD (0.01)	1.913	1.409	2.717	NS

(Figures in parenthesis are square root transformed values)

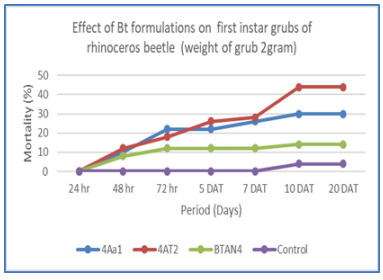


Fig. 17

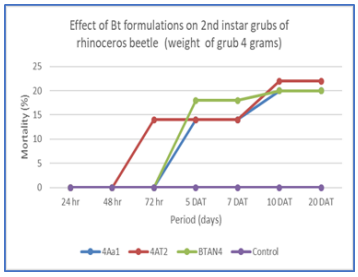


Fig. 18

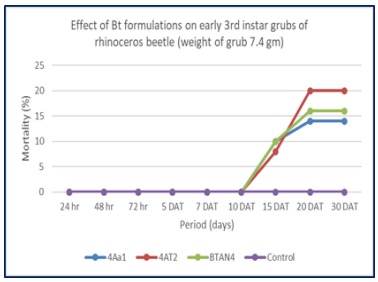


Fig. 19

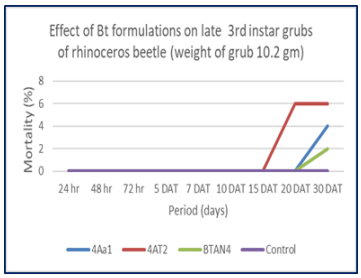


Fig. 20

Fig. 17 to Fig. 20. Effect of Bt formulations on various instars grubs of rhinoceros beetle

VEGETABLE CROPS

19 TOMATO

19.1 Bio-intensive management of *Helicoverpa armigera, Tuta absoluta* and sucking pests of tomato (YSPUHF, MPKV, PJTSAU, TNAU, PAU, AAU-A, IIVR)

19.1.1 YSPUHF, Solan

Experiment for bio-intensive management of *Helicoverpa armigera, Tuta absoluta* and sucking pests of tomato was conducted at the experimental farm of the Department of Entomology, YSP University of Horticulture and Forestry Nauni, Solan (HP). Bio-intensive Integrated Pest Management (BIPM) module comprising of pheromone trap (PCI), marigold as trap crop, six releases of *Trichogramma achaeae* @ 50000/ha, two sprays of azadirachtin 1500ppm @ 2ml/L, one spray of *Lecanicillium lecanii* (5g/L of 10^8 conidia/g) was evaluated against *Helicoverpa armigera, Tutaa bsoluta* and sucking pests of tomato (cv. Solan Lalima). Chemical control where the crop was sprayed with chlorantraniliprole 18.5EC and indoxacarb 14.5EC, and untreated control where no treatment was sprayed were used for comparison. The treatments were applied in June end, because initiation of *Tuta absoluta* attack was noticed. *Trichogramma achaeae* was released six times at weekly intervals and azadirachtin was applied twice at 15 days interval, while, only one spray of *Lecanicillium lecanii* was given towards the end of the cropping season when aphid, *Macrosiphum euphobiae* population appeared on the crop. In chemical control, two sprays of chlorantraniliprole 18.5EC and one of indoxacarb 14.5EC were given. Observations on the number of mines per leaf, number of fruits infested by *Tuta absoluta* and *Helicoverpa armigera* were recorded separately on 10 randomly selected plants per plot. The population of *Macrosiphum euphobiae* was also recorded in the top 10 cm length of 10 randomly selected plants per plot. The observations were recorded at fortnight interval starting from mid-July till the final harvest of the crop i.e. mid-September. Yield data from each plot were recorded at each picking and were pooled to get the total yield, which was extrapolated to get yield per hectare in each plot. The experiment was laid out in a randomized block design and data were subjected to analysis of variance. The results are presented in tables 3-5 and described as under.

Incidence of *T. absoluta* on leaves

The number of mines by *Tuta absoluta* as recorded on 16th of July 2017 were statistically on par in all the plots and varied from 5.3 to 5.7 mines/leaf. As the time progressed the incidence of *T. absoluta* decreased both in BIPM and chemical plots, while, in untreated plot it increased and on 1st August 2017, the pest incidence was 4.2 mines/leaf in BIPM plot, 3.4 mines/leaf in chemical plot and 8.5 mines/leaf in untreated plot (Table 120). On 17th of August, the incidence was 2.6, 2.4 and 5.8 mines per leaf in BIPM, chemical and untreated plots, respectively. Whereas on 4th of September the incidence was 2, 2.4 and 6.6 mines, respectively. Both the BIPM module and the chemical insecticides were equally effective in managing this pest. Between 1st and 17th of August, there was a natural reduction in the incidence of *T. absoluta,* probably due to more rainfall during the period as preliminary laboratory experiments revealed less oviposition by the pest on wet leaves than on dry leaves.

Table 120. Infestation of *Tuta absoluta* on tomato leaves in different plots

Treatment	Mines/leaf on indicated dates			
	July 16	August 1	August 17	September 4
BIPM	5.5 ± 0.8	4.2 ± 0.5	2.6 ± 0.5	2.0 ± 0.5
Chemical control	5.7 ± 0.7	3.4 ± 0.4	2.4 ± 0.4	2.4 ± 0.5
Untreated control	5.3 ± 0.6	8.5 ± 0.7	5.8 ± 0.7	6.6 ± 1.3
CD (0.05)	NS	1.3	1.5	2.4
CV (%)	24.7	25.9	44.9	68.5

Incidence of *T. absoluta* on fruits

The average fruit infestation recorded on 16th of July 2017 was statistically same in all the plots and varied from 0.66% in chemical plots to 0.78% in untreated plots. With the passage of time (17th of August 2017), the incidence increased in all the plots and was 1.68%, 1.26% and 3.16% in BIPM, chemical and untreated plots, respectively. (Table 121). Thereafter, the percentage of infested fruits decreased in the BIPM plot, whereas, it went on to increase gradually in both the chemical as well as untreated control plots and was 1.64%, 1.3% and 3.64%, and 1.28%, 1.4%, 5.44% on 4th and 18th September in BIPM, chemical and untreated plots, respectively. Both the BIPM and chemical insecticides were equally effective in reducing the fruit infestation caused by *T. absoluta*in in tomato. The yield was maximum (31 t/ha) in chemically treated plots, but, statistically on par (28.5 t/ha) with that recorded in BIPM plots. In untreated plots, the yield was, however, significantly lower (15.5t/ha) than recorded in the BIPM or the chemically treated plots.

Table 121. Infestation of *Tuta absoluta* on tomato fruits in different plots

Treatment	Infested fruits (%) on indicated date					Yield (t/ha)
	July 16	August 1	August 17	Sept 4	Sept 18	
BIPM	0.74 ± 0.10 (1.31 ± 0.04)	1.24 ± 0.12 (1.49 ± 0.04)	1.68 ± 0.15 (1.63 ± 0.05)	1.64 ± 0.13 (1.62 ± 0.04)	1.28 ± 0.16 (1.5 ± 0.06)	28.5 ± 1.5
Chemical control	0.66 ± 0.06 (1.29 ± 0.02)	0.96 ± 0.08 (1.4 ± 0.03)	1.26 ± 0.13 (1.5 ± 0.05)	1.3 ± 0.12 (1.51 ± 0.04)	1.4 ± 0.26 (1.53 ± 0.09)	31.0 ± 1.8
Untreated control	0.78 ± 0.1 (1.33 ± 0.04)	1.66 ± 0.11 (1.63 ± 0.04)	3.16 ± 0.28 (2.03 ± 0.08)	3.64 ± 0.41 (2.13 ± 0.1)	5.44 ± 1.07 (2.24 ± 0.18)	15.5 ± 1.0
CD (0.05)	NS	0.14	0.21	0.21	0.63	4.7
CV (%)	4.5	9.4	13.1	12.6	18.7	19.9

Incidence of *H. armigera*

The incidence of *Helicoverpa armigera* was very low throughout the cropping season. On 16th of July, 2017 the fruit infestation resulted by *H. armigera* varied from 0.62 to 1.18% and was statistically on par in different plots. Thereafter, only negligible fruit damage by the fruit borer was recorded and the data has not been presented in the report.

Incidence of *Macrosiphum euphorbiae*

Towards the end of the cropping season, the incidence of tomato aphid, *Macrosiphum euphorbiae* has been recorded on the tender shoots of the plants. The aphid population recorded on top 10 cm length of the shoot on 4th of September was lowest (5.4) on chemically treated plants, followed by on par population (13.8) in BIPM plots. In untreated control plots, the aphid population was 29.6 (Table 122). On 18th of September final harvesting of the fruits was done, hence the aphid population was not recorded, only the data on fruit infestation on that date was recorded.

Table 122. Incidence *Macrosiphum euphorbiae*on tomato shoots in different plots

Treatment	Aphids/ 10 cm length of top shoot				
	July 16	August 1	August 17	Sept 4	Sept 18
BIPM	-	-	-	13.8 ± 5.2	-
Chemical control	-	-	-	5.4 ± 2.3	-
Untreated control	-	-	-	29.6 ± 8.2	-
CD (0.05)				17.6	

19.1.2 MPKV, Pune

The experiment was conducted in the Research Farm of Agricultural Entomology Section, College of Agriculture, Pune. The experiment was carried out during 8/3/2017 to 27/08/2017. Tomato variety 'Namdhari 501' was used for the experiment and was sown in 90 x 45 cm spacing. The experimental field of an area 8.0 x 5.0 m plot size used for this study. The experiment was laid out in a randomized complete block design with following treatments.

T1: BIPM

i) Seed treatment with *Trichoderma harzianum* @ 10g/kg of seed.
ii) Raising marigold as trap crop.
iii) Use of NBAIR pheromone traps @ 1 trap per plot.
iv) *Trichogramma achaeae/ Trichogramma pretiosum* @ 50000 per release (6 releases)
v) Azadirachtin 1500 ppm @ 2 ml/lit.
vi) *Lecanicillum lecanii* (NBAIR) 1 x 10^8 spores/ g @ 5 g/lit for sucking pests

T2: Chemical control

i) Chlorantraniliprole 18.5% SC for *Tuta* and indoxacarb 14.5 SC for other pests

T3: Untreated control

The observations on the larval population of *H. armigera* and percent fruit infestation were recorded on ten randomly selected plants per plot. The observations of sucking pests such as thrips and whiteflies were recorded at 30, 45 and 60 days after transplanting (DAT). The yield

of healthy marketable fruits per plot was recorded at each picking. The fruit damage caused by *H. armigera* was recorded at weekly interval.

The results indicated that the treatments with BIPM were found significantly superior over other treatments by recording a minimum number of larval population of *H. armigera* (2.20 larvae/ten plants) with fruit damage on number basis (16.60%) and on a weight basis (14.80 %). In case of sucking pests population the treatment with BIPM recorded minimum number of 2.97 thrips/ plants and 2.93 whiteflies/plants. The highest marketable fruit yield (218.25 q/ha) was recorded in BIPM treated plots whereas untreated control plot recorded lowest yield (156.40 q/ha) (Table 123 & Table 124).

The incidence of American pinworm, *Tuta absoluta* on tomato was not observed throughout the season. Therefore the data on *T. absoluta* is not included in the report.

Table 123. Effect of BIPM against *H. armigera* on tomato

Treatment	Larval population/10 plants		Fruit infestation (%)		Yield (q/ha)
	Pre-count	Post count	No. basis	Wt. basis	
T1: BIPM	10.60a	2.20[a]	16.60[a]	14.80[a]	218.25[a]
T2: Indoxacarb 14.5 SC	10.80[a]	5.40[b]	19.20[b]	17.40[b]	187.70[b]
T3: Untreated control	10.60[a]	17.60[c]	35.80[c]	33.40[c]	156.40[c]
CD (p = 0.05)	NS	0.35	1.17	1.74	23.14

Table 124. Effect of BIPM against sucking pests on tomato

Treatment	Thrips/plant				whitefly/ plant			
	30 DAT	45 DAT	60 DAT	AV	30 DAT	45 DAT	60 DAT	AV
T1: BIPM	4.20[a]	2.70[a]	2.00[a]	2.97[a]	3.40[a]	3.10[a]	2.30[a]	2.93[a]
T2: Indoxacarb 14.5 SC	5.40[a]	8.00[b]	9.30[b]	7.57[b]	4.20[b]	4.80[b]	6.20[b]	5.07[b]
T3: Untreated control	7.60[b]	10.10[c]	13.50[c]	10.40[c]	5.60[c]	6.30[c]	8.20[c]	6.70[c]
CD (p = 0.05)	0.33	0.39	0.25	0.3	0.19	0.18	0.28	0.23

*DAT: Days After Transplanting; AV- Average

19.1.3 PJTSAU, Hyderabad

T1 = BIPM

Seed bio-priming with *Trichoderma harzianum* @ 10g/kg of seeds.
Use of pheromone traps @ 1 trap per plot.
Trichogramma achaeae / Trichogramma chilonis @ 50,000 per release (6 releases)
Chryosperla zastrowi sillemi @ 5000 larvae/ha and *Beauveria bassiana* @ 10^8 conidia/g for sucking pests
Azadirachtin 10000 ppm @ 2 ml/lit.

T2 = Chemical control
Chlorantraniliprole 18.5% SC for *Tuta* and indoxacarb 14.5 SC for other pests

T3 = Untreated Control

Design **:** RBD
Replications **:** Five
Plot Size **:** 4x5 m
Variety **:** Local
Season **:** *Rabi*, 2017-18

Methodology and observations:
The treatment applications wer started at initial occurrence of American pin worm. Six releases of parasitoids at weekly interval and three sprays of Bio Pesticides were given during evening hours at fortnightly interval.

- Randomly selected 10 plants in unit plot area were observed for presence of leaf mine caused by the larva.
- Randomly selected 10 plants/ unit plot area crop area and observed all the fruits for presence of holes/ damage caused by the larva.
- Observations were recorded at fortnightly interval from fruit formation to last harvest.
- Fruit damage percentage and yield.
- Cost-benefit ratio.

Status of the trial:

The trial is recently harvested in March, 2018. The outcome of the experiment will be submitted within week after processing and analyzing of data recorded.

19.1.4 TNAU, Coimbatore

The details of the experiment are given below

Name of the Farmer	: Th. Anandkumar
Location	: Thirumalayampalayam, Kinathukadavu
Date of sowing African Marigold	: 7.8.2017
Tomato Hybrid	: Laxmi
Spacing	: 60 x 45 cm
Date of Transplanting	: 18.8.2017
Installation of Pheromone trap	: 25.9.2017
Release of *Trichogramma pretiosum*	: 1.10.2013, 17.10.2017, 2.11.2017, 14.11.17, 28.11.17 and 11.12.17
Azadirachtin spray	: 27.9.2017
Lecanicillium lecanii spray	: 18.9.2017
Date of final harvest	: 7. 2.2018

Treatments

$T_{1:}$ BIPM package

Seed treatment with *Trichoderma harzianum* @ 10g/kg of seeds; Raising marigold as trap crop Use of NBAIR pheromone traps @ 1 trap per plot; *Trichogramma achaeae / Trichogramma pretiosum* @ 50,000 per release (6 releases); Azadirachtin 1500 ppm @ 2 ml/lit; *Lecanicillium lecanii* (NBAIR) 1x 10^8 spores/ g @ 5g/lt for sucking pests;

T2: Chemical control

Chlorantraniliprole 18.5% SC for *T. absoluta* and indoxacarb 14.5 SC for other pests

T3: Untreated Control

Plot size: 10 cents/treatment

Observations

The population of aphids, thrips, leaf hoppers, whiteflies and fruit borer were recorded at 15 days interval; a natural enemy activity was recorded; Yield data were also recorded.

The results indicated that in the bio-intensive IPM field, after 60 days after planting, the population of thrips was significantly lesser than farmers practice but with respect to the population of leaf hopper and whiteflies, both the treatments were on par and significantly better than control plot (Table 125).

The percent leaf damage caused by *T. absoluta* (4.10%) in BIPM plot was on par with chemical treatment plot (4.50%) and proved significantly better than control plot at 60 days after treatment (DAT) whereas at 105 DAT, the fruit damage caused by *H. armigera* (5.16%) was significantly lesser in BIPM plots when compared to chemical treatment plot (10.92%) and control plots (14.80%). At 105 DAT, the fruit damage caused by *T. aboluta* (5.30%) was significantly lesser in BIPM plots when compared to the chemical treatment plot (9.10%) and control plots (18.50%).

The fruit yield (30.65 t/ha) was significantly higher in BIPM plot as compared to chemically treated plot (27.45 t/ha) and control plot (23.00 t/ha) with a cost-benefit ratio of 1:5.95 (Table 126). The BIPM plot was significantly superior to farmers practice by recording lower population of sucking pests and lesser fruit damage by *H. armigera* and *T. absoluta* besides higher fruit yield.

Table 125. Field demonstration of BIPM package for the management of key sucking pests of tomato

Treatments	Population of Sucking pests- DAS (5 plants)								
	Leafhoppers			Whiteflies			Thrips		
	30	45	60	30	45	60	30	45	60
BIPM	11.10 (3.32)[a]	17.90 (4.22)[a]	11.50 (3.38)[a]	1.30 (1.09)[a]	3.50 (1.78)	3.10 (1.73)[a]	5.70 (2.38)[a]	4.70 (2.13)[a]	4.30 (2.07)[a]

Farmers practice	11.30 (3.36)[a]	20.10 (4.47)[ab]	11.50 (3.39)[a]	2.10 (1.44)[a]	4.10 (2.01)	4.10 (2.01)[a]	9.10 (3.01)[b]	5.10 (2.25)[a]	7.50 (2.73)[b]
Control	18.30 (4.28)[b]	24.10 (4.90)[b]	21.90 (4.67)[b]	4.10 (2.01) [b]	6.30 (2.50)	7.10 (2.50)[b]	12.10 (3.47)[c]	13.90 (3.71)[b]	15.90 (3.97)[c]
SEd	0.13	0.22	0.15	0.22		0.17	0.14	0.26	0.16
CD	0.29	0.51	0.35	0.51		0.40	0.32	0.600	0.37
CV	5.45	7.68	6.28	23.08	NS	12.84	7.42	15.27	8.70

Means followed by a common letter in a column are not significantly different by DMRT; Figures in parentheses are square root transformed

19.1.5 PAU, Ludhiana

The experiment on bio-intensive pest management of *Helicoverpa armigera* and sucking pests of tomato is being conducted at Entomological Research Farm, PAU, Ludhiana. The seedlings of tomato (commercial variety) were transplanted at the farm on February 26, 2018. The layout of the experiment has been done as per the following treatments.

Treatments:

T1: BIPM

- Seed treatment with *Trichoderma harzianum* @ 10g/kg of seeds
- Raising marigold as trap crop
- Use of NBAIR pheromone traps @ 1 trap per plot
- *Trichogramma achaeae / Trichogramma pretiosum* @ 50,000 per release (6 releases)
- Azadirachtin 1500 ppm @ 2 ml/lit.
- *Lecanicillium lecanii* (NBAIR) 1x 10^8 spores/ g @ 5g/lt for sucking pests

T2: Chemical control - Chlorantraniliprole 18.5% SC for *Tuta* and indoxacarb 14.5 SC for other pests

T3: Untreated Control

The experiment is in progress. The crop is daily monitored for the incidence of pests. The above mentioned treatments will be started given and the data will be recorded as soon as these pests are observed in the field. So far, there is no pest incidence in the crop in Ludhiana.

Table 126. Field demonstration of BIPM package for the management of *Helicoverpa* and *Tuta* in tomato in Coimbatore

Treatment	Per cent fruit damage by *Helicoverpa armigera*				Per cent leaf damage by Leaf miner				Per cent fruit damage by Leaf miner				Fruit yield (Kg/ha)	CB Ratio
	75 DAT	90 DAT	105 DAT	% reduction over control	30 DAT	45 DAT	60 DAT	% reduction over control	75 DAT	90 DAT	105 DAT	% reduction over control		
BIPM	7.41 (15.76)[a]	7.79 (16.19)[a]	5.16 (12.98)[a]	65.13	1.10 (5.66)	2.80 (9.56)[a]	4.10 (11.68)[a]	62.72	2.80 (9.62)[a]	4.10 (11.68)[a]	5.30 (13.28)[a]	71.35	30650 (4.49)[a]	5.95
Farmers practice	11.54 (19.82)[b]	12.04 (20.27)[b]	10.92 (19.24)[b]	26.21	1.30 (6.07)	4.40 (12.11)[b]	4.50 (12.25)[a]	59.09	4.40 (12.11)[b]	5.10 (13.02)[b]	9.10 (17.56)[b]	50.81	27450 (4.44)[b]	3.41
Control	14.78 (22.58)[c]	15.77 (23.40)[c]	14.80 (22.61)[c]	-	2.64 (9.01)	4.50 (12.25)[b]	11.00 (19.36)[b]	-	11.10 (19.46)[c]	15.50 (23.18)[c]	18.50 (25.47)[c]	-	23000 (4.36)[c]	2.48
SEd CD CV	0.70 1.61 5.70	0.59 1.37 4.72	0.99 2.28 8.56	-	NS	0.48 1.11 6.75	0.30 0.71 3.38	-	0.23 0.54 2.70	0.40 0.93 4.01	0.38 0.88 3.23	-	0.007 0.016 0.26	

Means followed by a common letter in a column are not significantly different by DMRT; Figures in parentheses are arcsine transformed values (Damage), Figures in parentheses are logarithmic transformed values (Yield); Values are mean of five replications

19.1.6 AAU, Anand

Year of commencement: 2017-18 - *rabi* season
Location: Farmer field, Runaj, Sojitra Taluk, Anand Dist
Methodology and treatments:

Variety	:	Alankar –Hybrid (F1)
Plot size	:	8x5 m
Spacing		60x30 cm
Layout	:	Randomized Block Design (RBD)
Treatments	:	**T1 = BIPM** 1. Seed bio-priming with *Trichoderma harzianum* @ 10g/kg of seeds. 2. Raising marigold as trap crop 3. Use of NBAIR pheromone traps @ 1 trap per plot. 4. *Trichogramma achaeae / Trichogramma chilonis* @ 50,000 per release (6 releases) 5. Azadirachtin 1000 ppm @ 2 ml/lit 6. *Lecanicillium lecanii* Vl-8 ($1x10^8$) @ 5g/lit for sucking pests **T2 = Chemical control** Chlorantraniliprole 18.5% SC for *Tuta* and indoxacarb 14.5 SC for other pests **T3 = Untreated Control**
Replications	:	Five
Methodology and observations	:	The treatment application was started at initial occurrence of pests. Six releases of parasitoids at weekly interval and three sprays of bio-pesticides were given during evening hours at fortnightly interval. • Randomly selected 10 plants/$40m^2$ crop area and observed all the leaves for presence of leaf mine / sucking pests caused by the larva. • Randomly selected 10 plants/ $40m^2$ crop area and observed all the fruits for presence of holes/ damage caused by the larva. • Observations were recorded at fortnightly interval from fruit formation to last harvest. • Fruit damage percentage and yield. • Cost-benefit ratio.

Fruit borer *Helicoverpa armigera* incidence was observed, whereas there was no incidence of *Tuta absoluta* and sucking pests during the experimental period. No significant difference was observed between BIPM package and chemical control with regard to the parameters *viz*., the number of larvae/plant and fruit damage as compared to untreated control. BIPM package found equally effective as a chemical control against *H. armigera*. Similarly with

regard to fruit yield recorded in chemical control module (16.43 t/ha) was at par with the yield recorded in BIPM package (16.25 t/ha). However, low yield was recorded in the untreated control (10.89 t/ha) (Table 127).

Table 127. Effect of different modules on incidence of *H. armigera* and yield of tomato

Modules		***H. armigera* larvae / plant***	**Fruit damage* (%)**	**Fruit yield (t/ha)**
BIPM Package		1.21 (1.46)	19.70 (11.36)	16.25
Chemical Control		1.19 (1.42)	19.68 (11.34)	16.43
Untreated Control		1.70 (2.89)	29.62 (24.43)	10.89
S. Em. ±	T	0.07	0.76	0.68
	P	-	-	-
	T x P	-	-	-
C. D. at 5 %	T	0.20	2.30	2.06
	P	-	-	-
	T x P	-	-	-
C. V. %		13.76	9.31	13.24
Mean of five observations; * $\sqrt{x + 0.5}$ transformed values; ** Arc sin transformed values, Figures in parentheses are retransformed values				

Additional Work

Location and agro climatic sub region: Gujarat

Work carried out during the current year:

In the year 2017-18 regular survey was conducted to ascertain the outbreak of invasive pest tomato pinworm.

Methodology:

a) Survey was conducted in randomly selected villages in few districts of Gujarat to determine the infestation of *T. absoluta*.
b) Initially during the crop growth period the activity of adult moths was monitored by using sex pheromone traps.
c) Percentage of plants infested with *T. absoluta* was assessed by observing 10 randomly selected plants in every 100 sq. m crop area and leaves were observed for the presence of leaf mine caused by larva and fruits were also observed for the presence of pin head sized holes.
d) The incidence of *Tuta* in other crop fields' *viz*., potato, brinjal, chilli, and tobacco was also surveyed and observations were recorded.

Observations recorded:

1. Date and place of survey
2. Crop plants infested and percent damage
3. Non host crops and weeds infested
4. Existing natural enemies in 25 randomly selected plants

Trace incidence was reported from farmers' fields in North Gujarat region. In the month of February 2018/ severe incidence was reported in Sabarkantha district of North Gujarat. Natural enemy *Nesidiocoris tenuis* was observed (Table 128).

Table 128. Survey and surveillance details on tomato pinworm *Tuta absoluta* in Gujarat

Date	Place	Crop plants infested, Non host crops and weeds	Pest Infestation (%)	Natural enemies
12/12/2017 14/01/2018 26/01/2018	Village: Maniyor Ta-Idar Dist- Sabarkantha	Tomato	NIL	NIL
13/12/2017 15/01/2018 27/01/2018	Village: Umedgadh Ta- Idar Dist- Sabarkantha	Tomato	NIL	NIL
13/12/2017 15/01/2018 27/01/2018	Village: Surpur Ta-Idar Dist: Sabarkantha	Tomato	Traces	NIL
09/02/2018	Village: Savasala Kampa Ta- Vadali Dist-Sabarkantha	Tomato	70-80%	*Nesidiocoris tenuis* (15-20/plant)

19.1.7 IIVR, Varanasi

Variety : Kashi Aman
Plot size : 8x5 m^2
Layout : Randomized Block Design.
Replication : Five

Bio-intensive pest management module (BIPM) comprising seed treatment with *Trichoderma harzianum@* 10g/kg of seeds; raising marigold as trap crop; use of NBAIR pheromone traps @ 1 trap per plot; inoculative six-release of *Trichogramma pretiosum@* 50,000 / release and spraying of Azadirachtin 1500 ppm @ 2 ml/lit; and *Lecanicillium lecanii*(NBAIR) $1x10^8$ spores/ g @ 5g/lit for sucking pests was compared with chemical control (Chlorantraniliprole 18.5% SC for *Tuta* and Indoxacarb14.5 SC for other pests) and untreated control against insect pests complex of tomato. The major insect pests encountered during the observation were whitefly (*Bemisiatabaci*), Aphid (*Aphisgossypii*), Jassid (*Amrasca* spp.), leaf miner (*Liriomyzatrifolii*) and tomato fruit borer (*Helicoverpaarmigera* and *Tutaabsoluta*) along with the predatory mirid bug (*Nesidiocoristenuis*) during January to April, 2018 at the experimental plots of ICAR-IIVR, Varanasi, Uttar Pradesh. From the Table 129, it is evident that lowest whitefly (0.27), aphid (0.20), jassid (0.23) and leaf miner (0.97) populations per leaf were recorded in the BIPM module followed by the chemical module with 0.43, 0.40, 1.30 and 0.30 pest population per leaf, respectively. In contrast, untreated control plots harbored maximum whitefly (1.17), aphid (1.13), jassid (2.15) and leaf miner (1.70) population per leaf. However,

lowest fruit damage by its borer complex was recorded in chemical control module (1.44%) followed by BIPM module (5.05%) where maximum fruit damage (19.54%) was recorded in the untreated control (Table 1).Similarly, the occurrence of predatory mirid bug (*Nesidiocoristenius*) was recorded maximum in untreated control plots (2.71 bugs/leaf) followed by BIPM module (2.29) treated plots and lowest predator population (0.30) was in plots treated with chemical insecticides (Plate 16).

Table 129. Effect of different pest management module of tomato

Treatments	Whitefly/ leaf	PROC#	Aphid / leaf	PROC#	Jassid / leaf	PROC#	Leaf miner / leaf	PROC#	Fruit damage (%)	PROC#	Predatory mirid bug /leaf
BIPM	0.27	76.92	0.20	82.30	0.23	89.30	0.97	42.94	5.05	74.16	2.29
Chemical control	0.43	63.25	0.40	64.60	1.30	39.54	0.73	57.06	1.44	92.63	0.30
Untreated control	1.17	--	1.13	--	2.15	--	1.70	--	19.54	--	2.71
CD (5%)	0.49		0.53		0.87		0.71		3.10		1.13

#PROC = Per cent reduction over control

Plate 16. Experimental layout of tomato at ICAR-IIVR, Varanasi

19.2 Large scale field trial for the management of *Helicoverpa armigera* infesting tomato (MPUAT – 2 ha)

An experiment on validation of Ha NPV against *H. armigera* in tomato at farmers' field was conducted.

Location: Farmers field

Crop: Tomato

Variety: Dev

IPM Modules:

1. Installation of pheromone traps @ 5/ha.
2. Release of *Trichogramma chilonis* @100,000/ha. (3 release at weekly interval)

3. Two sprays of *Ha* NPV first at flowering stage and second after 15 days of first spray.

Nursery Raising: Well prepared nursery beds were mixed with *Trichoderma* enriched FYM.
Date of Nursery: 15.08.2017
Date of Transplanting: 20-25 August, 2017
IPM Modules: IPM module comprises of 3 weekly releases of *T. chilonis* @ 1 lac/ha followed by 2 sprays of *Ha*NPV, first when 3-4 adult moths are captured in the pheromone trap and second spray @15 days after the first spray.

The data revealed that the lowest per cent fruit damage was recorded in IPM module (4.0%) followed by farmers practice (6.2%). The same trend has been observed with respect to yield. The Highest yield was recorded in IMP module (198.0 q/ha) followed by farmers practice (193.0 q/ha) (Table 130) (Plate 17).

Table 130. Validation of *Ha*NPV against *H. armigera* in tomato in farmers field (Average of 10 farmers)

Treatments	Per cent infested fruits	Yield q/ha.	
		Infested	Uninfested
IPM Practices (Mean of 10 Farmers)	4.0	8	190
Farmers practices (Mean of 10 Farmers)	6.2	12	181
Control	41.5	78	110

* The trial was conducted at village Piladar 10 farmers of 0.2 ha. each was selected and critical inputs was supplied at time to time i.e. for monitoring the infestation pheromone trap was installed @ 2/farmers and the spray were made time to time.

Plate 17. Seedling treatment with *Trichoderma*

20. BRINJAL

20.1 Role of habitat manipulation for insect pests, nematodes and natural enemies in brinjal (AAU-J; TNAU)

20.1.1 AAU, Jorhat

Location: Organic plot, Experimental Farm, Department of Horticulture, AAU, Jorhat
Plot size: 5 X 5.5 m^2
Replication: 5 and randomized block design
Date of planting: 07.10.2017

Treatments
T1: Brinjal intercropped with Coriander and Carrot as border crop.
T2: Brinjal intercropped with Carrot and Cowpea as border crop.
T3: Brinjal intercropped with Cowpea and Coriander as border crop.
T4: Brinjal as sole crop.

Observation on the population of sucking pests (aphids/ leaf) was recorded by selecting 5 plants randomly throughout the cropping season (starting from 25 days after treatment) at 15 days interval. Similarly, percent infestation on shoot and fruit stages of the crop was also recorded (Plate 18). The population of predators (coccinelids) was recorded on a plant at 15 days interval. Moreover, to collect the parasitoids from sucking and lepidopteran larvae, the insects were kept in the laboratory for the emergence of parasitoids, if any. The leafhopper population was negligible during the cropping season; therefore, statistical analysis could not be done. Marketable yield at each harvest was recorded and converted into q/ha.

The incidence of sucking pest (aphids/ leaf) and *Leucinodes orbonalis* in various treatments showed that, brinjal intercropped with either carrot or cowpea as border crop (Treatment-2) recorded the least population of aphid (0.86/leaf) and infestation of *L. orbonalis* in shoot (9.19%) and in fruit (12.94%) with an maximum yield of 201.87 q/ha over brinjal as sole crops (Treatment- 4). Significantly, higher number of coccinellids predator population of 2.92/ plant was also recorded in brinjal intercropped with carrot and cowpea as border crop (Treatment-2) followed by brinjal as a sole crop (Treatment - 4) and brinjal intercropped with coriander and carrot as a border crop (Treatment -1) with 2.80 and 1.52 /plant , respectively. The highest number of aphids (4.26/leaf) and damage to shoot (13.15 %) and fruit (20.0%) was recorded in brinjal as a sole crop with the lowest yield of 138 q/ha (Table 131).

Table 131. Effect of different treatments for insect pests and natural enemies in brinjal

Treatment	Aphids/ leaf	Leaf Hopper/ leaf	BSFB		No of predator /plant	Yield (q/ha)
			Shoot (%)	Fruit (%)		
T1	1.59[b]	1.0[a]	11.28[b]	14.05[b]	1.52[a]	190.72[b]
T2	0.86[a]	1.50[b]	9.19[a]	12.94[a]	2.92[b]	201.87[a]

T3	2.03 [c]	1.27 [b]	11.70 [c]	17.09 [a]	1.2 [a]	184.15 [c]
T4	4.26 [d]	1.61 [c]	13.15 [d]	19.91 [d]	2.80 [b]	138.63 [d]
CD (0.05)	0.36	0.25	0.15	0.20	0.50	6.55
CV%	11.71	13.89	3.35	3.69	17.02	2.66

Column mean followed by same letter do not differ significantly at 5% level of probability; *Data based on mean of four replications.

Plate 18. View of Experimental plot of habitat manipulation at Jorhat

20.1.2 TNAU, Coimbatore

Name of the Farmer : Mr. Balasubramanium
Location : Udayampalayam, Coimbatore district
Brinjal Variety : Co 4
Coriander variety : Kasthuri
White radish variety : URAL
Plot size : 8 x 5 m
Date of planting : 18.8.17
Date of sowing – intercrops : 7.9.17

Treatments

T1: Brinjal intercropped with Coriander and Carrot /radish or beetroot (TNAU) as border crop.
T2: Brinjal intercropped with Carrot/radish or beetroot (TNAU) and Cowpea as border crop.

T3: Brinjal intercropped with Cowpea and Coriander as border crop.
T4: Brinjal as sole crop.
No. of Replications: Five

The pest population assessed in brinjal crop raised with coriander as a inter crop and cowpea as a border crop, brinjal crop with intercrop of radish and border crop of cowpea and intercrop of cowpea and border crop coriander showed no significant variation on the incidence of shoot damage by *Leucinodes orbonalis* and hopper populations (Table 132). But the incidence of Epilachna beetle (0.2 numbers per plant) was recorded in brinjal intercropped with coriander and cowpea as a border crop (T1) and 1.57 numbers per plant in the sole crop. The natural enemies like coccinellids were high in T1 (2.68 numbers per plant) as against sole crop of brinjal which showed 0.6 numbers per plant. The nematode population (Root-knot and reniform nematodes) was significantly lower in Brinjal crop intercropped with radish (192.6 nematodes/250 gm soil) and coriander (201.6 nematodes /250 gm soil) whereas cowpea (458 nematodes/250 gm soil) as intercrop housed more numbers of nematodes, which was on par with the control plot (491 nematodes/250 gm soil).

Table 132. Habitat manipulation for insect pests, nematodes and natural enemies in brinjal

Treatments	Post treatment (Per cent shoot damage by shoot and fruit borer)	Post treatment (No. of Hopper /plant)	Post treatment (No. of Epilachna /plant	Post treatment (No. of coccinellid/plant)	Post treatment (No. of Nematode/ 250 gm soil)	Yield (Kg/ha)
T1: Brinjal intercropped with coriander and cowpea as border crop	24	0.84	0.2a	2.68a	201.6 (14.19)a	33700 (4.53)
T2: Brinjal intercropped with radish and cowpea as border crop	22	0.96	0.8a	1.2bc	192.6 (13.87)a	33154 (4.52)
T3: Brinjal intercropped with cowpea and coriander as border crop	20	0.64	0.8a	1.3b	458 (21.38)b	33570 (4.53)
T4 Brinjal as sole crop	26	1.16	1.57b	0.6c	491 (22.14)b	32310 (4.51)
CD(P=0.05)	19.16 NS	0.68 NS	0.64	0.23	1.14	0.02 NS
SEd	8.79 NS	0.31NS	0.29	0.11	0.52	0.01

Means followed by a common letter in a column are not significantly different by DMRT; Figures in parentheses are square root transformed values (Nematode), Figures in parentheses are logarithmic transformed values (Yield); Values are mean of five replications.

20.2 Bio-intensive insect pest management in brinjal (MPKV, TNAU, AAU-J, OUAT, KAU, SKUAST, NBAIR)

20.2.1 MPKV, Pune

The experiment was conducted in the Research Farm of Agricultural Entomology Section, College of Agriculture, Pune. The experiment was carried out during 7/3/ 2017 to 27/08/2017. Brinjal var. Panchganga was used for the experiment and was sown in 90 x 60 cm spacing. The experimental field of an area 3.0 x 2.0 m plot size used for this study. The experiment was laid out in a randomized complete block design. The treatment details are as follows.

T1 = BIPM
For sucking pests
Azadirachtin 1500 ppm @ 2ml/lt
Lecanicillium lecanii (NBAIR strain) 1x 10^8 spores/ml @ 5g/lt

For BSFB
Release of *Trichogramma chilonis* multiple insecticide tolerant strain @ 100,000/ha, 8-10 releases at weekly interval from initiation of flowering.
Bacillus thuringiensis NBAII *Bt*G4 2% (not for AAU-J)

For mealybug
Cryptolaemus montrouzieri @ 5 grubs / plants or 1500/ha, twice at 15 days interval.

T2: Chemical Control: Indoxacarb 14 .5 SC 1ml/lit.

T3: Untreated control

The observations were recorded on five randomly selected plants per plot. Pre-treatment incidence of shoot infestation, post-counts of shoot and fruit infestation were recorded at a weekly interval. The yield of healthy marketable fruits per plot was registered at each picking. The shoot and fruit damage caused by *Leucinodes orbonalis* were recorded at weekly interval from initiation of treatment application and post counts are presented in Table 133.

The results indicated that the treatments with chlorpyriphos 0.04% and BIPM were found at par with each other by recording shoot infestation (7.72% and 9.16%), fruit damage on the number (6.33% and 7.82 %) and on the weight basis (3.92% and 4.61%), respectively. The highest marketable fruit yield (230.56 q/ha) was recorded in chlorpyriphos 0.04% treated plots which were at par with BIPM treated plot (217.46 q/ha).

Table 133. Efficacy of bioagents for management of shoot and fruit borer, *L. orbonalis* on brinjal

Treatment	Shoot damage (%)		Fruit damage (%)		Yield (q/ha)
	Pre-count	Post count	No. basis	Wt. basis	
T1: BIPM i) Azadirachtin 1500 ppm @2 ml/lit. ii) *Lecanicillium lecanii* (NBAIR strain) 1x10^8spores/ml @ 5g/lit. iii) Release of *Trichogramma chilonis* multiple insecticide tolerant strain @ 100000/ha, 8-10 releases at weekly interval from initiation of flowering. iv) *Bacillus thuringiensis* NBAII *Bt* G4 2%. v) *Cryptolaemus montrouzieri* @ 5 grubs/ plants or 1500/ha twice at 15 days interval	17.98[a]	9.16[a]	7.82[a]	4.61[a]	217.46[a]
T2: Chlorpyriphos 0.04%	18.06[a]	7.72[a]	6.33[a]	3.92[a]	230.56[a]
T3: Untreated control	17.92[a]	27.17[b]	42.45[b]	41.60[b]	165.80[b]
CD at 5%	NS	3.00	1.70	1.57	30.33

20.2.2 TNAU, Coimbatore

Name of the Farmer : Mr.Thangaraj
Location : Arasur, Coimbatore district
Brinjal Variety : Vari kathiri
Plot size : 8 x 5 m

Treatments
T1 - BIPM

For sucking pests
Azadirachtin 1500 ppm @ 2ml/lt
Lecanicillium lecanii (NBAIR strain) 1x 10^8 spores/ml @ 5g/lt

For BSFB
Release of *Trichogramma chilonis* multiple insecticide tolerant strain @ 100,000/ha, 8-10 releases at weekly interval from initiation of flowering.
Bacillus thuringiensis NBAII *Bt*G4 2% (not for AAU-J)

For Ash weevil
Entomopathogenic nematode (NBAIR strain) @ 2 billion IJs / ha, twice during season.

For mealybug
Cryptolaemus montrouzieri @ 5 grubs / plants or 1500/ha, twice at 15 days interval.
T2 - Chemical Control
T3- Control Plot

No. of replications- Six

The brinjal crop imposed with the treatments as per the technical programme showed the minimum damage of shoots and fruits by *Leucinodes orbanalis* (Table 134). The percent shoot damage noted was significantly low (3.64%) in BIPM plots as compared to spraying of pesticides in farmers practice (7.29%) and untreated check (19.79%). The BIPM plot also recorded a minimum number of damaged fruits (0.46 number per plant) as against farmers practice (1.46 number per plant). The control plot recorded 3.25 damaged fruit per plant. The cost-benefit ratio realized in BIPM is 1:7.64 against 1:2.25 in farmers practice and 1:1.6 in the untreated plot. The higher natural enemy, *viz*., *Chrysopa* and coccinellid activity was noticed in BIPM demonstration plot.

Table 134. Bio-intensive insect management in brinjal

Treatments	**Pre treatment (Per cent shoot damage shoot and fruit borer)**	**Post treatment (Per cent shoot damage shoot and fruit borer)**	**Post treatment (No. of damaged fruits per plant)**	**Yield Kg/40 m^2 plot**	**Yield Kg/ha**	**CB ratio**
T1: BIPM- Azadirachtin 1500 ppm @2ml/lit (one round of spray) + *Lecanium lecanii* (one round of spray) +*Trichogramma chilonis* (8 releases) + *EPN* soil application *Cryptolaemus montrouzieri*	13.54	3.64[a]	0.46[a]	138.33[a]	34583.33	7.64
T2: Spraying of imidacloprid (0.3 ml/lt) and flubendiamide (0.5 ml/ lt)	12.5	7.29[a]	1.46[b]	108.33[b]	27083.33	2.25
T3: Control	10.21	19.79[b]	3.25[c]	76.67[c]	19166.67	
CD(P=0.05)	9.65 NS	5.09	0.87	16.96		
SEd	4.33 NS	2.29	0.39	7.61		

Means followed by a common letter in a column are not significantly different by DMRT; Values are mean of six replications

20.2.3 AAU, Jorhat

Location: Farmes' field, Uttar Gorumora, Jorhat
Plot size: 200sqm
N:P:K: 50:50:50
Variety: JC-1; Date of Planting: 14.10.2018; Replication: 8; Treatments: 3

Treatments

T1 = BIPM
For sucking pests
Azadirachtin 1500 ppm @ 2ml/lt; *Lecanicillium lecanii* (NBAIR strain) 1x 10^8 spores/ml @ 5g/lt

For BSFB
Release of *Trichogramma chilonis* multiple insecticide tolerant strain @ 100,000/ha, 8-10 releases at weekly interval from initiation of flowering.

T2 = Chemical Control
Profenophos 50 EC @ 2 ml/l at 10 days interval

T3: Untreated control

The field trial on BIPM package of brinjal was evaluated in comparison to farmers' practice (chemical control) and the untreated check. The treatment blocks were subdivided into 8 subplots and considered each subplot as a replication (Plate 19). A distance of 100m was maintained in between BIPM and chemical control plots. Observations on pre-treatment incidence on shoots infestation and catches of *Leucinodes orbanalis* from pheromone traps were recorded. Traps were erected in the field from 25 DAT to 55 DAT@ 15 traps/ha. On an average 14.8 adults of *L. orbonalis* was trapped per pheromone traps. Post-treatment counts of infestation of shoots and fruit stages of the crop were recorded at fortnightly interval from 10 randomly selected plants in each treatment block after imposition the treatments. Percent fruit damage and weight of the marketable brinjal per-treatment block were recorded at the time of each harvesting. Four rounds of profenophos 50 EC @ 0.05% was sprayed at a fortnightly interval starting from 35 DAT. No management practices were followed in untreated check. The release of parasitoids was made at a weekly interval from initiation of flowering. Altogether, nine releases were made @ 1,00,000 in BIPM plots. Egg parasitism by *Trichogramma chilonis* was also recorded through retrieval by placing sentinel egg cards of *Corcyra* at five spots in each treatments block. Hand collection and destruction of infested shoots along with larval stages of *L. orbonalis* was done prior to flowering in all the treatments plots. The yield of marketable fruit per plot at each picking was summed up and converted into q/ha.

Four sprays of profenofos 50EC @ 2 ml/l at fortnightly interval found superior in reducing the shoots (9.33%) and fruits (8.31%) infestation with an maximum yield (256.26 q/ha) of marketable brinjal (Table 135). It was, however significantly different from those of BIPM and untreated control plots in respect of per cent shoot and fruit damage. The incidence of fruit and shoot infestation in BIPM plot was 13.35% and 12.30%, as against 16.215 and 26.05% in untreated control plots, respectively. However, both BIPM package and chemical control plots were at par with their efficacies in yield. The percent parasitisation on *Corcyra* sentinel cards by trichogrammatids species in BIPM plots was 8.3% as against 2.8% in chemical control plots. The yield of BIPM package of plots was 239.42 q/ha. Yield of 134.03 q/ha was recorded at untreated control plot.

Table 135. Effect of BIPM package against *Leucinodes orbanalis* on brinjal

Treatment	% shoot damage*		% fruit damage**	Parasitism (%) (*Trichogramma* spp.)	Yield (q/ha)
	Pre treatment	Post treatment			
BIPM	15.91 (3.98)	13.35 [b] (3.67)	12.30 [b] (3.50)	8.3	239.42[a]
Chemical control	14.07 (3.74)	9.33 [a] (3.04)	8.31 [a] (3.03)	2.8	256.26 [a]
Untreated check	15.48 (3.93)	16.21 [c] (2.02)	26.05 [c] (4.81)	4.4	134.03 [b]
CD	NS	0.23	0.28		21.33
CV (%)		6.13	7.01		9.48

*Mean of three observations; **Mean of six observations; Figures in parentheses are transformed angular values; Means followed by the same letter in a column are not significantly different

Plate 19. View of Experimental plot of brinjal

20.2.4 OUAT, Bhubaneswar

Variety: VNR -05
Plot size: 8 x 5m
Design: Randomozed block design

Treatments

T1: BIPM

For sucking pests
Azadirachtin 1500ppm @ 2ml /l - 3 sprays
Lecanicillium lecanii (NBAIR strain) $1x10^8$ spores/g @5g/l- 3 sprays
For BSFB
Release of *Trichogramma chilonis* multiple insecticide tolerant strain @
1, 00,000/ha, 7 releases were made at weekly interval from initiation of flowering
For Epilachna bettle and ash weevil
Entomopathogenic nematode (NBAIR strain) @ 2 billion IJs/ -2 spray

T2: Chemical control

Lambda cyhalothrin 2.5 EC @ 2ml /l - 3 sprays at 15-20 days interval
Coragen- 5 sprays at 15-20 days interval

T3: Untreated control
No. of replications: 8
Date of transplanting: 16.09.2017

The pheromone trap against BSFB was installed in BIPM plots and weekly moth catches were recorded. Pre-treatment incidence one day before spraying and post-treatment incidence 10 days after spraying were recorded against BSFB both at vegetative and reproductive stages of the crop. Finally, fruit yield and cost-benefit ratios were determined.

It is evident from Table 136 that, this was a significant reduction in BSFB damage in BIPM plots as compared to untreated control. Although, the shoot damage was more in BIPM plots as compared to chemical control but lower fruit damage and significantly higher yield than both untreated and chemical check was noted in it. The C:B ratio was 1:2.34 in BIPM plots as against 1:0.80 in chemical control.

Table 136. Effect of bio-intensive insect management in brinjal at Bhubaneswar

Treatments	Shoot damage (%)	Fruit damage (%)		Fruit yield (t/ha)	Increased yield over control (t/ha)	Avoidable loss (%)	Cost of increased yield over control (Rs/ha)	Cost of control (Rs.)	Net profit (Rs.)	C:B ratio
		No. basis	Wt. basis							
BIPM	7.17 (2.76)	44.92	44.87	13.80	3.03	-	60,600	18,121	42,479	1:2.34
Chemical control	2.52 (1.66)	50.93	52.72	12.63	1.86	8.48	37,200	20,645	16,555	1:0.80
Untreated check	16.83 (4.16)	64.16	62.24	10.77		21.96				
S.E. (m) ±	- (0.15)	0.90	0.75	0.07						
C.D. (0.05)	- (0.45)	2.71	2.25	0.21						

20.2.5 KAU, Thrissur

T1 = BIPM
For sucking pests
Beauveria bassiana @ 10^8 conidia/ ml; NSKE 5%; *Lecanicillium lecanii* (NBAIR strain) 10^8 spores/ml
For BSFB
Release of *Trichogramma chilonis* multiple insecticide tolerant strain @100,000/ha, 6-8 releases at weekly interval from initiation of flowering; *Bacillus thuringiensis* NBAII *Bt*G4 2%
For Ash weevil
Entomopathogenic nematode @ 2 billion IJs / ha, twice during season.
For mealybug
Cryptolaemus montrouzieri @ 1500/ha, twice at 15 days interval.

T2 = Chemical Control
Flubendiamide 25 g a.i/ha
.
T3: Untreated control

The experiment is in progress

20.2.6 SKUAST, Srinagar

Differences in percent shoot borer infestation before treatment was found statistically no significant. However, as a result of both chemical (2 sprays) and biological (5 weekly releases of *Trichogramma chilonis* (MITS) treatments, significant differences were observed in shoot borer infestation, when data compared using one way ANOVA at 15 DAT (*F*= 12.00**; d.f.= 2, 14, *P*= 0.0001), 30 DAT (*F*= 103.47**; d.f.= 2,14, *P* = 0.0001), 45 DAT(*F*= 202.41**; d.f.= 2, 14, *P* = 0.0001). Mean per cent infestation in case of T3 (untreated control) was observed as 16.29, whereas in T1 (releases of *T. chilonis*) and T2 (2 sprays of Chlorpyriphos 20 EC @ 1.0 ml/ lit. of water) it averaged 7.19 and 5.56 per cent respectively. Differences in mean shoot borer infestation was also worked out as statistically significant (*F*= 221.59**; d.f.= 2,14, *P* = 0.0001) (Table 137).

Data on per cent fruit infestation among the treatments, when compared using one way ANOVA indicated significant differences for pre treatment (*F*= 3.66*; d.f.= 14(2), *P* = 0.0001), 10 DAT (*F*= 45.51**; d.f.= 2,14, *P* = 0.0001), 20 DAT (*F*=100.77 **; d.f.= 14(2), *P* = 0.0001), 30 DAT(F= 226.73**; d.f.= 2,14, *P* = 0.0001), 40 DAT (F= 128.54**; d.f.= 14(2), *P* = 0.0001) and 50 DAT(*F*= 398.60**; d.f.= 2,14, *P* = 0.0001). Mean fruit infestation in treatments T1 (5 releases of *T. chilonis*), T2 (3 sprays of Chlorpyriphos 20 EC@ 1.0 ml/lit. of water) and T3 (Untreated check) was worked out as 10.64, 5.96 and 23.97 respectively. Difference in mean infestation when compared among treatments was found statistically significant (*F*= 541.25**; d.f.= 2,14, *P* = 0.0001). As a result of treatments, reduction in fruit infestation was 55.53% and 75.05% in case of treatments T1 and T2, respectively (Table 138). Marketable yield was calculated as 23.31, 25.26 and 19.83 t/ ha. In case of treatments T1 (Fig. 21), T2 and T3, respectively. Percent increase over untreated control (T3) in T1 and T2 was worked out as 17.55 and 27.38 ,respectively (Table 139).

Table 137. Effect of treatments on % shoot borer infestation, *Leucinodes orbonalis* on brinjal in Shalimar campus, Srinagar (2017)

Treatments	Pretreatment	15 DAT	30 DAT	45 DAT	Mean
T1 BIPM	6.12^{a}	6.42^{b}	6.86^{b}	7.05^{b}	7.19^{b}
T2 (Chemical)	6.49^{a}	5.37^{a}	5.47^{a}	5.52^{a}	5.56^{a}
T3 (Untreated)	5.53^{a}	7.79^{c}	11.31^{c}	14.61^{c}	16.29^{c}
CD (0.05)	1.76	0.86	0.74	0.85	0.96

Each figure in column represents mean of 40 observations; different superscripts indicate values statistically significant

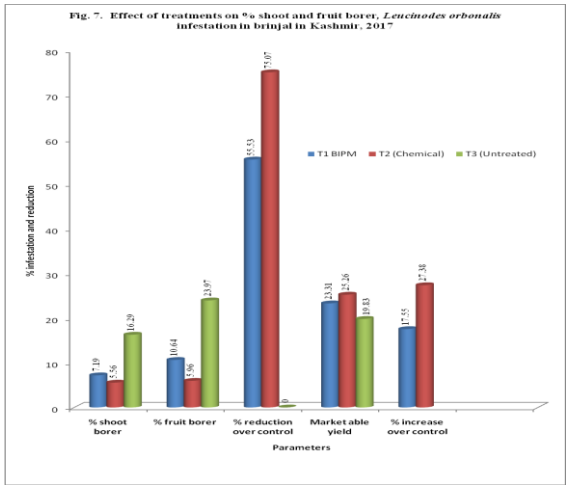
Table 138. Effect of treatments on % fruit borer *Leucinodes orbonalis* infestation on brinjal in Shalimar campus, Srinagar (2017)

Treatments	Pre treatment	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT	Mean	% reduction in infestation over control
T1 BIPM	10.43^{b}	12.22^{b}	12.4^{b}	10.43^{b}	9.61^{b}	8.52^{b}	10.64^{b}	55.53
T2 (Chemical)	9.11^{b}	5.02^{a}	7.09^{a}	5.43^{a}	8.38^{a}	3.89^{a}	5.96^{a}	75.07
T3 (Untreated)	6.99^{a}	15.58^{c}	22.56^{c}	24.9^{c}	27.2^{c}	29.54^{c}	23.97^{c}	--
CD (0.05)	1.99	1.98	1.94	1.67	2.31	1.70	0.99	

Each figure in column represents mean of 40 observations; different superscripts indicate values statistically significant

Table 139. Effect of BIPM and chemical insecticide on yield of brinjal in Kashmir (2017)

Treatment	Marketable yield (tonnne/ha.)	% increase over control
T1 (Biocontrol)	23.31	17.55
T2 (Chemical)	25.26	27.38
T3 (Untreated control)	19.83	--



20.2.7 NBAIR, Bangalore

A field trial was conducted to manage brinjal fruit and shoot borer through the release of *Trichogramma chilonis* (HQS strain). The trial was conducted at farmer field in village Thalahalli, Chikballapur. Twelve releases of *T. chilonis* (HQS) @ 100,000/ release were made against fruit and shoot borer. The observations on fruit damage, shoot damage and percent fruit damage were recorded after 15 days of application of Trichocards.

In the present study, results indicated that the percent fruit and shoot damage was less compared to the farmer practice. The percent fruit damage was recorded significantly lower in the biocontrol field in comparison to farmer practices (F = 112.29; df =1,119, P < 0.0001). Similarly, the percent shoot damage was also significantly lower in the biocontrol field in comparison to farmer practices (F = 103.73; df = 1,119, P < 0.0001) (Table 140).

Table 140. Effect of biocontrol based management practice on brinjal fruit and shoot borer

Treatment	% Shoot damage*	Fruit damage (%)*
T1: 12 releases of *Trichogramma chilonis* at weekly interval	3.05±0.29[a]	7.96±1.03[a]
T2: Farmer's practice (T_2)	11.11±0.37[b]	28.61±1.30[b]
P value	<0.0001	<0.0001

*Mean of four observations at 15 days interval

21. OKRA

21.1 Efficacy of biocontrol agents for the management of fruit borer, *Earias vittella* on bhendi (MPKV, TNAUand AAU-A)

21.1.1 MPKV, Pune

The experiment was conducted in the Research Farm of Agricultural Entomology Section, College of Agriculture, Pune. The experiment was carried out during 8/3/ 2017 to 27/07/2017. Okra variety 'Parbhani Kranti' was used for the experiment and was sown in 75 x 15 cm spacing. The experimental field of an area 8.0 x 5.0 m plot size used for this study. The experiment was laid out in a randomized complete block design. Three sprays of biopesticides and chemical insecticides were given at fortnightly interval on 14/09/2017, 30/09/2017 and 17/10/2017, whereas 6 releases of *T. chilonis* were carried out at weekly interval. The observations were recorded on five plants, those are selected randomly from each plot. Pre and post treatment application of the treatments, incidence of shoot infestation by *E. vittella* was recorded at weekly intervals and post treatment application, fruit infestation was recorded at weekly intervals. The yield of healthy marketable fruits per plot at each picking were converted into q/ha. The shoot and fruit damage caused by *E. vitella* were recorded at a weekly interval before the initiation of the treatment application and pooled means (2017-18) of post-treatment are given in Table 141, 142 & 143. The results indicated that the treatment with chlorpyriphos 0.04% was found to be significantly superior over all other treatments in reducing shoot infestation (5.43%), number of fruit damage (9.86%) and fruit weight (11.43%). It was, however, at par with *B. thuringiensis* @ 1 kg/ha in respect of shoot infestation (6.25%) and number of fruit damage (11.62%) as well as fruit weight (12.94%). The highest marketable fruit yield (201.21 q/ha) was recorded in chlorpyriphos 0.04% treated plots which were not significantly different from the plots treated with *B. thuringiensis* @ 1 kg/ha (196.88 q/ha).

Table 141. Efficacy of bioagents for management of fruit borer, *Earias vittella* on okra

Treatment	Shoot damage (%)		Fruit damage (%)		Yield (q/ha)
	Pre-count	Post-count	No. basis	Wt. basis	
T1: *M. anisopliae* (NBAIR) @ $1x10^8$ spores / g @ 5g/L.	11.20^a	9.39^b	12.51^b	16.02^b	184.63^b
T2: *B. bassiana* (NBAIR) $1x10^8$ spores / g @ 5g/L.	10.56^a	8.48^b	11.69^b	14.25^b	188.24^b
T3: *T. chilonis* 6 releases @ 50,000 parasitoids/ha	11.09^a	21.02^c	18.23^c	22.87^c	160.58^c
T4: *B. thuringiensis* G @ 1 kg/ha	9.54^a	4.87^a	9.54^a	10.60^a	199.86^a
T5: Azadirachtin 1500 ppm@ 2 ml/lit	8.64^a	18.93^c	16.87^c	20.33^c	163.21^c
T6: Chlorpyriphos 0.04%	9.29^a	4.21^a	8.97^a	9.94^a	201.21^a
T7: Untreated control	10.23^a	35.14^d	34.09^d	36.83^d	136.41^d
SE(m) ±	(0.87)	(0.69)	(0.54)	(0.84)	3.14
CD at 5%	(NS)	(2.09)	(1.64)	(2.55)	9.43
CV (%)	(11.21)	(12.06)	(10.14)	(10.60)	13.87

Table 142. Influence of *E. vittella* on fruit yield and cost economics

Treatment	Dose	Total fruit yield (q/ha)	Increased fruit yield over control	Increased income over control (Rs./ ha)	Plant protection cost (Rs./ ha)	Net profit (Rs./ha)	ICBR
T1: *M. anisopliae* (NBAIR) @ $1x10^8$ spores / g @ 5g/L.	5 g/lit	181.75	41.31	90,882/-	3,750/-	87,132	1 : 23.23
T2: *B. bassiana* (NBAIR) $1x10^8$ spores / g @ 5g/L.	5 g/lit	185.67	45.23	99,506/-	3,750/-	95,756	1 : 25.53
T3: *T. chilonis* 6 releases @ 50,000 parasitoids/ha	3 card/6 releases/ha	167.52	27.08	59,576/-	1800/-	57,776	1 : 32.09
T4: *B. thuringiensis* G @ 1 kg/ha	1 kg/ha	196.88	56.44	1,24,168/-	6,750/-	1,17,418	1 : 17.39
T5: Azadirachtin 1500 ppm@ 2 ml/lit	5 %	171.73	31.29	68,838/-	4,050/-	64,788	1 : 15.99
T6: Chlorpyriphos 0.04%	0.04 %	201.77	61.33	1,34,926/-	3,330/-	1,31,596	1 : 39.51
T7: Untreated control	-	140.44	-	-	-		-

(Okra fruit cost: Rs. 2,200/quintal)

Table 143. Market rates used for calculation of economics

Biopesticide	Cost of biopesticides (Rs. lit/kg)	Quantity/ per (l/kg/ha.)	Qty. used/ha for 3 sprays	Cost (Rs./ha)	Labour charges (Rs./ha)	Total cost (Rs./ha)
T1: *M. anisopliae* (NBAIR) @ $1x10^8$ spores / g @ 5g/L.	200/ kg	2.5 kg	7.5 kg	1,500/-	2250/-	3,750/-
T2: *B. bassiana* (NBAIR) $1x10^8$ spores / g @ 5g/L.	200/ kg	2.5 kg	7.5 kg	1,500/-	2250/-	3,750/-
T3: *T. chilonis* 6 releases @ 50,000 parasitoids/ha	50/card	3 cards	18 cards	900/-	900/-	1800/-
T4: *B. thuringiensis* G @ 1 kg/ha	1500/ kg	1 kg	3 kg	4,500/-	2250/-	6,750/-
T5: Azadirachtin 1500 ppm@ 2 ml/lit	30/kg	20 kg	60 kg	1,800/-	2250/-	4,050/-
T6: Chlorpyriphos 0.04%	360/lit.	1 lit.	3 lit.	1,080/-	2250/-	3,330/-
T7: Untreated control	--	-	-	-	-	-

21.1.2 TNAU, Coimbatore

Name of the Farmer : Mr.Thangaraj
Location : Arasur, Coimbatore District
Bhendi Hybrid : Samrat
Plot size : 8 x 5 m
D.O.P : 30.11.2017

Treatments

T1: *Metarhizium anisopliae* (NBAIR) $1x10^8$ spores/ g @ 5g/lt
T2: *Beauveria bassiana* (NBAIR) $1x10^8$ spores/ g @ 5g/lt
T3: *Trichogramma chilonis* @ 50,000 parasitoids/ha, 6 releases at weekly interval.
T4: *Bacillus thuringiensis* @ 1 kg/ha
T5: Azadirachtin 1500 ppm@ 2 ml/lit
T6: University recommended insecticide, 2-4 sprays.
T7: Untreated control

Replications: Three

Methodology and observations:

Releases of parasitoids at a weekly interval and three sprays of entomopathogens and azadirachtin done at fortnightly interval.
The observations were recorded on five randomly selected plants/ plot.
1. Pre and post-treatment counts on fruit infestation at a weekly interval and yield of healthy marketable fruits at each picking.

The field trial was conducted during December to March 2018 at Arasur in Coimbatore district. The treatments were imposed at 15 days interval as per the treatment schedule (for three times) and the parasitoid was released in weekly intervals @ 50,000/ha (Table 144). Four rounds of spray with flubendiamide @ 0.3 ml/lt was imposed after the pre-treatment count. The damage reduction of fruit borer, *Earias vittella* was assessed 15 days after the treatment imposition. The results indicated that three releases of *Trichogramma* @ 50000 /ha was able to control the damage 100% and was on par with flubendiamide treatment (2.72% damage) while realizing the fruit yield of 9.7 t/ha. This treatment was superior to all other treatments involving biocontrol agents and untreated check except pesticide treatment. The other bioagent treatments when applied alone was also effective with 68.88% to 78.72% reduction of fruit damage over control. The higher number of natural enemies like Coccinellids, Chrysoperla, Spiders and Preying mantids were observed in the biocontrol plots.

Table 144. Biological control of fruit borer, *Earias vitella* on bhendi

Treatments	Pre Treatment	15 days after I release/spray	15 days after II release /spray	15days after III release/spray	Per cent reduction over control	Yield t/ha	CB ratio
	Per cent fruit damage	Per cent fruit damage	Per cent fruit damage	Per cent fruit damage			
Metarhizium anisopliae 1x10^8 spores/ g @ 5g/lt	50.50 (45.29)	36.06 (36.81)^{d}	26.06 (30.62)^{c}	16.06 (23.44)^{b}	68.88	8833.33 (3.95)^{bc}	2.15
Beauveria bassiana (NBAIR) 1x10^8 spores/ g @ 5g/lt	53.84 (47.21)	31.61 (34.17)^{cd}	24.95 (29.92)^{c}	14.95 (22.62)^{b}	72.91	8900.00 (3.95)^{bc}	2.18
Trichogramma chilonis @50,000 parasitoids/ha, 6 releases	46.06 (42.72)	22.72 (28.42)^{b}	3.83 (9.01)^{a}	0.50 (4.05)^{a}	100.00	9766.67 (3.99)^{a}	3.19
Bacillus thuringiensis @ 1 kg/ha	52.72 (46.57)	24.95 (29.92)^{bc}	11.61 (19.88)^{b}	11.61 (19.88)^{b}	78.72	9350.00 (3.97)^{ab}	2.34
Azadirachtin 1500 ppm@ 2 ml/lit	50.50 (45.28)	34.95 (36.22)^{d}	19.39 (26.11)^{bc}	11.61 (19.64)^{b}	77.78	8416.67 (3.93)^{cd}	2.01
Flubendiamide@ 0.3 ml/l	51.61 (45.92)	13.83 (21.74)^{a}	3.83 (9.01)^{a}	2.72 (7.88)^{a}	95.66	9766.67 (3.99)^{a}	1.71
Control	52.72 (46.56)	50.50 (45.29)^{e}	52.72 (46.59)^{d}	52.72 (46.57)^{c}	-	8166.67 (3.91)^{d}	1.47
SEd	NS	2.32	4.37	2.04		0.01	
CD		5.05	9.53	4.44		0.02	
CV		8.55	21.92	12.14		0.39	

Means followed by a common letter in a column are not significantly different by DMRT; Figures in parentheses are arcsine transformed values (Fruit damage), Figures in parentheses are logarithmic transformed values (Yield); Values are mean of three replications

21.1.3 AAU, Anand

Year of commencement: 2017-18 - kharif/summer
Location: Agronomy farm, AAU, Anand

Methodology and treatments:

Variety	:	GAO 5
Plot size	:	8 x 5 m
Spacing		45x30 cm
Layout	:	Randomized Block Design (RBD)
Treatments	:	T1: *Metarhizium anisopliae* (NBAIR strain) @ $1x10^8$ spores/g @ 5g/L T2: *Beauveria bassiana* (NBAIR strain) @ $1x10^8$ spores/g @ 5g/L T3: *Trichogramma chilonis* @ 50,000 parasitoids/ha, 6 releases at weekly interval T4: *Bacillus thuringiensis* @ 1 kg/ha T5: Azadirachtin 1500 ppm @ 2ml/L T6: Emamectin benzoate 5 SG @ 0.0025%(12.5 g.a.i./ha) (5g/10 litre water) 2-4 sprays. T7: Untreated control
Replications	:	Three
Methodology	:	Releases of parasitoids at weekly interval and three sprays of entomopathogens, and azadirachtin at fortnightly interval.

Observations:

1. Pre and post- treatment counts on fruit infestation at weekly interval.
2. Yield of healthy marketable fruits at each picking.

Results: There was **no incidence of pest** during *kharif* season (2017-18). Summer season trial is under progress.

21.2 Effect of biopesticides for the management of shoot and fruit borers *Earias vittella* in bhindi (KAU, Vellayani)

Earias vitella damage to the crop bhindi was reduced significantly in the plots treated with biopesticides *Beauveria bassiana* (ITCC 6063) talc based formulation @ 20g/l and *Metarhizium anisopliae* @ 5g/l and the treatment was on par with the effect of insecticide Malathion 50 EC 0.1 % and *Numurea rileyii* (NBAIR Culture) @ 5g/l . Higher yield was also obtained as 19.2, 18.5, 18.12 t/ha from the plots treated with Malathion 0.1%, *and B. bassiana* 20g/l and M. anisopliae @ 5g/l, respectively. (Table 145).

Table 145. Effect of different treatments on the per cent infestation of shoot and fruit borer *Earias vitella* in bhindi

Treatments	3 DAS	7 DAS	14 DAS	21 DAS	Yield (t/ha)
Beauveria bassiana (ITCC6063)	36.676 (6.040)	22.496 (4.673)	7.780 (2.746)	6.866 (2.619)	18.587
Numurea rileyii	34.820 (5.891)	32.476 (5.694)	28.346 (5.324)	20.200 (4.364)	17.462
Metarhizium anisopliae	25.510 (4.962)	30.540 (5.517)	17.610 (4.091)	14.640 (3.676)	18.125
Malathion	14.366 (3.701)	23.066 (4.778)	10.693 (3.174)	12.900 (3.555)	19.212
Check	37.646 (6.099)	54.600 (7.362)	64.106 (7.983)	74.123 (8.527)	13.000
CD (0.05)	1.516	1.211	1.383	2.233	

Figures in parentheses are √X transformed values

22. CABBAGE

22.1 Evaluation of *Steinernema carpocapsae* and *Heterorhabditis indica* (NBAIR strain) against lepidopteran pest complex (SKUAST)

Because *Steinernema carpocapsae* and *Heterorhabditis indica* (NBAIR strain) were not supplied by the Head quarter. After preliminary evaluation of *Heterorhabditis pakistanensis* (NBAIR strain) against *Pieris brassicae* in the laboratory, this species used for the cabbage field trail for the management of cabbage butterfly, *Pieris brassicae*, as per the technical programme this species meant for the management of Codling moth, *Cydia pomonella.* Field trials showed that, no mortality of *P. brassicae* larvae was noticed on first day after foliar application of *H. pakistanensis* nematodes. However, 27.77% mortality of *P. brassicae* larvae was recorded on second day after application of 12 lakh IJs/4 m^2 plot, followed by T3 (23.12), T2 (21.52) and T1(19.04). As the time increases, the percent larval mortality was also increased on 3rd, 4th and 5th day after nematode application (Plate 8). Increase in rate of larval mortality was dependent on both increase in nematode dosage from 6.0 to 12.0 lakh IJS/ 4 m^2 plot and also with time (Table 146) (Plate 20). One way ANOVA analysis showed that treatments were statistically different on 2nd day (F= 41.43**; d.f.= 4, 16; $P < 0.0001$), 3rd day (F= 36.31**; d.f.= 4,16; $P < 0.0001$), 4th day (F= 182.46**; d.f.= 4, 16; $P < 0.0001$)and 5th day (F= 152.93**; d.f.= 4, 16; $P < 0.0001$).

Table 146. Field efficacy of *Heterorhabditis pakistanensis* on 3rd instar larvae *of Pieris brassicae* on kale in Kashmir (2017)

Treatments (IJs/ 4 M^2 plot)	Per cent mortality					Total mortality
	Days after application					
	1st day	2nd day	3rd day	4th day	5th day	
6.0 lakh	0.0 (4.05)	19.04 (25.77)^{b}	24.71 (29.73)^{b}	67.11 (55.19)^{b}	77.20 (61.98)^{b}	97.44
8.0 lakh	0.0 (4.05)	21.52 (27.19)^{b}	30.63 (33.21)^{b}	79.76 (63.40)^{c}	80.25 (63.98)^{b}	100.00
10.0 lakh	0.0 (4.05)	23.12 (28.74)^{b}	32.38 (34.55)^{b}	82.07 (65.06)^{c}	87.94 (69.73)^{c}	100.00
12.0 lakh	0.0 (4.05)	27.77 (31.7)^{bc}	37.97 (37.89)^{bc}	84.20 (67.30)^{c}	89.6 (71.71)^{c}	100.00
Untreated control	0.0 (4.05)	0.0 (4.05)^{a}	0.0 (4.05)^{a}	0.0 (4.05)^{a}	0.0 (4.05)^{a}	0.0 (4.05)
CD (0.05)		4.25	5.58	4.86	5.66	

- Each figure in column represents mean of 5 observations; figures in parentheses represent arc sin transformation n+0.5; different alphabetical superscripts in column indicate values statistically significant at $P < 0.05$

Plate 20

Effect of *Heterorhabditis pakistanensis* on *Pieris brassicae* on kale in field: Figs (L to R): 1st row: Morbid larvae collected from field, change in color of a larva, cuticle of larva devoid of inner content. **2nd row (L to R):** EPN out of body, effect of EPN on pupa, change in pupal color and pupal case without inner content

22.2 Biological control of lepidopteran pest complex and aphid on cabbage [NBAIR (0.4 ha); TNAU (0.4 ha); CAU (0.1 ha)]

22.2.1 ICAR-NBAIR, Bengaluru

On farm trial was conducted to manage the insect pests infesting cabbage through application of biological control agents. Field trial was conducted at farmer field in village Thalahalli, Chikballapur, Karnataka to evaluate biocontrol agents *Trichogramma chilonis* and *Bacillus thuringiensis* (T_1) against diamond back moth (DBM), *Plutella xylostella* in comparision with the farmer practice (T_2). Only DBM incidence was observed during the experimental period. Five release of *Trichogramma chilonis* MITS @ 100,000/ release and two sprays of *Bacillus thuringiensis* (NBAIR-*Bt*G4) @ 2% were carried. The observation on number of larvae per plant, number of holes on the leaves and percent head damage was recorded after 45 days of application.

In the present study, results indicated that the number of larvae per plant was less compared to the farmer practice. The mean number of holes on cabbage leaves were significantly ($P < 0.05$) lower in biocontrol based management practices. The percent head damage was recorded significantly lower in the biocontrol agents applied field in comparison to farmer practices (Table 147).

Table 147. Effect of biocontrol based management practice on diamond back moth, *Plutella xylostella* infesting cabbage

Treatment	Mean No. of holes/plant	Mean No. larvae/plant	Head damage (%)
T_1	2.21 ± 0.35^a	0.26 ± 0.09^a	7.00 ± 1.34^a
T_2	8.04 ± 1.02^b	1.13 ± 0.21^b	32.2 ± 4.37^b
P value	$P < 0.0001$	$P < 0.004$	$P < 0.0001$

22.2.1 TNAU, Coimbatore

Treatments

T1: Raising of mustard as intercrop (TNAU & CAU), Release of MITS of *Trichogramma chilonis* @ 100,000/release against *Plutella xylostella*, 6 releases to be made at 30 days after transplanting, release of *Chrysoperla zastrowi sillemi* @ 2000/ release, 2 releases to be made at 15 days interval against cabbage aphid, *L. lecani* $1x10^8$ spore/ ml @ 5ml/lt and *Bt* (NBAIR) three sprays and *Bacillus thuringiensis* NBAII *Bt*G4 2%.

T2: Farmers practices

Replications: Five

Methodology and observation

Pre- release observation – No. of holes on the leaves, No. of larvae per plant, such 5 spot to be selected for observation including 10 plants each spot, observation were taken 4 times at 15 days interval. 100 eggs collected and parasitisation rate observed during 4 times.

Aphid – observation recorded in 5 random spots including 10 plants each spot for aphid infestation and counted total number of infested plant. Five observations were taken on the aphid colony infesting leaves by using the 1cm window. Cabbage Variety was Red cabbage – Peejo and date of planting was 27.11.17. The results are presented in Table 148.

Table 148. Field demonstration of biointensive pest management in Cabbage

Treatments	Pre Treatment	45 – DAT- 15 days after I release/spray	60- DAT- 15 days after II release /spray		75- DAT -15days after II I release/spray		90 - DAT -30days after II I release/spray		Yield t/ha	CB ratio
	No. of larvae/plant	No. of larvae/plant	No. of larvae/plant	Parasitoid emergence / 5 Leaves	No. of larvae/plant	Parasitoid emergence/ 5 Leaves	No. of larvae/ plant	Parasitoid emergence/ 5 Leaves		
Mustard + *Trichogramma chilonis* @ 100,000/release + *Chrysoperla* @ 2000/ release, *L. lecani* @ 5ml/lt and *Bt*G4 2%.	0.96	1.44 (1.20)[a]	1.28 (1.13)[a]	5.6 (2.37) [a]	1.3 (1.14)[a]	9.6 (3.10)[a]	0.84 (0.92)[a]	16.6 (4.07)[a]	44000 (209.76)[a]	9.75
Chlorpyriphos @ 0.04% + imidacloprid	0.96	2.22 (1.49)[b]	1.28 (1.13)[a]	0 (0.00)[c]	3.86 (1.96)[b]	0 (0.00)[c]	2.26 (1.50)[b]	0 (0.00)[c]	43400 (208.33)[a]	4.09
Control	0.88	4.14 (2.03)[c]	6.64 (1.13)[b]	2 (1.41)[b]	8 (2.83)[c]	3.8 (1.95)[b]	8.88 (2.98)[c]	2.2 (1.48)[b]	39000 (197.48)[b]	2.52
SE d	NS	0.0709	0.0325	0.4320	0.0594	0.4143	0.0431	0.4333	1.6091	
CD(0.05)	NS	0.1635	0.0750	0.9962	0.1369	0.9553	0.0995	0.9992	3.7106	

Means followed by a common letter in a column are not significantly different by DMRT; Figures in parentheses are square root transformed values (Larvae/Parasitoid), Figures in parentheses are logarithmic transformed values (Yield); Values are mean of five replications.

The results revealed that the efficacy of BIPM practices was significantly superior in reducing the population of DBM by recording 0.84 larvae/plant after three rounds of spray while it was 2.26 and 8.88 larvae/plant in chemical treatment and control plot. Inundative release of *Trichogramma* worked out effectively and parasitoids were recovered from cabbage plants at the level of 5.6 to 16.6/five leaves in BIPM plot. In control plots also, 2 to 2.2 larvae/five leaves were recorded indicating the movement of the wasp. A highest yield of 44 t/ha was recorded in BIPM plot which was on a par with chemical treatment (43.4 t/ha) (Table 148). Yield from control plot was 39 t/ha. Since the organic produce fetched a high price of Rs.15/kg, the cost benefit (CB) ratio was 9.75 in BIPM plot and it was only 4.09 in chemical treatment.

22.2.3 CAU, Pasighat

On farm trial was conducted in the field of department of plant protection, Collage of Horticulture and Forestry, Pasighat to manage the insect pests of cabbage. The experimental field of an area 0.1 ha was divided into 5 equal size units and each unit considered as a replication. The experiment was carried out during Rabi season, 2017-18. Cabbage variety 'rareball' was used for the experiment and transplanted at 60x45cm spacing. The first treatment (T1) is the biocontrol based component and second treatment (T2) farmer's practice was followed. The experiment was laid out in a randomized complete block design.

In the biocontrol module, raising of mustard as intercrop (pair rows of mustard for every 15 rows of cabbage), six release of MITS of *Trichogramma chilonis* after 30 day of transplanting at weekly interval @100,000/release against *Plutella xylostella*, two release of *Chrysoperla zastriwi sillemi* @ 2000/release at 15 days interval against aphid and two spray of *Bacillus thuringiensis* (NBAIR BtG4) 2% were sprayed. In the farmer's practice two rounds of spray were made with profenophos @0.05% at 30 DAT, 45 DAT and observations were recorded on 3rd and 7th day after each treatment. The observation of number of larvae/plant, number of holes on the leaves per plant were recorded at 15, 30 and 45 day after treatment. Four times, egg parasitization was also recorded randomly. Simultaneously observation was recorded on number of aphid/plant and number of aphid/cm window (aphid colony) and yield q/ha.

The number of holes per plant were significantly ($P < 0.05$) less in field treated with biocontrol based component than farmers practice ($F= 102.23$, df = 1, 70, $P< 0.0001$), there is no significant difference in number of holes per plant at 15 and 30 days after treatment but we found significantly ($P < 0.05$) less number of larvae per plant at 45 days after treatment ($F = 21.86$, df = 2, 70, < 0.0001) (Table 149). In the present study the number of diamond back moth larvae significantly ($P < 0.05$) reduced in the field treated with biocontrol based component than farmers practice ($F = 69.32$, df = 1, 70, $P< 0.0001$), there is a significant difference in number of larvae per plant at 15, 30 and 45 days after treatment ($F= 8.26.32$, df = 2, 70, $P = 0.0006$) but there was no significant difference between 30 and 45 days after treatment (Table 150). The percent reduction of aphids per plant was significantly more in the field treated with biocontrol based component than farmers practice ($F= 15.34$, df = 1, 14, $P = 0.0015$) Fig. 22, similarly percent reduction of aphids per cm window also less in cabbage plants treated with biocontrol based component than farmers practice ($F= 5.33$, df = 1, 14, $P = 0.0036$) (Fig. 23). The percent parasitization by *T. chilonis* in cabbage plants treated with biocontrol based component found to be more as compared to farmers practice, we recorded an about 4.88% parasitization in plants treated with biocontrol based component where as 1.52% in farmers practice field. Finally we

could harvest more heads (161.86 quintals per ha) in plants treated with biocontrol based component while in farmers practice field 140.80 quintals per ha.

Table 149. Effect of biocontrol management practices on diamondback moth, *Plutella xylostella* infecting cabbage

Treatments	Mean Number of holes/plant			
	Before treatment	Days After treatment		
		15	30	45
T1	4.84 ± 0.54	6.87 ± 0.61	4.38 ± 0.60	2.11 ± 0.29
T2	4.92 ± 0.48	16.74 ± 1.16	14.72 ± 2.04	7.89 ± 0.86
P value				
Treatments (T)	<0.0001			
Days (D)	<0.0001			
T x D	0.0640			

Table 150. Effect of biocontrol management practices on diamondback moth, *Plutellaxylostella* infecting cabbage

Treatments	Mean Number of larvae/plant			
	Before treatment	Days After treatment		
		15	30	45
T1	0.57± 0.05	0.52 ± 0.06	0.38 ± 0.03	0.32 ± 0.03
T2	0.56± 0.07	0.81 ± 0.05	0.66 ± 0.06	0.67 ± 0.05
P value				
Treatments (T)	<.0001			
Days (D)	0.0006			
T x D	0.6379			

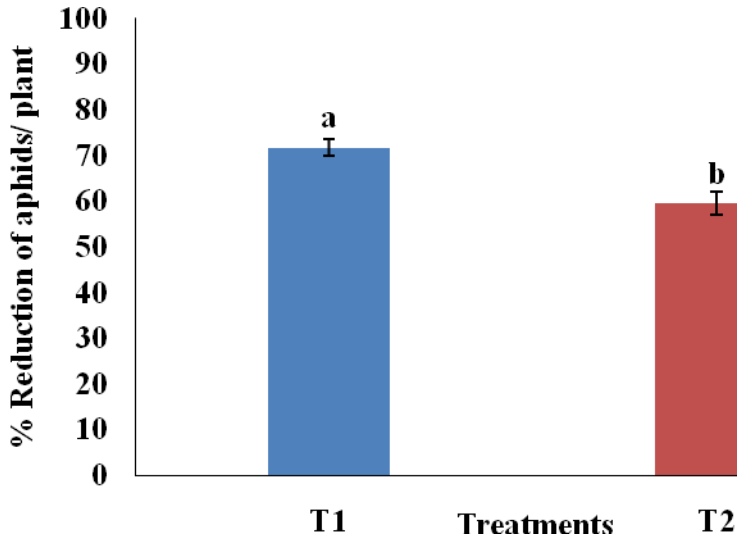


Fig. 22. Per cent reduction of aphids per cabbage plant treated with biocontrol based component (T1) and farmers practice (T2)

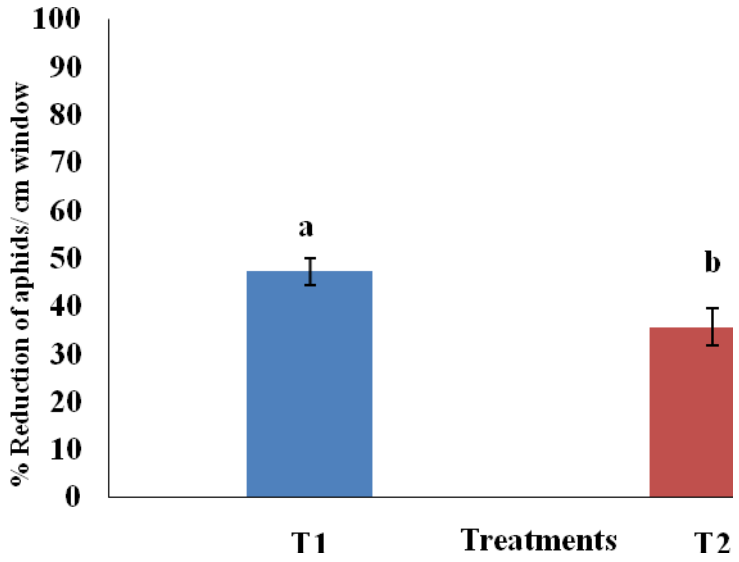


Fig. 23. The percent reduction of aphids per cm window of cabbage leaf after treating the plant with biocontrol based component (T1) and farmers practice (T2)

POLYHOUSE INSECT PESTS

23.1 Management of cucumber sucking pests using anthocorid predator, *Blaptostethus pallescens* under polyhouse condition (KAU)

T1: *Blastostethus pallescens*@ 10 nymphs/m row twice at 15 days interval
T2: *Blastostethus pallescens* @ 20 nymphs/ m row twice at 15 days interval
T3: Spiromesifen 45SC @100g.a.i ha^{-1} twice at 15 days interval or recommended insecticide for use in polyhouse
T4: Control

The experiment is in progress.

23.2 Management of red spider mite *Tetranychus urticae* infesting rose in polyhouse condition (MPKV)

The trial was laid out under polyhouse conditions at Regional Fruit Research Station (RFRS), Ganeshkhind, Pune to evaluate four fungal pathogens and predatory mite in comparision with abamectin against red spider mite, *Tetranychus urticae* on rose *var*. Samurai. However, the infestation of mites is not sufficiently build-up till February 2018. Hence, the trial was not conducted.

23.3 Evaluation of biocontrol agents for the control of sucking pests in capsicum under polyhouse (YSPUHF, PAU)

23.3.1 YSPUHF, Solan

An experiment for the evaluation of biocontrol agents, *viz*., *Metarhizium anisopliae, Lecanicillium lecanii, Beauveria bassiana* (5g/L of 10^8conidia/ g each), *Chrysoperla zastrowi sillemi* (4 larvae /plant), *Blaptostethus pallescens* (30 nymphs/ m row length) and azadirachtin (2ml/L of 1500ppm) in comparision with imidacloprid (0.5ml/L) as chemical control and water spray as absolute control for the control of sucking pests in capsicum (cv. Callifornia Wonder) under polyhouse conditions was laid at the experimental farm of YSP University of Horticulture and Forestry, Nauni, Solan. During the experimental period only aphid, *Myzus persicae* was recorded as pest on the capsicum, hence the evaluation of bioagents was done only against *M. persicae.* The experiment was laid in a randonized block design with each treatment replicated three times.All the treatments were applied twice at 10 days interval and the aphid polulation was recorded on 10 randomly selected plants before treatment and 5, 7 and 10 days after treatment of first and second spray/ release of biocontrol agent. The data thus recorded were conversted in to per cent reducrion over absolute control and analysed after arc sine transformation and the results are presented in table 6.Results of the experiment reveal that imidacloprid (0.5ml/L) was the best treatment resulting in 92.6 to 95.1 per cent reduction in the aphid population at different time intervals after the first and the second spray. Among biocontrol agents, *Chrysoperla zastrowi sillemi* (4 larvae/ plant) resulted in the maximum reduction (49.1%) in aphid population over control 10 days after the first spray/ release, which was, however, on par with that resulted by other bioagents (40.3-45.3%) except *Metarhizium anisopliae* (5g/l of 10^8 spore/ g) where the

reduction was 35.9 per cent. Ten days after the second spray/ release, among biocontrol agents, *Chrysoperla zastrowi sillemi* (4 larvae / plant) resulted in the highest (73.8%) reduction in the aphid population followed by on par reduction by azadirachtin (2ml/L of 1500ppm) (68.6%) and *Lecanicillium lecanii* (5g/l of 10^8conidia/ g) (66.2%). Other biocontrol agents resulted in 44 to 58.3 per cent reduction in the aphid population over control 10 days after the second spray/ release (Table 151).

Table 151. Evaluation of biocontrol agents for the control *Myzus persicae* in capsicum under polyhouse

Treatment	% reduction in aphid population over control after indicated days of I and II spray/ release					
	I spray/ release			II spray/ release		
	5	7	10	5	7	10
Metarhizium anisopliae (5g/l of 10^8conidia/ g)	14.6 (22.3)c	25.3 (30.1)d	35.9 (36.6)c	42.3 (40.3)c	49.5 (44.9)c	44.0 (41.3)c
Lecanicillium lecanii (5g/l of 10^8conidia/ g)	22.7 (28.4)b	27.7 (31.7)c	42.2 (40.5)bc	48.5 (44.1)c	58.3 (49.8)b	66.2 (55.4)b
Beauveria bassiana (5g/l of 10^8conidia/ g)	18.9 (25.6)bc	25.3 (30.2)d	40.7 (39.6)bc	46.4 (42.9)c	55.6 (48.2)b	58.3 (49.2)c
Chrysoperla zastrowi sillemi (4 larvae / plant)	23.1 (28.6)b	31.7 (34.2)bc	49.1 (44.5)b	62.4 (52.2)b	65.8 (54.2)b	73.8 (59.2)b
Blaptostethuspallescens @ (30 nymphs/ m row)	13.8 (21.8)c	19.8 (26.3)e	40.3 (39.3)bc	45.8 (42.6)c	47.2 (43.3)c	51.5 (45.9)c
Azadirachtin (2ml/L of 1500ppm)	23.4 (28.8)b	36.2 (36.9)b	45.3 (42.2)b	58.9 (50.1)b	62.3 (52.1)b	68.6 (55.9)b
Imidacloprid (0.5ml/L)	95.1 (78.7)a	94.1 (76.3)a	93.8 (76.1)a	94.3 (75.4)a	93.7 (75.5)a	92.6 (74.3)a
CD (p=0.05)	(6.2)	(2.8)	(5.4)	(7.6)	(6.4)	(7.4)
CV (%)	19.4	29.5	33.7	17.2	28.1	22.3

Figures in parantheses are arc sine transformed values

23.3.1 PAU, Ludhiana

The experiment on evaluation of biocontrol agents for the control of sucking pests in capsicum under polyhouse is being conducted at Entomological Research Farm, PAU, Ludhiana. The capsicum seedlings (commercial variety) were transplanted under protected conditions according to agronomic practice norms on October 17, 2017. The layout of the experiment is as per the following treatments.

Treatments:

T1: *Metarhizium anisopliae*(NBAIR)1X10^8spore/ g @ 5g/lt
T2: *Lecanicillium lecanii*(NBAIR)1X10^8spore/ g @ 5g/lt
T3: *Beauveria bassiana*(NBAIR)1X10^8 spore/ g @ 5g/lt
T4: *Chrysoperla zastrowi sillemi* @ 4 larvae /plant, 2-3 releases(weekly) to be made.
T5: Five (weekly) releases of *Blaptostethus pallescens* @ 30 nymphs/ m row length

T6: Azadirachtin @ 2ml/L of 1500ppm
T7: Insecticide as per label claim/University recommendation
T8: Control

The crop is being monitored for the incidence of aphids, whitefly and mites. Till date the incidence of aphid has been recorded and accordingly the treatments of above mentioned entomopathogenic fungal formulations are being given. The data on the population of aphid is being recorded and the experiment is in progress.

23.3.2 Monitoring diversity of pests and diseases of yard long bean (*Vigna unguiculata*) under polyhouse conditions and their management (KAU, RARS – Kumarakom)

i) Survey and documentation of pest and diseases of yard long bean

Survey work was conducted at 7 polyhouses of Kottayam district during the period from September 2017 to January 2018 for incidence of pests and diseases. Incidence of serpentine leaf miner, *Liriyomyza trifolii* was recorded in 40% of polyhouses surveyed with 5 to 20 percentages of infested leaves. Incidence of Tetranychid mite *Tetranychus truncatus* Ehara(population ranging from 2-5/cm^2) were observed in 40 percent of polyhouses surveyed. At one polyhouse infestation of Spodoptera litura could be seen. Incidence of powdery midew, leaf blight, leaf spot and rust diseases were also observed (Table 152).

Table 152. Per cent pests and disease incidence on yard long bean in polyhouse

Location (Kottayam dt.)	Percentage of pests and disease incidence observed									
	Pests					Diseases				
	Tetranychid mites	Mealy bugs	Aphids	Spodoptera litura	Serpentine Leaf miner	Powdery mildew	Anthracnose	Leaf blight	Leaf spot	Rust
Vaikom	20%	10%	-	-	-	-	5%	-	-	-
Kanakkari	-	5%	5%	-	-	15%	-	10%	10%	-
Ettumanoor	-	-	-	-	-	5%	-	-	-	-
Vadavathoor	5%	-	-	-	-	-	-	-	-	-
Thambalakkadu	15%	-	-	60%	20%	-	-	-	25%	-
Nedumkunnam	-	-	5%	10%	5%	10%	-	-	-	-
Mammoodu	-	-	-	-	5%	50%	-	10%	-	60%

ii) Evaluation of microbial agents for the management of major pests of yard long bean

The experiment was laid out in RBD with 6 treatments and 4 replications (3 plants per replication) under protected condition at RARS, Kumarakom with KAU variety Lola during

November 2017. Three sprayings were given at an interval of 15 days and observations on pest incidence was recorded.

Treatments

1. *Lecanicillium lecani*i NBAIR 1%(10^8 spores/ml)
2. *Lecanicillium lecani*i NBAIR 1% (10^9 spores/ml)
3. *Beauveria bassiana*NBAIR 1% (10^8 spores/ml)
4. *Beauveria bassiana* NBAIR 1%(10^9 spores/ml)
5. Spiromesifen 22.9SC@ 96 g ai ha^{-1}
6. Untreated control

Incidence of aphids was observed in poly house. Data on population of aphids was insignificant to be analysed after first spraying and second spraying. Observations recorded on 3, 5 and 7 days after third spraying (Table 153) showed that *Beauveria bassiana* 1% (10^8 spores/ml and 10^9 spores/ml) and *Lecanicillium lecani*i 1% (10^8 spores/ml and 10^9 spores/ml) were effective in reducing aphid population.

Table 153. Evaluation of microbial agents for the management of major pests of Yard long bean under protected conditions

Treatments	Mean no. of aphids / 5cm shoot length		
	After third spraying		
	3 days	5 days	7 days
Lecanicillium lecanii NBAIR 1% (10^8 spores/ml)	39.75 (6.23)	30.25 (5.43)	20.75 (4.44)
*Lecanicillium lecani*i NBAIR 1% (10^9 spores/ml)	23.5 (4.81)	16.75 (3.99)	13.75 (3.63)
Beauveria bassiana NBAIR 1% (10^8 spores/ml)	48.25 (6.80)	52.00 (7.12)	34.25 (5.77)
Beauveria bassiana NBAIR 1% (10^9 spores/ml)	52.75 (7.22)	57.75 (7.52)	41.75 (6.40)
Spiromesifen 22.9 SC@ 96 g ai ha^{-1}	9.5 (3.08)	8.75 (2.93)	3.00 (1.67)
Untreated control	104.25 (10.15)	102.00 (10.04)	118.25 (10.81)
CD (0.05)	1.26	1.50	1.40

Figures in each column represents mean of 4 replications; Values in parantheses are square root transformed values

23.4 Evaluation of microbial insecticides against cole crop (*viz*., cauliflower / cabbage) in shade net house (DRYSRHU)

Experimental details

Season and year: *Rabi* 2017
Design: RBD
Plot size: 2x5m

Treatments: 6
Replications: 4
Target pest: Aphids

Treatment details
T1: *Metarrhizium. anisopliae* @5 g /L
T2: *Lecanicillium lecanii* @ 5 g /L
T3: *Beauveria bassiana* @ 5 g /L
T4: Azadirachtin 1500 ppm @ 2 ml/L
T5: Methyl demeton (0.025%) (chemical check)
T6: Control

Frequency of spray: At 10 days interval after initial population is observed

Observations to be recorded:
No. of aphids/ 5 leaves before treatment; No. of aphids/ 5 leaves after every treatment; Per cent leaf infestation/ 5 plants; yield at harvest

No incidence of aphids was observed this season under shade net house.

FLOWERS

24. JASMINE

24.1 Management of bud worm, blossom midge and whitefly on jasmine (TNAU)

Treatments

T1 - Azadirachtin 1500 ppm @ 2ml/L; three times starting from bud initiation stage at 10 days interval

T2 - Release of *T. chilonis* @ 50,000/ acre at 10 days interval for two months from bud initiation based on light trap monitoring + release of *Chrysoperla zastrowi sillemi* 5000 nos./ha from bud initiation

T3 - T2+ three rounds of spraying with *Beauveria bassiana* NBAIR formulation ($1x10^8$ spores/g) @ 5g / litre at 10 days interval

T4 - T2+ three rounds of spraying with *Metarhizium anisopliae* NBAIR formulation ($1x10^8$ spores/g) @ 5g / litre at 10 days interval

T5 - Soil drenching with *Metarhizium anisopliae* 10^9 spores/ha-two times at fifteen days interval

T6 - Soil application of Neem cake @250 kg/ha two times per year

T7 - Soil application of Carbofuran 3G @ 20 gm/plant

T8 - Control

Replications: Three

Methodology and observations

No. of plants per treatment: 10

No. of Replications: 3; 3 branches / plant / replication

No. of infested buds/ flowers counted on 7 days after each application per cent damage

Name of the Farmer : Th.Brahmagiri, Chellapampalayam, Annur block

Variety : Ramnad local

Plot size : 8 x5 m

The flower damage due to jasmine bud borer and blossom midge were assessed at the bud initiation stage before imposing treatment. The data were recorded seven days after each round of spray on numbers of bud borer and blossom midge. After third round of spray, among all the treatments tested, application of *Beauveria bassiana* (NBAIR formulation) at 5g/ litre along with 6 releases of *Trichogramma chilonis* and *Chrysoperla* at 7 days interval was found superior with minimum bud damage of 18.01 per cent while other treatments recorded 23.06 to 32.27 per cent damage including chemical treatment . In control, the damage was 36.15 per cent (Table 154). The data recorded on blossom midge damage in treatment plots revealed that application of spraying of Azadirachtin @ 1500 ppm @ 2ml/L, three times at 10 days interval proved significantly superior by showing only 9.25 per cent bud damage. All other treatments recorded 10.18 to 37.85 per cent damage, while it was 48.95 per cent in control. Yield was higher in treatment with *Beauveria bassiana* (NBAIR formulation) at 5g/ litre along with 6 releases of *Trichogramma chilonis* and *Chrysoperla* at 7 days interval with CB ratio of 2.50.

Table 154. Efficacy of biocontrol agents in suppression of bud borer and blossom midge in jasmine

Treatments	Pre Treatment		Per dent damage 7 days after I spray		Per cent damage 7 days after II spray		Per cent damage 7days after III spray		Per cent reduction over control		Yield Kg/ha	CB ratio
	Bud borer	B.m	Bud borer	B.m	Bud borer	B.m	Bud borer	B.m	Bud borer	B.m		
T1- Azadirachtin 1500 ppm @ 2ml/L	64.68	9.89	48.17 (43.95)	17.36 (24.62)^{b}	22.43 (28.26)^{bc}	8.18 (16.52)^{a}	29.71 (33.03)^{cd}	9.25 (17.70)^{a}	17.81	81.10	1750.0 (41.83)^{c}	2.06
T2 - *T. chilonis* @50,000/acre + *Chrosoperla zastrowi sillemi* 5000 nos/ha	62.88	11.03	51.57 (45.90)	17.68 (24.64)^{b}	20.29 (26.77)^{bc}	10.59 (18.99)^{a}	29.73 (33.04)^{cd}	12.44 (20.65)^{b}	17.76	74.59	1883.3 (43.40)^{abc}	2.38
T3 – T2+ *B. bassiana* (NBAIR) @5g/l	61.79	10.63	46.82 (43.17)	17.40 (24.65)^{b}	10.17 (18.59)^{a}	9.11 (17.56)^{a}	18.01 (25.11)^{a}	10.25 (18.67)^{ab}	50.18	79.06	2000.0 (44.72)^{a}	2.50
T4 – T2+ *M.anisopliae* (NBAIR) @5g/l	64.47	10.76	44.60 (41.90)	17.63 (24.82)^{b}	15.35 (23.06)^{ab}	9.46 (17.91)^{a}	23.06 (28.69)^{ab}	10.18 (18.60)^{ab}	36.21	79.20	1933.3 (43.97)^{ab}	2.38
T5 – Soil drenching *M. anisopliae* (NBAIR)	64.10	10.32	45.97 (42.68)	17.51 (24.73)^{b}	23.07 (28.70)^{c}	32.90 (30.50)^{c}	28.53 (32.28)^{bc}	27.77 (31.80)^{d}	21.08	43.27	1583.3 (39.79)^{d}	1.77
T6 – Soil application of Neem cake @ 250 kg/acre	63.80	10.33	47.01 (43.28)	16.69 (24.11)^{b}	26.56 (31.02)^{c}	37.85 (37.96)^{c}	32.27 (34.63)^{cd}	37.85 (37.96)^{e}	10.73	22.68	1616.7 (40.21)^{d}	1.69
T7- Soil application of Carbofuran @ 20g/plant	62.02	11.16	45.72 (42.54)	13.24 (21.33)^{a}	25.17 (30.11)^{c}	22.13 (28.06)^{b}	30.94 (33.79)^{c}	17.77 (24.93)^{c}	14.41	63.70	1800.0 (42.43)^{bc}	1.93
Control	63.83	10.43	48.69 (44.25)	19.49 (26.19)^{c}	46.76 (43.14)^{d}	45.89 (40.64)^{d}	36.15 (39.90)^{d}	48.95 (44.31)^{f}	-	-	1233.3 (35.21)^{e}	1.27
SE d	**NS**	**NS**	**NS**	**0.3529**	**2.4798**	**1.5664**	**1.9168**	**1.3946**			**0.7337**	
CD (0.05%)	**NS**	**NS**	**NS**	**0.7569**	**5.3191**	**3.3600**	**4.1115**	**2.9915**			**1.5738**	

Means followed by a common letter in a column are not significantly different by DMRT; Figures in parentheses are arcsine transformed values; Values are mean of three replications

25. TRIBAL SUB PLAN

25.1 YSPUHF, Solan

Name of the project proposal: Eco-friendly management of pests of apple, almond, peas, beans, cauliflower and cabbage.

1. Details of the location of tribal area where TSP was implemented: District Kinnaur, Himachal Pradesh

2. No of village covered: 2 and number of farmers benefitted: 100

Sr. No.	Village	Date of training/demonstration	No of farmers
1	Telangi	18.03.2018	50
2	Sangla	19.03.2018	50
	Total		100

3. Crops covered: Apple, almond, peas, beans, cauliflower and cabbage

4. Area covered:

Crop	Area (ha)
Apple	50
Almond	10
Peas	15
Beans	10
Cauliflower & cabbage	15
Total	100

5. Objective of the Project

Management of the insect-pests and diseases of important cash crops of the area through eco-friendly methods to reduce the application of chemical pesticides on these crops.

6. IPM technologies demonstrated/ implemented

i) Use of *Metarhizium anisopliae*, *Beauveria bassiana* and azadirachtin for the management of apple root borer and apple stem borer.
ii) Use of *Trichoderma* for the management of diseases in apple and vegetable nursery.
iii) Use of azadirachtin in cabbage and cauliflower for the management of caterpillars.
iv) Need based and safe use of insecticides for the conservation of parasitoids of apple woolly aphid and other natural enemies.
v) Use/conservation of predatory mites in beans and apple against phytophagous mites.

7. Inputs supplied to the farmers

Sr. No.	Material	Number/ quantity
1	*Metarhizium anisopliae*	20 Kg
2	*Beauveria bassiana*	50L
3	Neem Baan	25L
4	*Trichoderma viride*	50Kg
5	Literature (Package of practices for fruit crops)	100

8. Training/ demonstration conducted

Trainings and demonstrations were organized at Telangi and Sangla villages of Kinnaur district of Himachal Pradesh in which 100 farmers participated. Farmers were trained and demonstrated regarding the use of above said bio-pesticides for the management of insect and mite pests of apple, almond, peas, beans, cauliflower and cabbage. The farmers of the area were exposed to the use of bio-pesticides for the management of crop pests for the first time.

9. Expenditure:

Total amount allocated for the year : Rs. 50,000/-
Amount received: Rs. 50,000/-
Amount spent till date: Rs. 30,344/-

10. Outcome of the project:

One hundred farmers of Telangi and Sangla villages of Kinnaur district of Himachal Pradesh were benefited through the trainings/demonstrations. These farmers were exposed to the use of bio-pesticides for pest management for the first time. In peas, beans, cauliflower and cabbage there was a reduction of 2 sprays of chemical pesticides. In case of apple, farmers saved about Rs 14000/- per hectare by avoiding chemical treatment for the control of apple root borer.

Photographs of TSP activities:


Farmers taking part in the training programme at Telangi district Kinnaur

Farmers taking part in the training programme at Sangla district Kinnaur

Farmers receiving the inputs

A view of Sangla valley

25.2 ANGRAU, Anakapalle

Awareness cum training programmes on Organic farming in Paddy, Organic farming in Rajmah, Organic farming in Ginger, tricho cards of *Trichogramma chilonis* production using Eri silk worm eggs in Tribal areas

Interventions:

- Three Training programmes were conducted in Koyyuru, Asarada, Anakapalle on organic farming practices in Paddy, Rajmah and Ginger on 30.10.2017, 22.11.2017 and one exposure visit and training programme on *Trichogramma chilonis* production using Eri silkworm eggs at RARS,Anakapalle on 15.3.18
- Total 74 farmers of Chintapalli region, Visakhapatnam district were benefitted.

Imparted training to 29 tribal farmers of Chittempadu village, Koyyuru mandal, Chinthapalli division. Farmers were benefitted with awareness and training on nutrient management and pest management in organic paddy cultivation with special emphasis on biological control. Conducted training cum awareness programme on Organic farming in Rajma with emphasis on nutrient management, pest management and post harvest practices to 30 farmers at Asarada, GK veedhi mandal, Chinthapalli.Conducted farmers awareness cum training programme on Trichocard production using Eri silkworm eggs.15 tribal farmers from Asarada, GK veedhi mandal, Chinthapalli were benefitted through exposure visit and training on Trichocard production using Eri silkworm and *Corcyra* eggs at AICRP on Biological control, RARS, Anakapalle. Prepared Booklet on "Mukkyamaina pantalalo Jeevaniyantrana paddathula dwara hanikaraka purugula nivarana" under TSP programme of AICRP on Biological Control and released.Total 74 tribal farmers benefitted through awareness cum training programme on organic farming in paddy, rajmah and Trichocard production in tribal areas. Trichocard production unit was constructed at Asarada village under TSP for the benefit of tribal farmers "Trichocard rythumithra group" was formed with 15 tribal farmers of Asarada village.

25.3 AAU, Anand

25.3.1 Biocontrol technologies for the management of *Fusarium* wilt and pod borer (*Helicoverpa armigera*) in chickpea

Season – Rabi 2017-18

1. Selection of Tribal Farmers.

In Rabi season (2017), 50 tribal farmers (chickpea growers) were selected from Dahod district. Area coverage was ~1 acre/farmer.

Khedut Shibir and training programmes

In association with Tribal Research and Training Centre, Devagadhbariya, Dahod District, khedut shibir and training programme was organized in the month of January 2018 to train the farmers on use of biocontrol inputs and strategies in chickpea crop to tackle *H. armigera* and *Fusarium* wilt.

Distribution of bio-inputs

The following bio-inputs were distributed to farmers.

(Microbial based bio-inputs (NBAIR strains) are being mass produced at the centre and distributed under TSP programme)

1. *Trichoderma harzianum* (Th-3) 1% WP - 1kg / farmer
2. *Beauveria bassiana* (Bb-5) 1% WP - 1kg / farmer
3. *Bacillus thuringiensis* (NBAII-BTG-4) 1% WP - 1kg / farmer
4. *Pseudomonas fluorescens* (Pf-1) 1% WP -1kg / farmer
5. Azadirachtin 1500ppm- 1 lit / farmer
6. Pheromone trap and lures (*H. armigera*) - 10 Nos / farmer

Field visits to record bio-efficacy and on-farm interactions with the farmers

Fields were visited to record the use of bio-inputs by the farmers and bio-efficacy of inputs. There was a significant reduction (65-70%) in incidence of *Fusarium* wilt and *H. armigera* and 12-15% higher yield was recorded in the treated fields compared to untreated.

25.3.2 Biological interventions to enhance the production and productivity of okra in tribal areas of Tapi district in Gujarat

Season - Rabi 2017-18

1. Selection of Tribal Farmers.

In *Rabi* season (2017), 50 tribal farmers (okra growers) were selected from Tapi district. Area covered (~1 acre/farmer)

Khedut Shibir and training programmes

In association with Krishi Vigyan Kendra (KVK), Vyara, Navsari Agricultural University, khedut shibir and training programme was organized in the month of February 2018 to train the farmers on use of biocontrol inputs and strategies in okra crop to tackle key pests and diseases to achieve sustainable production.

Distribution of bio-inputs

The following bio-inputs were distributed to farmers

(Microbial based bio-inputs (NBAIR strains) are being mass produced at the centre and distributed under TSP programme)

1. *Trichoderma harzianum* (Th-3) 1% WP - 1kg / farmer
2. *Beauveria bassiana* (Bb-5) 1% WP - 1kg / farmer

3. *Bacillus thuringiensis* (NBAII-BTG-4) 1% WP - 1kg / farmer
4. *Paecilomyces liliacinum* (Agriland Biotech) 1% WP-1kg / farmer
5. Biofertilizers (AAU Bio NPK Consortium) - 2 lit / farmer
6. Tricho cards (*Trichogramma chilonis*)- 5 Nos / farmer
7. Azadirachtin 1500 ppm- 1 lit/ farmer
8. Pheromone trap and lures (*Earias vitella*) - 10 Nos / farmer
9. Yellow sticky traps – 5 Nos/famers

Field visits to record bio-efficacy and on-farm interactions with the farmers

Fields were visited to record the use of bio-inputs by the farmers and bio-efficacy of inputs distributed. Significant reduction (55-60%) in pest and disease was observed with 10-15% increase in the fruit yield.

25.3 SKUAST, Srinagar

- 7 days Training Programme on "Empowerment of Tribal Women through Scientific Bee Keeping" was organized (5^{th} May– 11^{th} May, 2017).
- A function in Pollination centre for distribution of bee hives to farmers under Tribal sub Plan was organized.

26. GENERAL INFORMATION

26.1 Functioning of the co-ordinated project

26.1.1 Scientific Staff Position (2017-18)

Sl. No.	Name	Designation	Date Of joining ICAR/SAUS	Date of joining present position
1	Dr. Chandish R. Ballal	Director	06.02.1985	18.07.2016
2	Dr. S. K. Jalali	HOD, DIGR	06.02.1985	30.09.2014
3	Dr. N. Bakthavatsalam	HOD, DIGC&U	21.03.1985	21.03.2006
4	Dr. B. Ramanujam	Pl. Scientist (Pl. Path.)	16.04.1986	28.09.2006
5	Dr. A. N. Shylesha	Pl. Scientist (Ento.)	21.01.1992	09.12.2007
6	Dr. T. Venkatesan	Pl. Scientist (Ento.)	10.11.1993	01.01.2009
7	Dr. K. Srinivasa Murthy	Pl. Scientist (Ento.)	25.07.1994	25.07.2009
8	Dr. T. M. S. Swamy	Pl. Scientist (Ento.)	25.07.1994	01.01.2009
9	Dr. Sunil Joshi	HOD, DIGC&C	21.07.1993	22.07.2010
10	Dr. G. Sivakumar	Pl. Scientist (Micro.)	30.12.2008	30.12.2014
11	Dr. M. Mohan	Pl. Scientist (Ento.)	16.04.2003	30.08.2014
12	Dr. Jagadeesh Patil	Scientist (Nemato.)	20.04.2010	20.04.2014
13	Dr. Richa Varshney	Scientist (Ento.)	01.01.2015	01.01.2015
14	Dr. Omprakash Navik	Scientist (Ento.)	01.01.2016	01.01.2016
15	Dr. M. Sampath Kumar	Scientist (Ento.)	11.05.2010	11.05.2014
16	Dr. Amala U	Scientist (Ento.)	15.09.2011	15.09.2011
17	Dr. K. Selvaraj	Scientist (Ento.)	27.04.2011	27.04.2015
Anand Agricultural University, Anand				
1	Dr. D. M. Mehta	Pl. Res. Scientist	July 2012	Continuing
2	Dr. B.L. Raghunandan	Asso. Res. Scientist	2015	Continuing
Assam Agricultural University, Jorhat				
1	Dr. D. K.Saikia	Pl. Scientist (Ent.)	23.03.2001	Continuing
2	Dr.R. Borkakati	Scientist (Ent.)	22.08.2014	Continuing
Acharya N. G. Ranga Agricultural University, RARS, Anakapalle				
1	Dr. M. Visalakshi	Sr. Scientist (Ent.)	Apriul 2015	Continuing
Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar				
1	Dr. Anand Kumar Tewari	Professor (Pl. Patho.)		Continuing
2	Dr. Roopali Sharma	Junior Res. Officer	12.01.2006	Continuing
Kerala Agricultural University, Thrissur				
1	Dr. Madhu Subramanian	Professor (Ent.)	2015	Continuing
Mahatma Phule Krishi Vidyapeeth, Pune				
1	Dr. D.S. Pokharkar	Sr. Entomologist	21.07.2016	Continuing

2	Dr. S.M. Galande	Asst. Entomologist	01.08.2013	Continuing
3	Dr. U.B.Hole	Entomologist	01/08/2017	Continuing
4	Dr. R.V. Nakat	Entomologist	06/12/2017	Continuing
Punjab Agricultural University, Ludhiana				
1	Dr. K.S. Sangha	Senior Entomologist	31.08.1995	Continuing
2	Dr Neelam Joshi	Senior Microbiologist	08.05.1997	Continuing
3	Dr Rabinder Kaur	Asstt. Entomologist	20.12.2004	Continuing
4	Dr. Sudhendu Sharma	Asstt. Entomologist	18.07.2005	Continuing
5	Dr Parminder Singh Shera	Asstt. Entomologist	09.05.2003	Continuing
Professor Jayashankar Telangana State Agricultural University, (PJTSAU) Hyderabad				
1	Dr. S.J Rahman	Professor & Head	Feb. 2007	Continuing
Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar				
1	Dr. Jamal Ahmad	Associate Professor	Nov. 2007	Continuing
2	Mr. Sajad Mohi-ud-din	Assistant Professor	June 2013	Continuing
Tamil Nadu Agricultural University, Coimbatore				
1.	Dr. S. Sridharan	Professor (Ento.)	12.06.2014	07.01.18
2.	Dr. P.A. Saravanan	Asst. Prof. (Ento.)	11.06.2014	07.01.18
3	Dr. S.Jeyarajan Nelson	Professor	08.01.2018	Till date
4	Dr. A.Suganthi	Asst. Professor	25.10.2017	Till date
Dr. Y.S. Parmar University of Horticulture and Forestry, Solan				
1	Dr. P. L. Sharma	Pl. Scientist (Ento.)	21.11.1995	Continuing
2	Dr. S. C. verma	Pl. Scientist (Ento.)	30.11.1995	Continuing
Central Agricultural University, Pasighat				
1	Dr. Raghubir K Patidar	Asso. Prof. (Ento.)	2015	Continuing
Maharana Pratap University of Agriculture & Technology, Udaipur				
1	Dr. B. S. Rana	Prof. (Ento.)	2007	28.02.18
2	Dr. M. K. Mahla	Asso. Prof. (Ento.)	01.03.18	Continuing
Orissa University of Agriculture & Technology, Bhubaneshwar				
1	Dr. Bhagaban Patro	Prof. (Ent.)	29.06.2015	Continuing
University of Agriculture Sciences, Raichur (Voluntary Centre)				
1	Dr. Arunkumar Hosmani	Asso. Prof. (Ento.)	2015	Continuing
Central Institute of Sub-Tropical Horticulture, Lucknow				
1	Dr. Gundappa, B.	Scientist (Ento.)	2013	
2	Dr. P. K. Shukla	Scientist (Ento.)	2018	
Central Plantation Crops Research Institute, Regional Station, Kayamgulam				
1	Dr. Chandrika Mohan	Pl. Scientist (Ento.)	01.04.1996	
2	Dr. Sujithra, M.	Scientist	2018	
Central Tobacco Research Institute, Research Station, Guntur				
1	Dr. V. Venkateswarulu	Scientist (Ento.)	2018	
Indian Institute of Horticultural Research, Bangalore				
1	Dr. Gopal Krishna Pillai	Pl. Scientist (Ento.)	2018	

2	Ms. Jayanthi Mala	Scientist (Ento.)	2018	
Indian Institute of Millet Research, Hyderabad				
1	Dr. G. Shyam Prasad	Pl. Scientist (Ento.)	2018	
Indian Institute of Rice Research, Hyderabad				
1	Dr. Chitra Shanker	Pl. Scientist (Ento.)	2018	
2	Dr. C. Kannan	Pl. Scientist (Pl. Path.)	2018	
Indian Institute of Vegetable Research, Varanasi				
1	Dr. A. B. Rai	Pl. Scientist (Ento.)	2018	
2	Dr. Jaydeep Halder	Scientist (Ento.)	2018	
National Centre for Integrated Pest Management, New Delhi				
1	Dr. Anoop Kumar	Scientist (Ento.)	2018	
2	Dr. Mukesh K. Khokhar	Scientist (Pl. Patho.)	2018	
Dr. Y. S. R. University of Horticulture, Ambajipeta				
1	Dr. N. Chalapathi Rao	Assoc. Prof. (Ento.)	2018	
2	Dr. B. Neeraja	Asst. Prof. (Pl. Patho.)	2018	
Indira Gandhi Krishi Vishwavidyalaya, Raipur				
1	Dr. R. N. Ganguli	Prof. (Ento.)	2018	
2	Dr. Jayalakshmi Ganguli	Asso. Prof. (Ento.)	2018	
Kerala Agricultural University, RARS, Kumarakom				
1	Dr. Sible G. Varghese	Asso. Prof. (Ento.)	2018	
2	Dr. Anu G. Krishnan	Asst. Prof. (Pl. Patho.)	2018	
Kerala Agricultural University, RARS, Vellayani				
1	Dr. Jiji Rajmohan	Prof. (Ento.)	2018	
Uttar Banga Krishi Viswavidalaya, Pundibari				
1	Dr. S. K. Sahoo	Asso. Prof. (Ento.)	2018	
2	Dr. Moulita Chatterjee	Asso. Prof. (Ento.)	2018	
3	Dr. D. Chakraborty	Asst. Prof. (Pl. Patho.)	2018	

26.2 Budget of AICRP for 2017-2018

Budget of AICRP on Bio control for 2017-18

Item of Expenditure	Sanctioned and allotted grants (Rs. in lakh)	Grants released during2016-17 from ICAR (Rs. in lakh)	Total expenditure (Rs.)
Pay and allowances	409.00	409.00	409.00
Rec. Contingencies	45.63	45.63	45.63

T.A	8.11	8.11	8.11
TOTAL	**462.74**	**462.74**	**462.74**

26.3 Problem encountered during the year

ANGRAU, at RARS, Anakapalley

1. Surveillance for pest outbreak and alien invasive pests helps in educating state departments and farmers for timely management of pests and diseases.
2. Surveillance for pest outbreak and alien invasive pests also helps in cataloguing major pests and diseases to fix up research priorities for emerging problems.

Dr. Y.S. Parmar University of Horticulture and Forestery, Solan

1. Tribal area of the state is high mountainous region and remains covered with snow during winter; hence for effective and timely utilization, all the funds under TSP may kindly be released by the end of September.

AAU – Jorhat

1. Survey and collection of natural enemies from different Agro-ecological zone, demonstration and field trials on farmers fields are very much essential to carryout in due time. In this context, university vehicle is generally not available in time due to various activities of the university. Therefore, separate provision may be made in budget for hiring the vehicle from the outside.

MPKV, Pune

1. The technical staffs are not sanctioned in the project. Hence, permission may please be given to appoint Technical Asstt/ Skilled helper on contractual basis from the sanctioned recurring contingencies.

TNAU, Tamil Nadu

1. Prevalence and spread of Coconut Rugose whitefly in various districts of Tamil Nadu was observed. The natural enemies like *Encarsia* spp were collected and redistributed to farmers. Apart from that, *Chrysoperla zastrowi silemmi* is being supplied to farmers for the management of this invasive pest.
2. Incidence of Coconut black headed caterpillar was reported from Krishnagiri Dt. *Goniozus* and *Braconids* were distributed to farmers for management

26.4 Meteorological Data (2017-18)

KAU, (Vellanikkara, Thrissur)

Year	Month	Max. Temp	Min. Temp.	RH I (%)	RH II (%)	Rainfall (mm)	Wind speed (kmph)	Evaporation (mm/day)	Bright Sunshine hours
2017	Apr	35.7	26.0	85	55	19.1	2.1	4.0	6.5
2017	May	34.6	24.9	84	60	167.5	1.8	3.6	5.5
2017	Jun	30.4	23.5	95	78	630.2	1.1	2.5	2.0
2017	Jul	30.8	22.8	95	74	385.5	1.2	2.7	2.9
2017	Aug	30.1	23.3	96	78	478	1.0	2.6	3.1
2017	Sep	31.5	22.9	94	74	413.9	0.7	2.8	4.2
2017	Oct	31.7	22.3	93	70	183.4	0.2	2.3	4.9
2017	Nov	33.0	21.8	87	58	58.3	1.9	3.0	6.4
2017	Dec	32.4	21.1	63	49	11.5	5.1	3.9	7.3
2018	Jan	33.5	20.9	68	37	0	5.4	4.4	8.2
2018	Feb	35.7	22.5	63	30	5.2	5.7	5.6	9.5
2018	Mar	36.3	24.0	79	39	33.2	3.3	5.0	8.0

SKUAST Kashmir

Date	Max. Temp. ℃	Min. Temp. ° C	Av. Temp.	Rainfall	Max. Humidity	Min. Humidity	Av. Humidity	SSH
Jan 1-15	8.3	-2.0	3.1	1.2	90	70.8	80.4	2.5
Jan 16-31	10.4	-2.2	4.1	0.9	89.6	57.3	73.45	3.8
Feb 1-15	11.2	-1.6	4.8	1.9	92.3	69.8	81.05	4.2
Feb 16-29	15.9	-0.4	7.7	2.0	92.9	72.8	82.85	7.1
March 1-15	16.4	2.6	9.5	3.1	94.5	78.9	86.7	10.5
March16-31	15.72	3.7	9.7	9.2	94.3	82.1	88.2	3.0
April 1-15	17.5	6.9	12.2	4.7	86.1	72	79.05	3.2
April 16-30	20.9	6.3	13.6	3.8	82.1	65	73.55	6.2
May 1-15	24.9	9.7	17.3	1.6	76	55.7	65.85	6.4
May 16-31	28.7	10.8	19.7	1.0	75	47.9	61.45	8.6
June 1-15	30.2	13.9	22.05	0.2	71.3	44.2	57.75	9.8
June 16-30	31.6	16.2	23.9	0.0	68.3	52	60.15	8.5
July 1-15	31.8	17.2	24.5	0.4	71	43.2	57.1	8.2
July 16-31	29.5	16.8	23.1	4.0	85	55.7	70.35	6.9
Aug 1-15	27.3	16.5	21.9	3.2	82.3	53.1	67.7	7.1
Aug16-30	26.5	14.2	20.3	3.1	82.9	58.2	70.55	5.2
Sep 1-15	28.9	13.3	21.1	0.9	69.1	54.1	61.6	7.5
Sep 16-31	29.0	9.2	19.1	0.1	65.4	39.2	52.3	8.6
Oct 1-15	27.8	6.7	17.2	0.5	75.3	38.9	57.1	7.8
Oct 16-31	23.9	3.3	13.6	0.2	79.3	44.2	61.75	6.9
Nov 1-15	11.2	-1.7	4.7	0.0	89	57.8	73.4	3.6
Nov 16-30	10.7	-3.5	3.6	0.0	82	54.1	68.05	0.7
Dec 1-15	8.9	-4.2	2.3	0.5	94.2	59.3	76.75	1.0
Dec 16-31	7.3	-5.3	1.4	0.0	93.2	55.7	74.45	0.5

Dr. Y.S. Parmar University of Horticulture and Forestery, Solan

Month	Temperature (^{0}C)		Relative Humidity (%)		Total Rainfall (mm)	No. of Rainy days
	Max.	Min.	Morning	Evening		
March, 2017	22.9	7.8	57	32	33.2	06
April, 2017	29.3	13.2	55	53	57.8	08
May, 2017	30.5	15.8	62	43	100.8	09
June, 2017	28.7	17.9	76	60	197.8	14
July, 2017	27.6	20.4	88	74	162.3	16
August, 2017	26.7	20.1	89	75	233.8	20
September, 2017	27.2	16.8	85	68	133.8	08
October, 2017	27.3	10.8	72	48	00.0	00
November, 2017	22.2	5.9	73	64	2.4	02
December, 2017	20.4	4.5	69	51	19.4	02

January, 2018	19.1	2.1	61	39	18.0	01
February, 2018	20.2	5.3	63	38	50.2	04

UAS, RAICHUR

2017	**Std Week**	**Max.T (°c)**	**Min.T (°c)**	**RF (mm)**	**R Day**	**RHI (%)**	**RH II (%)**
July 09-15	28	32.8	24.0	3	0	77	55
July 16- 22	29	33.4	23.7	0	0	80	48
July 23- 29	30	35.2	24.0	3	1	77	41
July 30- Aug 05	31	34.8	23.9	4.1	0	81	44
Aug 06-12	32	33.5	20.9	81.6	4	86	56
Aug 13-19	33	31.6	23.9	3.8	1	88	62
Aug 20-26	34	31.1	22.8	27.1	4	87	64
Aug 27-Sept 02	35	30.9	23.3	82	5	89	66
Sep 03- 09	36	30.9	23.7	74.4	3	92	69
Sep10-16	37	32.5	24.3	35.3	2	89	64
Sep 17- 23	38	29.4	22.5	50.5	1	89	76
Sep 24-30	39	31.0	22.5	88.2	5	97	82
Oct01-07	40	30.2	23.5	42.5	2	96	75
Oct 08 -14	41	30.4	22.9	130.8	5	96	72
Oct 15-21	42	31.0	21.5	20.2	1	91	68
Oct 22-28	43	31.1	22.1	0	0	91	63
Oct 29-Nov 04	44	30.5	19.0	0	0	82	51
Nov 05-11	45	30.3	19.6	0	0	85	53
Nov 12-18	46	31.2	19.1	0	0	82	45
Nov 19-25	47	31.8	21.8	0	0	85	47
Nov 26-Dec 02	48	30.3	17.7	0	0	78	49
Dec 03-09	49	29.8	18.8	0	0	82	52
Dec 10-16	50	31.3	16.6	0	0	87	39
Dec 17-23	51	28.7	14.0	0	0	89	49
Dec 24-31	52	29.1	14.4	0	0	83	39
2018 Jan 01-07	1	30.0	15.7	0	0	78	42
Jan 08-14	2	30.2	17.7	0	0	81	46
Jan 01-07	3	30.0	15.7	0	0	78	42
Jan 08-14	4	30.1	14.8	0	0	77	44
Jan 15-21	5	30.2	15.1	0	0	76	45

PAU, Ludhiana

Month	Temp (°C)		RH (%)		Total rainfall	Evaporation (mm)	BSSH	Rainy days
	Max.	Min.	Morn.	Even.				
April 2017	36.9	20.0	57	23	14.8	239.6	10.0	2
May 2017	38.8	25.1	50	27	31.6	284.9	9.4	2
June 2017	36.7	26.2	64	42	127.0	219.4	8.7	7
July 2017	34.6	27.5	79	60	112.0	174.0	6.9	8
August 2017	33.9	26.7	82	66	131.4	133.1	6.3	6
September 2017	33.7	23.9	87	56	24.4	131.5	8.3	3
October 2017	33.3	18.5	88	38	0.0	113.7	6.8	0
November 2017	24.7	11.5	93	47	7.0	47.4	3.8	1
December 2017	20.9	7.5	91	47	24.0	51.0	5.7	1
January 2018	18.7	6.2	94	56	18.4	46.0	5.5	1
February 2018	22.8	9.1	90	46	27.0	64.4	8.0	1
March 2018	29.3	13.1	85	38	0.0	129.5	9.0	0

AAU – Jorhat

Month	Temperature (^{0}C)		R/H (%)		Total rainfall (mm)	Wind speed (km/hr)	BSSH (hrs)	Rainy days
	Max.	Min.	Morn.	Even.				
April	28.6	20.2	94	73	209.1	2.6	126.7	15
May	30.4	22.7	94	75	249.7	2.5	126.4	16
June	32.3	25.2	95	77	267.5	2.3	99.4	17
July	33.0	25.3	96	77	576.0	2.4	152.3	20
August	31.1	25.7	94	79	269.1	2.2	105.7	17
September	32.7	25.3	94	78	324.5	1.9	97.6	16
October	31.0	23.0	96	77	129.8	1.4	160.5	8
November	28.4	16.2	95	68	14.7	1.0	222.5	2
December	25.8	12.7	99	69	0.0	0.8	168.2	0
January	23.9	11.0	98	69	2.7	1.1	144.6	0
February	24.5	13.2	97	67	29.1	1.5	94.9	2
March	27.3	16.0	95	64	76.0	2.3	124.1	6

MPKV, Pune

Met. week (MW)	$T_{max}{}^0C$	$T_{min}{}^0C$	RH-I (%)	RH-II (%)	Rain (mm)	Rainy days	BSS (hrs)
14	37.4	18.0	61	18	0.0	0	9.6
15	39.9	18.9	61	10	0.0	0	10.0
16	39.3	21.6	51	16	0.0	0	10.3
17	37.0	21.0	64	17	0.0	0	10.8
18	39.6	22.0	60	16	0.0	0	9.3
19	40.0	23.3	57	21	1.9	0	10.1
20	38.1	23.1	65	28	4.6	1	8.8
21	38.2	24.4	67	31	0.0	0	10.3
22	36.8	24.2	75	39	4.8	1	9.9
23	34.5	24.7	72	48	0.0	0	6.9
24	32.1	23.1	81	67	116.4	4	3.4
25	32.1	23.9	81	67	45.0	1	9.3
26	28.2	22.6	88	79	47.1	6	2.5
27	28.4	22.9	83	67	13.4	2	4.0
28	28.7	22.5	83	70	52.3	2	5.8
29	28.9	22.5	89	82	85.5	7	0.9
30	27.7	22.4	88	76	35.4	5	1.9
31	28.1	21.8	86	75	6.5	0	3.3
32	28.9	22.1	86	67	2.4	0	4.8
33	28.0	21.9	85	71	3.6	1	4.1
34	27.1	20.8	91	73	94.7	3	3.4
35	27.9	21.5	88	78	57.6	4	3.9
36	30.5	21.6	89	58	23.0	1	6.2
37	31.8	22.6	91	65	33.6	3	4.9
38	27.4	21.6	91	82	69.6	4	2.5
39	32.0	21.5	90	66	25.4	2	6.9
40	33.4	21.9	87	51	2.2	0	7.0
41	30.5	22.1	94	80	135.1	6	3.3
42	32.0	20.2	92	49	24.1	2	6.0
43	31.6	18.7	92	40	19.5	1	7.4
44	30.8	14.8	93	31	0.0	0	8.4
45	30.3	14.1	93	38	0.0	0	9.1
46	29.9	12.5	92	35	0.0	0	7.6
47	30.9	17.0	91	53	13.9	1	5.7
48	30.1	12.4	96	48	0.0	0	7.7
49	28.4	17.9	89	58	2.8	1	5.0
50	30.2	14.6	95	48	0.0	0	7.8
51	29.0	11.8	88	38	0.0	0	7.1
52	29.2	10.3	94	30	0.0	0	8.3
1	29.06	11.49	97	36	0.0	0	7.0
2	29.07	13.43	94	52	0.0	0	7.1
3	31.46	13.81	93	29	0.0	0	7.9

4	29.97	10.77	96	27	0.0	0	8.8
5	30.81	10.87	94	24	0.0	0	9.0
6	30.47	13.27	86	26	0.0	0	6.0
7	31.24	13.47	89	33	0.0	0	8.7
8	33.77	14.70	85	21	0.0	0	8.7
9	35.03	15.51	83	19	0.0	0	8.8
10	35.46	18.04	84	20	0.0	0	7.0
11	33.91	18.49	68	27	0.1	0	5.0
12	34.70	15.28	82	18	5.1	1	8.7
13	37.7	17.4	71	13	0	0	8.5

26.5 Visitors

AAU, Anand

Sr. No.	Visitors	Total
1	Trainees from Govt/Pvt organization	12
2	Farmers	220
3	Students	450
4	Agri-Input Dealers	18
	Total	**700**

1. Dr. M Mohan, Principal Scientist ICAR-NBAIR Bengaluru visited AICRP-BC Anand centre on 06/07 -11-2017
2. Dr. Ramya, Scientist ICAR-NBAIR Bengaluru visited AICRP-BC Anand centre on 13/14-02-2018

KAU, Thrissur

1. Dr. Chandish R. Ballal, Director, NBAIR, Bengaluru visited the Centre on 02/11/2017 for review of the activities of the centre.

SKUAST, Kashmir

1. Sanjeev Kumar (SMS Kathua, J&K), Sandeep Sharma (SMS Uddhampur, J&K), NusratNabi (Agr. Ext. Asst. Srinagar) and MasratShafi (Agr. Ext. Asst. Baramullah) visited Biocontrol laboratory on 10.10. 2017.
2. Visit of three Agr. Ext. Asst. from line department of Kathua, Udhampur and Srinagar on 14. 11.2017 regarding Mass production of bioagents
3. Visit of two ADA, one SMS and Agr. Ext. Asst. from Jammu & Kashmir and Madhya Pradesh on 12.12.2017. regarding Mass production of *Trichogramma* and their field use.
4. Visit of four SMS, three AEAs and one from ATMA from Jammu & Kashmir on 28.03. 2018 to understand the role of biological control agents, their conservation and exploitation

5. Visit of 10 officers from Line Department of Jammu & Kashmir, on 29.03.2018.
6. Visit of officers/farmers/Line departments on 12- 13.3.2018 in stall of Entomology Division and interaction with scientists regarding use of bio agents against different crops, in Exhibition cum sale of seed in SKUAST-K, Shalimar
7. Visit of 50 farmers led by Agriculture Extension Officer Zone Dangarpora Sub Division Sopore on 30.3.2018.

Dr. Y.S. Parmar University of Horticulture and Forestry, Solan

1. 150 farmers visited the biocontrol research laboratory.
2. Sixteen scientists from different parts of the country attending advance training at HAU, Hissar visited the biocontrol research laboratory on 17-11-2017**.**
3. Delegation of Horticulture Officers from Bhutan visited AICRP Biocontrol Laboratory on 24-5-2017.
4. Group of PG students from Badu Sahib University district Sirmaur (HP) visited AICRP Biocontrol Laboratory on 30-5-2017.
5. A team of DUS scientists from Protection of Plant Varieties and Farmers' Rights Authority, India along with German delegate visited Biocontrol Research Laboratory on 8-6-2017.
6. Group of 10 students from Jodji (Bhojnagar) visited AICRP Biocontrol Laboratory on 27.02.2018.

PAU, Ludhiana

S.NO.	DATE	VISITORS	PURPOSE
1.	26.10.17	Director of Agriculture, Tamil Nadu	To conduct training programme for extension functionaries on the management of rugose white fly
2.	29.1.2018 and 30.1.2018	Dr.B.Ramanujam, Scientist, NBAIR, Bengaluru	Review of AICRP biocontrol of crop pests scheme

S. No.	Name	Date of visit
1.	Sh Ajay Vir Jhakhar, Chairman, Punjab Farmers Commission	July 12, 2017

AAU – Jorhat

1. A group of farmers visited Biocontrol laboratory on 25th October, 2017.

2. Interaction with students from Sikkim University was held on 18.12.17 at Biocontrol laboratory, Department of Entomology, AAU and Jorhat.
3. Dr. Sandish Ballal, Director NBAIR, Bengaluru visited AICRPBC Jorhat centre, Assam Agricultural University, Jorhat on 26th January,2018 to review the progress of the research programme.
4. Dr. P. K. Chakravarty, Director, NBAIR, Bengaluru visited AICRPBC Jorhat centre, Assam Agricultural University, Jorhat on 15th February, 2018.
5. University monitoring team constituted by Honb'l Vice Chancellor, AAU, Jorhat visited the experimental fields as well as the AICRPBC laboratory on 12.01.2018 to review the progress of research programme on biocontrol.

MPKV Pune

1. Dr. Chitra Srivastava, Head, Entomology, IARI, New Delhi visited biocontrol laboratory, on 11.05. 2017.
2. Hamedullah Ahmadzai, Lecturer, National Agriculture College, Afghanistan and other 4 lecturers visited biocontrol laboratory, Pune on 11.05.2017.
3. Dr. S.B. Kharbade, Head, Department of Entomology, MPKV, Rahuri visited biocontrol laboratory, Pune on 15.05.2017.
4. Dr. S. Sithanantham, Former scientist, ICRISAT, Hyderabad and Director, Sun Agro Biotech Research Centre, Chennai (T.N.) visited biocontrol laboratory on 12.7.2017.
5. Hon. Chandrakanth Bellad, Ex. Minster, Karnataka visited biocontrol laboratory on 02.8.2017.
6. Dr. Parmeshwarappa, Ex. Dean, University of Agricultural Sciences, Bangalore visited biocontrol laboratory on 02.8.2017.
7. Dr. K.P. Vishwanatha, Hon. Vice Chancellor, MPKV, Rahuri visited biological control laboratory and taken review of on-going research activities and production of biocontrol agents on 04.10.2017.
8. Hon. Dr. Venkateshrallu, ADG (Education), ICAR, New Delhi visited biocontrol laboratory and taken the review of on-going research activities and production of biocontrol agents on 04.10.2017.
9. Dr. Neelu Nangia, Prof and Head, Dept. of Sericulture, University of Agricultural Science, G.K.V.K Bangalore visited biological control laboratory on 28.12.2017.
10. Dr. P.S. Jagdish, Prof (Emaritus) Entomology G.K.V.K., Bangalore visited biological control laboratory on 28.12.2017.
11. Dr. Narayan G. Hegde, Trustee, BAIF, Pune visited biological control laboratory on 22.01.2018 and taken the information on production of biopesticides.
12. Dr. S. V. Giramkar, Dept. of Zoology, PDEA, Baburaoji Gholap College Sangvi, Pune visited biological control laboratory on 09.02.2018
13. Dr. Vipul Solanki, Horticulture Department, Ahemedabad, Gujrat visited biological control laboratory on 09.03.2018.

PJTSAU Hyderabad

1. Dr. T.Pradeep, Director of Research, PJTSAU visited the Centre on 23.12.2017
2. Dr. P. K. Chakravarthy, ADG (Plant Protection & Bio Safety), ICAR, New Delhi visited the Centre on 18.1,2018
3. Dr. I. Srinivas, CEO, Agri. Experiential Learning, PJTSAU visited the centre on 23.1.2017
4. QRT Team & Dr. Chandish Ballal, Director, NBAIR and Project Coordinator, AICRP on Biological control visited the Centre on 28.2.2018

26.6 Awards/Honours/Recognition

26.6.1 Awards

AAU, Anand

1. Dr Raghunandan, B.L. awarded 'Best Poster' award for the research paper entitled 'Field evaluation of different biological control agents against chilli anthracnose disease' presented in Special symposium on 'Microbial Antagonists and their role in Biological Control of Plant Diseases and West Zone Meet of Indian Phytopathological Society (IPS) (2017) on October 5- 7, 2017 held at Anand Agricultural Univeristy, Anand.

UAS-Raichur

Sl. No.	Particulars	Date	Venue
1.	Secured second place in Krishimela 2017 for Display of biocontrol agents	08 to 11th December 2017	Raichur
2.	Recived appreciation certificate for display of biocontrol agents in Millet mela 2017	24 to 25th December 2017	Raichur

GBPUAT, Pantnagar

1. **Best Master's Thesis Award (**2017) of GBPUAT, Pantnagar to Mr. Sourav Kumar Modak on "Potential of *Brassica juncea* as bio-fumigant for the management of damping off in tomato" under the supervision of Dr. Roopali Sharma.

MPKV, Pune

1. Dr. R. V. Nakat awarded with **"Krishiratna Dr. Panjabrao Deshmukh Prerana Award"** by Amachi Mati Amachi Manase and Jaykisan Farmers Forum, Nashik on **27.12.2017**.
2. Dr. R. V. Nakat obtained the registration for biopesticides developed by MPKV, Rahuri from CIBRC, Faridabad.

26.6.2 Recognition

SKUAST, Kashmir

1. Dr. Jamal Ahmad acting as P.I. Bio control of SKUAST-K, centre w.e.f. June' 2014.
2. Dr. Jamal Ahmad acting as *In Charge* Head, Entomology, SKUAST-K from 20th December' 2016 till date.
3. Dr. Jamal Ahmad acting Acted as Member for Academic Council, SKUAST-K.
4. Dr. Jamal Ahmad acting Acting as Chairman, comprehensive package of Practices for Royal Spring Golf, Srinagar.
5. Dr. Jamal Ahmad acting as Dean P.G. Nominee of M.Sc. student of Ag. Statistics, SKUAST-K.
6. Dr. Jamal Ahmad acting as Dean, P.G. Nominee for M. Sc. (Pathology) student of SKUAST-K.
7. Dr. Jamal Ahmad acting as Major Advisor for Ph.D. student entitled "Studies on the taxonomy of hymenopteran parasitoids of agricultural pests of Kashmir".
8. Dr. Jamal Ahmad acting as Major Advisor for Ph.D. student entitled "Bio rational management of insect pests of cabbage in Kashmir".

PAU, Ludhiana

1. Dr K.S. Sangha, Sr. Entomologist appointed as Member Board of studies for Agriculture, Punjabi University, Patiala for another three year term**.**

YSPUHF, Solan

1. Bio-intensive management of *Helicoverpaarmigera, Tutaabsoluta*and sucking pests of tomato.
2. Evaluation of biocontrol agents for the control of sucking pests in capsicum under polyhouse

PJTSAU, Hyderabad

1. Dr. S. J. Rahman, Principal scientist & University Head of Entomology as Member of Apex/Statutory Committees of Central & State Government.
2. Dr. S. J. Rahman Expert Member for Telangana State Bio Diversity Board (TSBDB), Govt. of Telangana.
3. Dr. S. J. Rahman Expert Member for Committee for developing Effective Vector Control practices by ICMR, New Delhi.
4. Dr. S. J. Rahman Member of Review Committee on Genetic Manipulations (RCGM), Ministry of Science & Tech., Govt. of India.
5. Dr. S. J. Rahman Member of High level Expert Committee on Environmental Risk Assessment (ERA), Ministry of Environment, Forests and Climate Change, Govt. of India

26.7 Education & Training

AAU – Jorhat

1. Dr.D.K.Saikia, principal Scientist acted as member of AAU Monitoring team from8th to 11th January, 2018**.**
2. Dr. D.K.Saikia, Principal Scientist was appointed as external question setter for Umroi, Umiam Meghalya for comprehensive examination.
3. Dr. D.K.Saikia, Principal Scientist was appointed as examiner for thesis evaluation of M. Sc. (Ag.) of Nagalang University.
4. Dr. D.K.Saikia, Principal Scientist was appointed as examiner for thesis evaluation of PhD thesis from Jain University, Bangalore-560024**.**
5. Dr.D.K.Saikia, Principal Scientist conducted Ph.D courses on Recent trends in Biological control (ENT-606), Advanced Insect Ecology (ENT 604), Insect Behavior (ENT- 605) and Advanced Six Ph.D students are being carried out P.G. research work under the guidance of Dr. D.K.Saikia,**.**
6. Dr. D.K.Saikia, Principal Scientist act as a course instructor for Experiential learning programme (Bio-control agents and bio-pesticide) offered to B.Sc. (Agri) student**s.**
7. Dr. D.K.Saikia, Principal Scientist impart coaching to UG students for JRF examination**.**
8. Dr. D.K.Saikia acts as a Co- investigator in the Biopesticides programme under DBT – AAU, Centre**.**
9. R. N. Borakakati, Jr. scientist, act as a course leader of UG course "Pests of crops, stored grain and their management" (Ent 323). Besides this he also acts as course instructor of PG courses like Biological Control (ENT 507) and IPM (Ent510).
10. R. N. Borakakati, Jr. scientist, act as a course instructor for experiential learning programme (Bio-control agents and bio-pesticide) offered to B.Sc. (Agri) student**s.**
11. Two M.Sc (Agri) students are being carried out P.G. research work under the guidance of R. N. Borakakati.
12. R. N. Borakakati acted as resource person of Farmer's Scientists Interaction at Farmers Fair, RARS, Titabor, 7.11.2017**.**
13. R. N. Borakakati, Scientist also associated with one DBT and one GEF project.Other activities performed by R. N. Borkakati are:

- Lecture delivered to RAWEP students of Plant Protection on 17.07.2017
- Lecture delivered to RAWEP students of Plant Protection on 05.01.2018
- Member of Helpdesk of Counseling of UG/PG programme from 19th July to 27th July,2017 at Dr. M.C. Das Memorial Auditorium, AAU, Jorhat-13
- Member of Helpdesk of Counseling of UG/PG programme on 7th August, 2017 at Dr. M.C. Das Memorial Auditorium, AAU, Jorhat-13

Training Imparted

Sl. No.	Programme	Place	Resource person	Date	Trainee
1	Biological Control of Crop Pests	Conference hall, DoEE,AAU, Jorhat	Dr.D.K.Saikia	01.06.2017	SMS/PA from KVK, AAU, Jorhat
2.	Leboratory techniques for making trichocard	ELP Laboratory, AAU, Jorhat	Dr.D.K.Saikia R. N. Borkakati	01.06.2017	SMS/PA from KVK, AAU, Jorhat
3	Pest Management in organic Agriculture (Rice, toria, pea, potato and vegetable)	Hatkhola Village, Chabua	Dr.D.K.Saikia	26.08.2017	Farmers
4	Recent Advances in Integration of Bioagents in Pest Management	Conference hall, Deptt. of Plant Pathology, AAU, Jorhat	Dr.D.K.Saikia	07.09.2017	Scientist
5	Pest and Disease Management in Post Flood Situation	EEI, AAU, Jorhat	Dr.D.K.Saikia	08.09.2017	Agricultural Inspector, Meghalaya
6	Awareness programme by Deptt. of Extension Education, AAU, Jorhat	Koronga Holowgaon primary school	R. N. Borkakati	27.10.2017	Farmers
7	CAFT training on "Culturing techniques for biofertilizers and biopesticides"	Department of Soil Science, AAU, Jorhat	Dr.D.K.Saikia R. N. Borkakati	21.11.2017	Scientist
8	CAFT training on "Culturing techniques for biofertilizers and biopesticides"	Department of Soil Science, AAU, Jorhat	Dr.D.K.Saikia R. N. Borkakati	21.02.2018	Scientist

AAU – Anand

1. Technical guidance regarding 'Biological Control of Crop Pests' was provided through lectures and demonstrations to the extension officers and farmers in various training programs organized by Directorate of Extension Education, AAU, Anand, State Department of Agriculture, Govt. of Gujarat and NGOs.
2. Participated and arranged exhibition stall during Krushi Mahotsav, farmers' meeting and other special occasions as per the directions received from Directorate of Extension Education, AAU, Anand and Extension Education Institute.

Details of Khedut Shibirs/farmers day/training programmes organized during 2017-18

Sr. no	Date	Village & Taluka	No. of farmers attended
1	12-02-2018	Vyara. Tapi Dist, Gujarat	64
2	23-03-2018	Devagadhbaria, Dahod Dist, Gujarat	50

Lectures and demonstrations were conducted to the students/farmers on 'Biological Control of Crop Pests' during their visit to the Laboratory

Sr. No	Date	Visitors (No.)	Visitors/Trainee details
1	14/02/2017	Students (35)	College of Horticulture SDAU, Jagudan
2.	20/02/2017	Farmers (24)	Group of soil and water testing farmers
3	18/03/2017	Dairy farmers (11)	Ralanpur
4	22/03/2017	BASF Trainees (12)	BASF Ltd. Ahmedabad
5	23/03/2017	Farmers (18)	ATMA Project, Raigad, Maharashtra
6	24/03/2017	Farmers (18)	Jalaram Fertilizers, Bodeli
7	04/04/2017	Students (66)	ACHF, NAU
8	06/04/2017	Students (41)	College of Horticulture AAU, Anand
9	02/08/2017	Farmer trainees (25)	IPM, EEI, Anand
10	14/09/2017	Farmers (25)	Solapur, Maharashtra Farmers group
11	12/10/2017	Farmers (12)	Anand and Kheda District
12	23/10/2017	Students (40)	BACA, AAU, Anand
13	25/10/2017	Students (40)	BACA, AAU, Anand
14	27/10/2017	Students (40)	BACA, AAU, Anand
15	27/10/2017	Farmers (11)	Anand and Kheda District
16	14/11/2017	Farmers (43)	NGO, BCI Project, Dhakadva, Amreli
17	22/01/2018	Students (42)	College of Horticulture SDAU, Jagudan

18	29/01/2018	Students (48)	Shree R. P. Ananda Collage of Education, Borsad
19	17/02/2018	Agri-Input dealers (18)	Input dealers SSK, AAU
20	27/02/2018	Students (63)	ACHF, NAU
21	27/02/2018	Farmers (33)	IFFCO Kalol Unit, Kasturinagar
22	28/03/2018	Farmers (10)	Anand and Kheda District
23	03/04/2018	Students (35)	Junagadh Agricultural University, Junagadh

Guest lecturers were delivered at the training on **'ORGANIC FARMING'** organised by Organic Farming Cell, Department of Agronomy and Anand Agricultural University

Sr. No	**Date**	**Place**	**No. of trainees**
1	28/08/2017	Agronomy Farm, Training Hall, AAU, Anand	48
2	07/12/2017	Agronomy Farm, Training Hall, AAU, Anand	38
3	16/12/2017	Sardar Smruti Kendra, AAU, Anand	42
4	29/01/2018	Agronomy Farm, Training Hall, AAU, Anand	37
5	17/02/2018	Sardar Smruti Kendra, AAU, Anand	48
6	21/02/2018	Sardar Smruti Kendra, AAU, Anand	46
7	26/02/2018	Agronomy Farm, Training Hall, AAU, Anand	37
8	30/01/2018	Sardar Smruti Kendra, AAU, Anand	36

ANGRAU, Anakapalle

1. Dr M. Visalakshi conducted training programme to 29 tribal farmers of Chittempadu village, Koyyuru mandal, Chinthapalli division benefitted with awareness and training on nutrient management and pest management in organic paddy cultivation on 30.10.17 with special emphasis on biological control .
2. Dr M. Visalakshi conducted Training programme cum awareness programme on Organic farming in Rajma with emphasis on nutrient management, pest management and post harvest practices in rajma to 30 farmers at Asarada, GK veedhi mandal, Chinthapalli on 22.11.17.

3. Dr M. Visalakshi conducted farmers awareness cum training programme on Trichocard production using Eri silkworm eggs and 15 tribal farmers from Asarada, GK veedhi mandal, Chinthapalli benefitted through exposure visit and training on Trichocard production using Eri silkworm eggs and Corcyra eggs on 15.3.18 at AICRP on Biological control, RARS, Anakapalle.

GBPUAT, Pantnagar

1. Conducted trainings at Kotabagh, Patkot, Batalghat and Haldwani, district Nainital to promote biocontrol technologies for the crop health management and organic cultivation of quality produce.
2. 1.5 tons of PBAT-3 was distributed to the farmers especially for the management of soil borne plant pathogens and to increase yield and in rice, chickpea, lentil, pea and fruit and vegetable crops.

KAU, Thrissur

Sl. No	Date of training	Classes handled by	Topic	Venue	Beneficiaries
1	24/08/17	Dr. Madhu Subramanian, Professor	IPM in major crops	RATTC, Vyttila	Agrl. Officers
2	23/0917	Dr. Madhu Subramanian, Professor	IPM in paddy	KCPM, Alapuzha	Agrl. Officers
3	13/11/17	Dr. Smitha M.S., Asst. Professor	Production technology of common biocontrol agents	AICRP on BCCP	Farmers of Palakkad district under RATTC, Malampuzha
4	06/12/17	Dr. Smitha M.S., Asst. Professor	Biocontrol agents an introduction	AICRP on BCCP	Students of VHSS, Ramavarmapuram, Thrissur
5	04/01/18	Dr. Madhu Subramanian, Professor	Mass production of natural enemies	RATTC, Malampuzha	Farmers
6	18/01/18	Dr. Smitha M.S., Asst. Professor	Production technology of common biocontrol agents	AICRP on BCCP	Agrl. Officers of RATTC, Palakkad
7	19/02/18	Dr. Smitha M.S., Asst. Professor	Recent plant protection techniques in cashew	ARS, Anakkayam, KAU	Farmers
8	24/02/18	Dr. Smitha M.S., Asst. Professor	Biological control of crop pests	AICRP on BCCP	A team of 30 students from College of

					Agriculture, Kolhapur
9	09/03/18	Dr. Smitha M.S., Asst. Professor	Pest management in organic spice cultivation	College of Horticulture	Farmers

Lectures delivered

PAU, Ludhiana

Title of the lecture	Event, Date and Venue
Dr Parminder Shera	
Different useful and harmful insects	Three months Training Course for Farm Workers on 28.4.2017 at Kairon Kisan Ghar, PAU, Ludhiana
Dr Rabinder Kaur	
Producing safe food by bio-control agents	Training programme on Organic Farming for Soil and Water Conservation on 13.12.2017 and 26.3.2018 at PAMETI, PAU, Ludhiana

MPKV, Pune

1. Dr. D.S. Pokharkar conducted the practical classes of PG Course No. ENT- 507 (Biological control of crop pests and weeds).
2. Dr. S. M. Galande conducted the practical classes of PG Course No. ENT 508 (Toxicology of Insecticides).
3. Dr. D.S. Pokharkar conduced two UG Courses No. ENT- 353 (Crop Pests,Stored grain pests and their management **)** and ENT-242 (Insect Ecology, Integrated pest management and beneficial insects) and two PG Course No. ENT-505 (Insect Ecology) and ENT-507 (Biological control of crop pests and weeds).
4. Dr. D.S. Pokharkar, Professor of Entomology and Chairman of RAWE Entomology centre attended Monthly meeting of RAWE programme and explained the Entomology schedules to the students on 19.7.2017.
5. Dr. S. M. Galande attended Monthly meeting of Agril. Botany centre of RAWE programme and explained the Entomology schedules to the students at Khupsungi village of Mangalveda Tahasil of Solapur district on 22.7.2017. Hon. Vice –Chancellor Dr. K.P. Vishwanatha interacted with RAWE students and farmers of Khupsungi, Patkhal, Junoni and Marapur villages of Mangalveda Tahasil of Solapur district.
6. Dr. U. B. Hole, Entomologist, participated and attended one day training programme on, "Damaged leaf area analysis due to pests and diseases" organized by the Professor of Agronomy, College of Agriculture, Pune 16.9.2017.
7. Dr. U. B. Hole, Entomologist, attended the comprehensive viva-*voce* examination of Ph.D. student at Department of Entomology, MPKV, Rahuri, on 14.10.2017.

8. Dr.R.V.Nakat worked as Senior Superviser for conducting theory examination at VSBT College of Biotechnology, Baramati during December 2017.
9. Dr. R.V. Nakat conducted the practical examination of ENT 505 of PG student on 16/01/2018 at College of Agriculture, Dhule.
10. Dr.R.V.Nakat worked as External Examiner for practical examination UG Course ENT-364 at college of Agriculture, Ambi.
11. Dr. R. V. Nakat, Entomologist worked as supervisor for MCAER common entrance examination on 23rd and 25th March, 2018 at A.C. Pune and Sane Guruji Vidyalaya, Hadapsar, Pune respectively.
12. Dr.R.V.Nakat conducted the practical of UG Course ENT-364 (Introductory Nematology) and one PG Course ENT-507 (Biological control of crop pests and weeds).

26.8 Trainings/ training camps organized

Programme	Dates
Training on "Mass production and utilization of biocontrol agents" held at PAU, Ludhiana for the technical staff of The Nawanshahar Co-operative Sugar Mills Ltd. Nawanshahar (SBS nagar), Morinda Co-operative Sugar Mills Ltd. Morinda (Roop Nagar) and Biocontrol Laboratory, Regional Station, Abohar	March 6-7, 2018

SKUAST, Kashmir

Dr. Sajad Mohiuddin:

1. Involved in attending and organizing of Exhibition cum Sale- seedMela on 12-13, March' 2018
2. Delivered T.V. talk on Insect pest management infesting apple on 22-11-2017.
3. Delivered T.V. talk on *Importance of Biocontrol*on 09-12-2017.
4. Delivered T.V. talk on *Insect pests of apple and their managemen*t on 02-03-2018.
5. Delivered T.V. talk on Importance of Organizing of Kisan Melas on 12-03-2018.

Dr. Sajad delivered Lectures in trainings for line departments/Scientists

1. Integrated pest management in temperate fruits and vegetables organized by Directorate of SAMETI, SKUAST-K, Shalimar
2. Polyhouse pests and their management on 21.3.2018.
3. Vegetable pests and their management on 12.04.2018.

Dr. Sajad provided trainings to farmers

1. Interaction with farmers during Kisan Mela organized by SKUAST_K, Shalimar, on 4.07.2017.
2. Attended scientist- farmers interaction organized by Directorate of Extension SKUAST-K, Shalimar, on 17.01.2018.

3. Training to farmers in various locations of District Kargil regarding management of Codling moth infesting apple and other pests, from 1.6.2017. to 4.6.2017.

YSPUHF, Solan

SN	Title of training	Place	Date	No of farmers
1	Use of eco-friendly methods of pest management in apple and vegetable crops under TSP	Chaugaon (Tapri), Kinnaur	20.04.2017	50
2	Use of eco-friendly methods of pest management in apple and vegetable crops under TSP	Ponda, Kinnaur	21.04.2017	50
3	Role of biocontrol in pest management of vegetable and fruit crops	Nauni	14.10.2017	40
4	Role of biocontrol agents in suppression of temperate crop pests	Nauni	17.11.2017	16 scientists from different states
5	Biological control of insect pests of vegetable crops	Nauni	23.12.2017	35
6	Use of eco-friendly methods of pest management in apple and vegetable crops under TSP	Telangi	18-03-2018	50
7	Use of eco-friendly methods of pest management in apple and vegetable crops under TSP	Sangla	19-03-2018	50

26.9 Demonstrations

a) Demonstrations on the management of apple root borer using *Metarhizium anisopliae*

SN	**Location**	**Number of orchards**
1	Rohru, district Shimla	5
2	Choupal, district Shimla	3
3	Shilai, district Sirmaur	1
4	Rajgarh, district Sirmaur	1
5	Dharokidhar, district Solan	1
	Total	11

b) Demonstrations under TSP

SN	topic	Location	Number of farmers
1	Demonstrated the use of *Metarhizium anisopliae, Beauveria bassiana, Trichderma* and neem insecticide for the management of insect pests and diseases in apple and vegetable crops	Telangi	50
2	Demonstrated the use of *Metarhizium anisopliae, Beauveria bassiana, Trichderma* and neem insecticide for the management of insect pests and diseases in apple and vegetable crops	Sangla	50
	Total		100

MeraGaonMera Gaurav

S. No.	Date	Place	No. of Farmers	Purpose/ activity
i)	6.7.2017	Nainatikkar	12	Farmers were suggested control measures of different insect pests of tomato and capsicum
ii)	11.7.17	Samrod	50	Farmers were suggested control measures of different insect pests of tomato and capsicum
iii)	13.02.2018	Nainatikkar	8	Farmers were suggested control measures of different insect pests of cole crops, onion, garlic and peaches
iv)	12.03.2018	Samrod	22	Farmers were suggested control measures of different insect pests of cole crops, onion, garlic, coriander, peaches and plums

MPKV, Pune

1. Organized one-day training programme and demonstrations of biopesticide and biofertilizer application to the tribal farmers under TSP programme on 19.06.2017 at Dalapatpur village of Trimbakeshawar tahasil of Nashik district.
2. Dr. S. M. Galande delivered lecture on IPM of paddy and other important pests of *Kharif* crops.
3. Dr. N.D. Tamboli conducted the demonstrations on enrichment of FYM with Biopesticide and Biofertilizer with its application in fruit orchard**.**
4. Thirty five Surveyors of CROPSAP 2017-18 visited Biocontrol laboratory, Pune on 14.7.2017.
5. Dr. S. M. Galande delivered lecture on "Integrated Pest Management of Rice" as Master's Trainer in the Training Programme under CROPSAP 2017-18 at Krushi Bhavan, Pune on 12.7.2017.
6. Dr. N.D. Tamboli delivered lecture on "Beneficial Insects" in the Masters Trainer's Training Programme under CROPSAP 2017-18 at Krushi Bhavan, Pune on 12.7.2017.

7. Dr. N.D. Tamboli delivered lecture on "Integrated Pest Management of pigeon pea" in Surveyors training programme under CROPSAP 2017-18 at Krushi Bhavan, Pune on 14.7.2017.
8. Dr.R.V.Nakat worked as plant protection expert for the crops planted in demonstration plot during *Kharif* and *Rabi* Technological Week in September 2017 and February 2018.
9. Hon. Devendra Fadnavis, Chief Minster, Maharashtra state and Hon. Panduranji Fundkar, Minister for Agriculture, Maharashtra visited the stall of AICRP on Bio-control which was installed in the exhibition of "Agri-Tech Fest-2017' on 10.9.2017.
10. Hon. Pandurang Pundalik Fundkar alias Bhausaheb Fundkar, Minister of Agriculture Horticulture, Government of Maharashtra visited the stall of AICRP on Bio-control which was installed in the exhibition of "Agri-Tech Fest-2017' on 10.9.2017.
11. Hon. Arun Jetali, Union Minister for Finance, Govt. of India, visited the stall of AICRP on Bio-control which was installed in the exhibition of " Agri-Tech Fest-2017' on 10.9.2017.
12. Hon. Sharadchandraji Pawar, MP & Ex. Minister for Agriculture, Govt. of India, visited the stall of AICRP on Bio-control which was installed in the exhibition of "Agri-Tech Fest- 2017' on 10.9.2017.
13. Hon. Ajitdada Pawar, MLA & Opposition Leader, Vidhansabha-Legal Assembly, Maharashtra, visited the stall of AICRP on Bio-control which was installed in the exhibition of "Agri-Tech Fest-2017' on 10.9.2017.
14. Hon. Dr. Y. S. Nerkar, Ex. Vice-Chancellor, Hon. Dr. Umrani, Ex. Director of Research, MPKV, Rahuri visited the stall of AICRP on Bio-control installed in the exhibition of "Agri-Tech Fest-2017' on 11 & 12.9.2017.
15. More than 500 farmers from Maharashtra visited the laboratory and took information on use of bioagents for pest management in various crops during "Agri-Tech Fest-2017 " held on 10 to 13.9.2017.
16. Twenty five trainees CAFT- Fundamentals of Agril Micrometrology and 30 B.Sc.(Agri.) students from College of Agriculture, Kolhapur visited biocontrol laboratory, Agril. College, Pune on 14 & 15.9.2017. Dr. U. B. Hole has given information of importance of biagents in agricultural important pest management**.**
17. Nearly about 120 farmers are visited to trial entitled, "Demonstration on biological suppression of *Spodoptera litura* with Nomuraea *rileyi* in Soybean" in Agronomy field.
18. Post Graduate students of Entomology of Dr PDKV, Akola visited the Biocontrol Laboratory 31.3.2018.
19. The success story on participation of girls students in mass production of biopesticides published in Agrowon on 8th March 2018 and circulated among the farmers of Maharashtra.

TNAU

UG courses

1. EXP401 – Commercial production of biocontrol agents (0+5) – Dr.S.Jeyarajan Nelson and Dr.A.Suganthi
2. AEN 201 Fundamentals of Entomology (2+1) - Dr.S.Jeyarajan Nelson

3. AEN 401 Pests of Horticultural Crops and their Management (2+1) - Dr.S.Jeyarajan Nelson.

P.G.Courses

1. ENT 607 – Biological control of crop pests and weeds (2+1) – Dr.A.Suganthi

Ph.D courses

1. ENT 822 – Entomophages (2+1) - Dr.S.Sridharan

Trainings imparted

Paid hands on one day training programme on "Mass production of biological control agents" under Venture Capital Scheme by Dr.S.Sridharan, Professor and Dr.P.A.Saravanan, Asst.Professor.

S. No.	**Training/Seminar/ Conference**	**Trainees participated**	**Date/ Period**	**Activity**
1	Mass production of insect biocontrol agents	10	12.10.17	The participants were provided with technologies on the mass production of insect biocontrol agents and also supplied with technical manual, illustrative CD and certificate

Training imparted / lectures delivered during the year

Sl.No.	**Title of the training /lecture**	Beneficiary /participants	Date	Sponsor
1	Mass Production of biocontrol agents	B.Sc. (Ag) Students	29.06.17	PSMO College, Mallapura, Kerala
2	Mass Production of biocontrol agents	B.Sc. (Ag) Students	10.07.17	College of Horticulture, Bangalore
3	Mass Production of biocontrol agents	Farmers	21.11.17	Mallapore
4	Mass Production of biocontrol agents	B.Sc. (Ag) Students	08.12.17	STISAT, Vedasanthur
5	Mass Production of biocontrol agents	Diploma Students	01.03.18	NPRC, Vamban
6	Mass Production of biocontrol agents	PG students	02.03.18	AC&RI, Killikulam

Extension / Outreach programmes participated

Sl. No.	Date	Title of Program	Benificiary/ Participants	Organizers
1	14.12.2017	Interaction with farmers.	Farmer's	ATMA – Sarkar Samakulam block
2	9.02.18 and 10.02.18	Farmers day	Farmers and Public	Directorate of Extension, TNAU

PJTSAU, Hyderabad

- Trained as Bio Safety Expert under UNEP-GEF Programme by MoEF &CC, Govt. of India, New Delhi.

Trainings (As Organizer/Resource Person)

Dr. S. J. Rahman, Principal scientist & University Head (Ento)

- Imparted training on "Biological Control as viable component of Pest Management" to First & Second batch MAOs under Govt. Telangana programme, "Agro Technologies for Productive & Profitable Agriculture in Telangana State" for 5 batches during 2017.
- Imparted training on "Strengthening of mass production of Bio Agents & Bio Pesticides" to all the staff of State Bio Agent Production Units/Labs under Govt. Telangana.
- Imparted training on "Bio Intensive Pest Management" to the delegates from other countries under International Programme organized by NIRD, Hyderabad during 2017.

26.10 Radio / TV talk

AAU – Jorhat

SL. NO.	TITLE	NAME OF RESOURCE PERSON	RECORDING DATE	BROADCASTING DATE
1	Hello Krishak Vani (Radio programme) (AIR JORHAT)	R. N. Borkakati	16.05.2017	20.05.2017
2	Radio programme Greesmakaleen Xak Pachalir Keet Potanga Niyantran (AIR DIBRUGARH)	R. N. Borkakati	22.06.2017	26.06.2017
3	Radio programme Ada Khetir Bibhinna Keet Potanga Aru Rog Niyantran (AIR DIBRUGARH)	R. N. Borkakati	19.12.2017	22.12.2017

4	Hello Krishi darshan (Door Darshan Programme) Episode:2984	R. N. Borkakati	Telecasted on 30.08.2017(5.30pm)
5	Hello Krishi darshan (Door Darshan Programme) Episode:3119	R. N. Borkakati	Telecasted on 07.03.2018(5.30pm)
6	Hello Krishak Vani (Radio programme) (AIR JORHAT)	Dr. D. K. Saikia R. N. Borkakati	Broadcasted on 22.02.2018 (7.15 pm)
7	Phone in Programme at ATIC, AAU, Jorhat	R. N. Borkakati	recorded on 18.09.2017

ANGRAU at RARS, Anakapalle

1. Dr.M.Visalakshi delivered radio talk on 19.01.18 at All India Radio, Visakhapatnam and deliverwed talk on Rabilo saguchese vividha pantalaina minumu, pesara, kandi mariyu verusenaga lo cheeda peedalu chepattavalasina sasyarakshana charyalu"
2. Dr.M.Visalakshi delivered radio talk on25.01.18 at All India Radio, Visakhapatnam and delivered talk on "Rabi Pantalalo Samagra Sasyarakshana"

KAU, Thrissur

1. Radio talk: Dr. Smitha M.S., Plant protection in cashew -11/12/2017

PAU, Ludhiana

1. Dr P S Shera delivered TV talk on 'Management of insect pests of sugarcane' (Date of Recording – 25.4.2017)
2. Dr Sudhendu Sharma delivered Radio talk on '*Jhone ate basmati de kirian di gair-rsainik dhanga naal roktham*' (Date of Broadcasting – 1.9.2017)

Dr. Y.S. Parmar University of Horticulture and Forestery, Solan

1. Crop seminar on "Krishi Vividhta Ka Gramin Vikas Mein Yogdan" on dated 21-02-2018 (Live telecast on DD Shimla)

PJTSAU

1. Participated in several Radio Talks on Bio Agents & Bio Pesticides at All India Radio, Hyderabad during 2017.
2. Participated in Doordarshan Phone in Live Programme and answered the queries of farming community on Biological Control at Doordarshan Kendra, Hyerabad during 2017.

26.11 Post/under graduate teaching

AAU – Anand

Sr. No.	Name of Teacher	Courses offered	PG Students Guiding
1.	Dr. D. M. Mehta	ENT 602 - Immature Stages of Insects (1+1)	2 (Ph.D.) 1 (M.Sc)
		ENT 606 - Recent Trends in Biological Control (1+1)	
		ENT 514- Insect Vectors of Plant Viruses and other Pathogens (1+1) ** Cross linked with Plant Pathology Division*	
2.	Dr. Raghunandan B.L.	Ag. Micro 1.1 –Agricultural Microbiology (1+1) **Undergraduate course*	NIL
		MICRO 509 – Plant Microbe Interactions (3+0)	
		MICRO 506 – Food and Dairy Microbiology (2+1)	

ANGRAU, Anakapalle

1. Dr. M.Visalakshi as Chairman: Guidance to M.Sc (Ag) , Entomology student Miss. B.L.Manisha, Agricultural College, Bapatla under ANGRAU for research on "Eri silkworm as altérnate host for *Trichogramma chilonis.*
2. Dr.M.Visalakshi attended Pre colloquium at the time of thesis submission of M.Sc (Ag) , Entomology student Miss. B.L.Manisha, as Chairman of the Advisory Committee at Agricultural College, Bapatla on 2.12.17 .
3. Dr. M. Visalakshi conducted Final Thesis Viva-voice examination of M.Sc (Ag), Entomology student Miss. B.L.Manisha, as Chairman of the Advisory Committee at Department of Entomology, Agricultural college, Bapatla on 28.3.18.

Thesis evaluation as External Examiner

1. Evaluation of Ph D thesis entitled "Mechanism of insecticide resistance in the Brown plant Hopper, *Nilaparvata lugens* "from University of Mysore under the guidance of Dr. S.K.Jalali, Principal Scientist (Entomology), NBAIR, Bangalore during august, 2017.

KAU, Thrissur

1. Scientists of the Project have been handling classes on biocontrol and IPM for U.G, P.G. and Ph. D programmes as well as guiding M.Sc and Ph.D students on regular basis.

PJTSAU

1. B.Sc. (Ag.), M.Sc. (Ag.) and Ph.D. students of College of Agriculture, Rajendranagar, Hyderabad were trained different methodologies in rearing of different natural enemies and culturing & field use of microbial formulations.
2. Guiding M.Sc. (Ag) and Ph.D. students for their Research work in the capacity of Major guide & Member of Advisory Committee
3. Seventh Batch of AELP on Biological Control is being trained for entrepreneurship on mass production of Bio agents as part of B.Sc. (Ag) under graduation programme.

PAU, Ludhiana

Teacher	No. of courses taught	
	PG	UG
Dr K S Sangha	4	4
Dr Neelam Joshi	3	4
Dr Parminder Singh Shera	2	2
Dr Rabinder Kaur	1	2
Dr Sudhendu Sharma	1	2
	No. of PG Students Guiding/Guided	
	Ph. D.	M.Sc.
Dr K S Sangha	2	-
Dr Neelam Joshi	1	2
Dr Parminder Singh Shera	-	-
Dr Rabinder Kaur	1	-
Dr Sudhendu Sharma	-	1

SKUAST, Kashmir

1. Dr. Jamal Ahmad and Dr. Sajad Mohiuddin involved in teaching of eight different courses of UG and PG classes of Horticulture

Dr. Y.S. Parmar University of Horticulture and Forestry, Solan

Courses taught:

Course No	**Title**	**Credit hours**	**Teachers' name**
ENT-505	Insect Ecology	1+1	S C Verma
ENT-517	Soil arthropods and their management	1+1	P L Sharma and S C Verma
ENT-507	Biological Control of Crop Pests and Weeds	1+1	P L Sharma and S C Verma
ENT-513	Storage Entomology	1+1	Devender Gupta and SC Verma
ENT604	Advanced Insect Ecology	1+1	P L Sharma

ENT-606	Recent Trends in Biological Control	1+1	P L Sharma and S C Verma
ENT-609	Advanced Host Plant Resistance	1+1	P L Sharma and R S Chandel
ENT-616	Plant Biosecurity and Biosafety	2+0	PL Sharma
PPE-221	Insect-pests of Fruits, plantation, Medicinal and Aromatic crops	2+1	Devender Gupta and SC Verma
ENT-591	Master's Seminar	1+0	PL Sharma

Students guided for M.Sc and Ph D. degree:

SN	Student Name	Degree	Title of thesis	Guided By
1	Sarawati Negi	Ph D	Bio-ecology and management of invasive leafminer, *Tuta absoluta* (Lepidoptera: gelechidae) on tomato	PL Sharma
2	Anil Jaswal	PhD	Studies on insect pests and their natural enemies of cole crops in Himachal Pradesh	PL Sharma
3	Manohar TN	Msc	Laboratory evaluation of *Trichogramma* spp and *Neochrysocharis formosa* against invasive tomato pinworm, *Tuta absoluta*	PL Sharma
4	Khushi Ram	MSc	Spatial distribution and sequential sampling plan for *Tuta absoluta* and its biocontrol agents in tomato	PL Sharma
5	Gaikwad Mahesh Balasahab	PhD	Aphid-natural enemy diversity of horticultural crops in Himachal Pradesh and population dynamics of rose aphid (*Macrosiphum rosae*)	SC Verma
6	Shikha	MSc	Studies on natural enemy complex of important insect pests of cauliflower under mid-hill conditions of Himachal Pradesh	SC Verma
7	Deeksha Kumari	MSc	Studies on predatory fauna of cotton aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae) in cucumber	SC Verma
8	PranshuGuleria	MSc	To be decided	PL Sharma
9	Pryianka	MSc	To be decided	SC Verma

NBAIR, Bangalore

1. Capacity building training on Entomopathogenic nematodes for the management of insect pests from Aug. 28 – Sept. 1, 2017.
2. ICAR Sponsored 21 days training course on "Current techniques and advances in mass culturing of microbials for the production of biopesticides" from September 5-25, 2017.

3. Training on "Identification, mass production and utilization of parasitoids, predators and entomopathogens for sustainable insect pest management" for 7 days i.e. December 4th – 10th, 2017.
4. ICAR-sponsored "short course on Nanotechnological Approaches in Pest and Disease Management" was organised at NBAIR during 15-24 November 2017.
5. One day orientation programme for plant protection scientists of Karnataka KVKs was conducted at NBAIR on 5.2.18 as a part of HRD week organised by ATARI, Bengaluru.

26.12 List of Publications

AAU, Jorhat

Research papers

1. Buragohain, P., Saikia, D. K., Dutta, B. C. and Borkakati, R. N. (2017). Influence of colours and height of the sticky traps against sucking pests of *Bhut Jolokia*, *Capsicum chinense* Jacq. *Res. on Crops* **18** (1): 145-152 (2017)
2. Buragohain, P., Saikia, D. K., Borkakati, R. N., Dutta, B. C. and Thangjam, R. (2017). Pest Complex and the Population Dynamics of Major Pests of *Bhoot Jolokia*. *Ecology, Environment and Conservation.*23(**3**):265-272
3. Nath, R. K. and Saikia, D. K. (2018). Population dynamics of sugarcane plassey borer, *Chilo tumidicostalis*, Hempson (Lepidoptera: Pyralidae). Int. J. Curr. Microbiol. App. Sci. 7(3):1397-1405
4. Borah, N and Saikia, D. K. (2017). Seasonal incidence of major insect pests of brinjal & their natural enemies. *Indian Journal of Entomology.* 79(4): 449-455.
5. Mili, P., Devee, A. and Saikia, D. K. (2018). Diversity of carabids in Gerbera and Gladiolus crops of Jorhat, Assam. Journal of Entomology and Zoology Studies. 6(2): 116-124
6. Nath, R. K. and Saikia, D. K. (2018). Field studies on the nature of damage caused by sugarcane plassey borer, *Chilo tumidicostalis*, Hempson (Lepidoptera: Pyralidae). *Int. J. Plant Protection.*11(1) (accepted)
7. Nath, R. K. and Saikia, D. K. (2018). Peak period of moth emergence, fecundity, egg viability, egg parasitism and factors influencing the extent of carryover from one season to another of sugarcane plassey borer, Chilo tumidicostalis, Hempson (Lepidoptera: Pyralidae). *Int. J. of plant Sciences.* 13(2) (accepted)
8. Borkakati, R. N., Saikia, D. K., and Buragohain, P., (**2018**). Natural enemy fauna of agri-horti ecosystem of Assam. *Indian Journal of Entomology*. (Accepeted**)**
9. Daizy Sarma, D. K. Saikia and Rudra N. Borkakati (2018**).** Impact of Habitat Manipulation on Major Pest of Cabbage (*Brassica oleracea* Var. Capitata L.) *Indian Journal of Entomology*. (Accepeted**)**.

Books:

1. Saikia, R., Saikia, D. K. and Borkakati, R. N. (2017). Major Arthropods Diversity of Rice Ecosystem of Assam: Evaluation of rice varieties against yellow stem borer and leaf folder . Lambert Academic Publishing, Germany (ISBN: 978-3-330-32639-2)

Book chapter:

1) Saikia, D. K. and Borkakati, R. N. (2017). **Culturing Technique and Mass Multiplication Trichogrammatids** p. 206-8 In: Compendium of CAFT training on *"Recent*

Developments in Organic Production Systems" sponsored by ICAR,New Delhi and Organized by"Centre of Advanced Faculty Training (CAFT) in OrganicFarming", Department of Soil Science, Faculty of Agriculture, Assam Agricultural University, Jorhat: 785013, Assam,from 7th to 27th February, 2018.

2) Saikia, D. K. (2017). Recent Advances for Biological Control of Insect Pests. p. 83-88. In: Compendium of Short Course on "Preparation of Bioformulation of Fungal and Bacterial Biocontrol Agents for Management of Biotic Stress of Agricultural Crops" sponsored by ICAR, New Delhi and organized by Department of Plant Pathology, Assam Agricultural University, Jorhat-13, Assam from 1st to 10th Sept, 2017.
3) Borkakati, R. N. (2018). Kritrim Rasayanik Keetnashak Abihone Xasyar Utpadon Bridhhi. "Seuj Supan" a souvenir published on the occasion of 5th Assam International Agri-Horti show 2018.
4) Borkakati, R. N. (2017). Khadya Xankator Pora Muktir Chinta. "Abad" an agricultural annual magazine from KVK, Chirang. 6(1):27-29
5) Borkakati, R. N. (2017). Krishakor Aay Dugoon Koriboloi. "Agaranua", A souvenir published on behalf of Agro Trade Fair, 2017 at Golaghat.
6) Borkakati, R. N. (16-31st December). Pook Potangor Tuponi Dharene?. ***Prantik***. 37(2):34
7) Borkakati, R. N. and Saikia, D. K. (16-30th June, 2017). Xukma Chakori Tuta: Bilahir Nabagoto Xatru. ***Prantik***. 36(14):43

Leaflets: Published from AICRPBC, AAU, Jorhat centre in local language

Sl. No.	Title	Official AAU No.
1	*Lao Jatiya Pachalir Anistokari Borolia Pokar Niyantran Byabasthapona*	**AAU/DR/17(LL)/217/2017-18**
2	*Joibik Krishir Babe Prayujoniyo Upakoron*	**AAU/DR/17(LL)/218/2017-18**
3	*Omitar Anistakari Anistokari Potangor Byabasthapona*	**AAU/DR/17(LL)/219/2017-18**
4	*Tenga Jatiyo Fol-Mulor Potango Niyantran Byabasthapona*	**AAU/DR/17(LL)/220/2017-18**
5	*Kolgosor Anistokari Potangor Niyantran Byabasthapona*	**AAU/DR/17(LL)/221/2017-18**

Bulletin

Sl. No.	Title	Official AAU No.
1	Jawik Podhhatire Xashyar Keet Potango Niyantron	**AAU/DR/17(BU)/222/2017-18**

AAU – Anand

Research paper

1. Raghunandan, B.L. Godhani, P.H. and Sachin M Chavan. (2017) Tribal Sub Plan: A special reference to biological interventions to enhance crop production and productivity in tribal area of Tapi district in Gujarat. *Trends in Bioscience.,* 10(48): 9646-9648

Book Chapter

1. Raghunandan B.L. (2017) Rhizobacterial phosphate solubilizers in sustainable agriculture: concepts and prospects. In: Panpatte D.G. Jhala Y.K. Vyas R.V. and Shelat H.N. (eds) Microorganisms for green revolution. Microbes for sustainability, vol 6. Springer, Singapore, p107-124

Papers presented in symposium

1. Raghunandan, B.L. Godhani, P.H. Patel, N.M. and Mehta, D.M. (2017) Field evaluation of different biological control agents against chilli anthracnose disease. Paper presented at Special symposium on 'Microbial Antagonists and their role in Biological Control of Plant Diseases and West Zone Meet of Indian Phytopathological Society (IPS), Anand Agricultural Univeristy, Anand, 5- 7 October 2017
2. Raghunandan, B.L. Patel, N.M. and Mehta, D.M. (2017) Biodiversity and biocontrol potential of cold adapted yeasts : A conceptual note with special reference to biological control of post harvest diseases Paper presented at Special symposium on 'Microbial Antagonists and their role in Biological Control of Plant Diseases and West Zone Meet of Indian Phytopathological Society (IPS), Anand Agricultural Univeristy, Anand, 5- 7 October 2017

Folders

1. Patel N.M. Solanki C.G. Raghunandan B.L. and Mehta D.M. (2017) કપાસની જીવાતોના કુદરતી દુશ્મનોને જાણો !!
2. Patel N.M., Patel, M.V. Raghunandan B.L. and Mehta D.M. (2018) મગફળીના સફેદ મુંડાનું સંકલિત વ્યવસ્થાપન

Popular articles

1. Patel, N.M. Solanki, C.G. Raghunandan, B.L. and Mehta. D.M. (2017) જીવાતોના જૈવિક નિયંત્રણ માટેના અગત્યના નિયંત્રકો. કૃષિ જનાન સંપુટ - ૨૦૧૭, ૬૧-૬૫. આણંદ કૃષિ યુનિવર્સિટી, આણંદ
2. Patel, N.M. Raghunandan, B.L. (2018) A glimpse of *Nomuraea rileyi*: Potential microbial insecticide. *Readers shelf.,* 14(5): 63-64

ANGRAU, at RARS, Anakapalle

1. Dr.M.Visalakshi prepared booklet on ICAR- Tribal sub plan programme – A boost to the organic farming in the tribal areas in English under TSP.
2. Dr.M.Visalakshi prepared booklet on Mukkyamaina pantalalo Jeevaniyantrana paddathula dwara hanikaraka purugula nivarana in Telugu under TSP.

TNAU

1. Elango K., S. Sridharan, P. A. Saravanan and S.Balakrishnan. 2017. Relative Performance of Different Colour Laden Sticky Traps on the Attraction of Sucking Pests in Pomegranate. *Int.J.Curr.Microbiol.App.Sci.* , 6(11): 1110-1114
2. Elango K., S. Sridharan, P. A. Saravanan and S.Balakrishnan. 2017. Laboratory evaluation of insecticides and biopesticides against pomegranate aphid *Aphis punicae* Passerini. *International Journal of Chemical Studies,* 5(5): 1810-1812
3. Elango, K. and S.Sridharan. 2017. Population dynamics of pome granate sucking pests under high density planting in Tamilnadu. *Journal of Entomology and Zoology Studies,* 5(3):377-380.
4. Elango, K.and S. Sridharan. 2017. Parasitization potential of *Trichogramma* species and feeding potential of *Chrysoperla zastrowi sillemi* on pests of pomegranate and their biosafety. In: International Symposium on Horticulture: Priorities & Emerging Trends, (5 – 8 September, 2017), Indian Institute of Horticultural Research Bengaluru, India. Abst. p. 129.
5. Elango, K.and S. Sridharan. 2018. Influence of intercrops in coconut on *Encarsia guadeloupe* parasitisation of Rugose spiraling whitefly *Aleurodicus rugioperculatus*. In: Int. Conf. Biocontrol and Sustain. Dept. of Agricultural Entomology, TNAU, Killikulam, Jan., 27-31, Abst. P. 143-146.
6. Mohan, C. S. Sridharan, K.S.Subramanian, N.Natarajan and S.Nakkeeran. 2017. Safety of Nanoemelusion against beneficial insect with special reference to *Trichogramma embryophagum* (Trichogrammatidae Hymenoptera). In: Proceedings of 5th Annual Agricultural Graduate Students conference- 2017 "Tranforming Agriculture for future", TNAU, Coimbatore, May 4-5, 2017, Abst. P.383-385.
7. Mohan, C., S.Sridharan, K.Gunasekaran, K.S.Subramanian and N.Natarajan. 2017. Bio safety of Hexanal as nanoemulsion on egg parasitoid *Trichogramma* spp. *Journal of Entomology and Zoology Studies,* 5(2):1541-1544
8. Muthukumar, M. and S. Sridharan. 2017. Raising sorghum as a border crop to enhance the population of *Aprostocetus diplosidis* Crawford for natural biological suppression of bitter gourd gall midge, *Lasioptera falcata* Felt and *L. bryoniae* Schiner. In: International Symposium on Horticulture: Priorities & Emerging Trends, (5 – 8 September, 2017), Indian Institute of Horticultural Research Bengaluru, India. Abst. p. 132-133.
9. Muthukumar, M., S.Sridharan J.S.Kennedy, P.Jeyakumar and T.Arumugam. 2017. Biology and natural parasitisation of Gall fly *Lasioptera falcata* Felt and *L.bryoniae* Schiner infesting bitter gourd. *Journal of Entomology and Zoology Studies,* 5(3):1635-1639
10. Nasreen, A. and S.Sridharan. 2017. Screening of natural oviposition substrates of predatory anthocorid bug *Blaptostethus pallescens* (Poppius). In: Proceedings of 5th Annual Agricultural Graduate Students conference- 2017 "Tranforming Agriculture for future", TNAU, Coimbatore, May 4-5, 2017, Abst. P.355-356.

GBPUAT, Pantnagar

Research papers

1. Meenakshi Dwivedi and A. K. Tewari **(2017).** Crop specific growth promoting effect of native *Trichoderma* species. ***Indian Phytopathology***. 70 (4): 457-462

2. Dinesh Rai and A K Tewari **(2017).** Optimization of nutrient sources to increase the biomass production and development of *Trichoderma harzianum* Th 14 formulations. ***Journal of Mycology and Plant Pathology***. (47) 2: 153-167
3. Deepika Saxena, A K Tewari, Dinesh Rai **(2017).** In vitro antagonistic assessment of T. harzianum PBT 23 against plant pathogenic fungi. ***Journal of Microbiology and Biotechnology Research.*** 4(3):59-65.
4. Pandey, V.; Tewari, A. K**.** and Saxena Deepika **(2017).** Activities of defensive antioxidant enzymes and biochemical compounds induced by bioagents in Indian mustard against Alternaria blight". ***Proceedings of the National Academy of Sciences, Biological Sciences (NASB)***. ***Biological Sciences***. DOI 10.1007/s40011-017-0888-2:1-12
5. Devanshu Dev, Roopali Sharma, Nitish R. Bharadwaj and Bhupesh C. Kabadwal. (**2017)**. Isolation and biochemical characterization of *Pseudomonas fluorescence* isolated from rhizosphere of different host plants. ***Environment & Ecology*****.** 35(3A):1984-1987.
6. Sujata Singh, Roopali Sharma and Archana Negi (**2017)**. Induced biochemical changes due to seed treatment by biocontrol agents for controlling sheath blight of rice. ***Environment & Ecology***. 35(3B):2061-2065.
7. Bhupesh C. Kabadwal, Roopali Sharma, Rashmi Tewari and J. Kumar (**2017)**. A Common Minimum Programme for biointensive pest/disease management in small farms of Uttarakhand (India). ***Asian Journal of Agricultural Extension, Economics & Sociology.*** 16(3): 1-8.
8. Prasad, P. and Kumar, J. **(2017).** Management of Fusarium wilt of chickpea using Brassicas as bio-fumigants. ***Legume Research***. 40 (1) : 178-182
9. Akansha Singh, Nandini Shukla, B.C. Kabadwal, A.K. Tewari and J. Kumar **(2018)**. Review on plant-Trichoderma-pathogen Interaction. ***International Journal of Current Microbiology and Applied Sciences.*** 7(2): 2381-2397 (**Review Article**).

Papers presented in conferences:

1. Deepika Saxena, **A. K. Tewari,** and J. Kumar **(2017).** Development of *Trichoderma* Formulations to get higher CFU and Shelf-life. ***In***: Fifth National Conference on Biological Control on "Integrating recent Advances in Pest and Disease management" at NBAIR, Bangalore. Feb. 9-11, 2017 18 pp.

Abstracts Published:

1. B. C. Kabadwal, R. Sharma, A. Negi, R. Tewari and J. Kumar (**2017)**. A Common Minimum Programme for sustainable Tomato cultivation in Golapar area of District Nainital of Uttarakhand. National Symposium on Diagnosis and Management of Plant Diseases: Integrated Approaches and Recent Trends. Umiam, Meghalaya, held on January 9-11, 2017. pp. 65.
2. Bhupesh C. Kabadwal, Roopali Sharma, Rashmi Tewari, A. K. Tewari, R. P. Singh and J. Kumar (**2017)**. Management of major diseases of tomato using biointensive approaches in Golapar area of District Nainital of Uttarakhand. Fifth National Conference on Biological Control: Integrating Recent Advances in Pest and Disease Management. Bengaluru held on February 9-11, 2017. pp. 164.

3. Bhupesh Chandra Kabadwal, Roopali Sharma, Rashmi Tewari and J. Kumar (**2017)**. A Common Minimum Programme under integrated pest management in vegetable cultivation in Uttarakhand. Fifth National Conference on Biological Control: Integrating Recent Advances in Pest and Disease Management. Bengaluru, held on February 9-11, 2017. pp. 30
4. Deepika Saxena, A. K. Tewari, and J. Kumar (**2017)**. Development of *Trichoderma* Formulations to get higher CFU and Shelf-life. *In*: Fifth National Conference on Biological Control on "Integrating recent Advances in Pest and Disease management" at NBAIR, Bangalore. Feb. 9-11, 2017 18 pp.
5. R. Sharma, A. Negi, B. Chandra Kabadwal, A. K. Tewari and J. Kumar (**2017)**. Eco-friendly management for sheath blight of rice through potential biocontrol agents. National Symposium on Diagnosis and Management of Plant Diseases: Integrated Approaches and Recent Trends. Umiam, Meghalaya, held on January 9-11, 2017. pp. 87.
6. R. Tewari, B. C. Kabadwal, R. P. Singh, R. Sharma, and J. Kumar (**2017)**. Disease management in vegetables under organic cultivation. National Symposium on Diagnosis and Management of Plant Diseases: Integrated Approaches and Recent Trends. Umiam, Meghalaya, held on January 9-11, 2017. pp. 91
7. Roopali Sharma, Archana Negi, Bhupesh Chandra Kabadwal, A. K. Tewari and J. Kumar (**2017)**. Potential biocontrol agents for management of sheath blight of rice. Fifth National Conference on Biological Control: Integrating Recent Advances in Pest and Disease Management. Bengaluru, held on February 9-11, 2017. pp. 137.

Proceeding Articles:

1. A.K. Tewari (**2018)**. Commercial aspects of biocontrol agent (*Trichoderma*). **In:** Biopesticides for Crop Protection and Improvement: Emerging Technology to Benefit Farmers." under CAFT organized by Department of Plant pathology, GBPUAT, Pantnagar Feb. 02-22, 2018. 100-102.
2. A.K. Tewari (**2018)**.Factors affecting efficacy of *Trichoderma* under field conditions. **In:** Biopesticides for Crop Protection and Improvement: Emerging Technology to Benefit Farmers." under CAFT organized by Department of Plant pathology, GBPUAT, Pantnagar Feb. 02-22, 2018. 113-114
3. J. Kumar (**2018)**. Biocontrol agents: A key tool for pest management for low input sustainable agriculture. **In:** Biopesticides for Crop Protection and Improvement: Emerging Technology to Benefit Farmers." under CAFT organized by Department of Plant pathology, GBPUAT, Pantnagar Feb. 02-22, 2018. 33-36
4. J. Kumar (**2018)**. Chitosan: For knowledge-based plant protection. **In:** Biopesticides for Crop Protection and Improvement: Emerging Technology to Benefit Farmers." under CAFT organized by Department of Plant pathology, GBPUAT, Pantnagar Feb. 02-22, 2018. 115-119.
5. Roopali Sharma (**2018)**. Methods of isolation, quantification and screening techniques for the selection of effective Trichoderma. **In:** Biopesticides for Crop Protection and Improvement: Emerging Technology to Benefit Farmers." under CAFT organized by Department of Plant pathology, GBPUAT, Pantnagar Feb. 02-22, 2018. 176-181.
6. Roopali Sharma (**2018)**. Mass Production of Biocontrol agents and their application **In:** Biopesticides for Crop Protection and Improvement: Emerging Technology to Benefit

Farmers." under CAFT organized by Department of Plant pathology, GBPUAT, Pantnagar Feb. 02-22, 2018. 182-186.

7. A.K. Tewari (**2017)**. Biological control of post-harvest diseases of fruits and vegetables by microbial antagonists. **In:** Technological Advances to Minimize Pre-and Post-Harvest Losses in Agriculture and Horticultural Crops to Enhance Farmers Income" under CAFT organized by Department of Plant pathology, GBPUAT, Pantnagar Nov. 22-Dec. 12, 2017. 125-133
8. Roopali Sharma (**2017)**. Mass Production of Biocontrol agents. **In:** Technological Advances to Minimize Pre-and Post-Harvest Losses in Agriculture and Horticultural Crops to Enhance Farmers Income" under CAFT organized by Department of Plant pathology, GBPUAT, Pantnagar Nov. 22-Dec. 12, 2017. 228-231.

Booklets:

English: Success Stories of Biological Control

KAU, Thrissur

Research Notes: Nil

Papers presented in symposia/ seminar/ workshops: Nil

Book chapter/Scientific Reviews: Nil

PAU, Ludhiana

Research papers in referred journals:

1. Devi K, Joshi N and Sodhi H S (2017).UV-B radiation tolerance in the conidia of *Beauveria bassiana* (Balsamo) Vuillemin. *Journal of Mycology and Plant Pathology* **47** (4): 441-446. (**NAAS Rating 5.79).**

2. Dhawan M and Joshi N (2017).Enzymatic comparison and mortality of *Beauveria bassiana* against cabbage caterpillar *Pieris brassicae* LINN. *Brazilian Journal of Microbiology* **48**: 522-527. **(NAAS rating 6.87).**

3. Jamwal S, Kocher D K and Kaur R (2017).Studies on developmental stages of *Mesocyclops aspercornis* and maintenance of its pure culture under laboratory conditions.*Biochemical and Cellular Archives***17** (1): 289-293. **(NAAS rating 4.46).**

4. Karmakar P and Shera P S(2017). Toxicity of insecticides to *Aenasius arizonensis* (Girault) (=*Aenasiusb ambawalei* Hayat), a solitary endoparasitoid of *Phenacoccus solenopsis* Tinsley on Bt cotton under semi-field conditions. *Journal of Biological Control***31** (1): 5-9. (**NAAS rating 5.34).**

5. Kaur G and Joshi N (2017) Biosafety of *Bacillus thuringiensis* formulation on emergence of *Trichogramma chilonis. Pesticide Research Journal* **29** (2): 251-254. **(NAAS rating 5.90).**

6. Kaur P, Kaur R and Bhullar M (2017).Evaluation of anthocorid predator, *Blaptostethus pallescens* Poppius against two-spotted spidermite, *Tetranychus urticae* Koch on brinjal.*Journal of Experimental Zoology***20**(2): 1215-1219.**(NAAS rating 5.51).**

7. Kumar R, Shera P S, Sharma S and Sangha K S (2017).Standardization of release rate of *Trichogramma chilonis* (Ishii) in bio-intensive management of *Chilo partellus* (Swinhoe) in fodder maize.*Journal of Biological Control* **31**(4): 254-258. **(NAAS rating 5.34).**

8. Rani S, Joshi N and Sharma S (2017).Pathogenicity of *Metarhizium anisopliae* (METSCH.) on mustard aphid *Lipaphis erysimi* (Kalt.). *Journal of Insect Science* 30 (1): 91-95. **(NAAS rating 4.37).**

9. Sangha, K.S., Kumar R, Dhaliwal A K and Kaushik N (2017) Variation in Susceptibility of different Seed Sources of *Pongamia pinnata* (L.) to Leaf Blotch Miner, Acrocercops transecta (Lepidoptera: Gracillaridae) in NorthWestern India. *Indian Journal of Forestry* **40** (2): 147- 150. **(NAAS rating 3.78).**

10. Sharma T, Joshi N and Kalia A (2017).Scanning electron microscopic studies of *Beauveria bassiana* against *L. erysimi* Kalt.*Journal of Applied and Natural Science***9** (1): 461-465. **(NAAS rating 4.84).**

11. Shera P S, Sharma S, Jindal J, Bons M, Singh Gurpartap, Kaul A, Kaur R and Sangha K S (2017). On-farm impact of egg parasitoid, *Trichogramma chilonis* (Ishii) against maize stem borer, *Chilo partellus* (Swinhoe) in Punjab. *Indian Journal of Agricultural Sciences* **87** (10): 1412-15 (**NAAS Rating 6.17).**

12. Shera, P S and Karmakar, P (2017).Effect of mating combinations on the host parasitization and sex allocation in solitary endoparasitoid, *Aenasius arizonensis* (Girault) (Hymenoptera: Encyrtidae). *Biocontrol Science and Technology*. DOI: 10.1080 /09583157.2017.1413707. (**NAAS Rating 6.85).**

13. Singh K, Kaur R, Singh G and Chandi A K (2017). Influence of spinosad on reproduction of diamondback moth, *Plutella xylostella* (Linnaeus). *Indian Journal of Entomology*, **79**(4): 467-473**. (NAAS rating 5.89)**

Abstract:

1. Kaur R, Pandher S, Joshi N Singh S and Rathre P (2017). Involvement of whitefly chaperones in transmission of cotton leaf curl virus in host *Bemisia tabaci* In: Indo-US Symposium on "Curbing Whitefly Plant Virus Pandemics- the Departure from Pesticide to Genome Solution" held at PAU, Ludhiana on December 4th 2017, pp. 55.

Extension Articles:

1. Kaur R, Sharma S and Sangha K S (2018).Natural enemies of pests of rabi crops and their conservation. *Progressive farming*, January 2018, pp 25-27.
2. Kaur R, Shera PS and Sangha K S (2018). Harhi dian faslan de mittar kirian naal jaan-pachhan ate sambh sambhal. *Changi Kheti*, January 2018, pp 25-27.
3. Shera PS, Sharma S and Sangha K S (2017).Biological control of lepidopteran insect pests in major *kharif* crops.*Progressive farming*, May 2017, pp 25-26.
4. Shera P S, Kaur R and Sangha K S (2017).*Mittarkeeriyanraahi* s*auni diyan mukh fasladehaneekarak keeriyandee roktham*.*Changi Kheti,* May 2017, pp 22-23.

Extension Pamphlet

1. *Mittar Kirian Di Saambh-Sambhal Sambandhi Kuch Ahim Nukte*, Punjab Agricultural University, Ludhiana (March 2018)

SKUAST, Kashmir

1. Ahmad, M.J.,Mohiuddin, S. and Pathania, S.S. (2017). Effect of Protein enrichment of maize based diet on important biological parameters of rice meal moth, *Corcyra cephalonica* (Stainton). *Journal of Experimental Zoology*, India.**20 (**1).471-477.

2. Ahmad, M.J, Swarnjit Singh Pathania and Sajad Mohiuddin (2017). Laboratory evaluation of anthocorid predator, *Blaptostethus pallescens* against storage pest, *Corcyra cephalonica* in rice, *Journal of Experimental Zoology*, India.**20 (2**): 897-900.
3. Ahmad, M.J.,Mohiuddin, S. and Pathania, S.S. (2018). Pheromone trapping and trunk banding : Effective and eco friendly approach for the management of Codling moth, *Cydia pomonella* (Lepidoptera : Tortricidae) infesting apple in Ladakh. *Journal of Experimental Zoology*, India.**21 (1**): 127-131.
4. SajadMohi-ud-din, Zaki, F. A., M. Jamal Ahmad and Malik, M.A. 2018. *In vitro* studies on ovipositional preference of Pomegranate fruit borer (*Deudorix epijarbas*). *International Journal of Current Microbiology and Applied Sciences* **3**(Accepted).
5. Tarique H. Askari& M. Jamal Ahmad (2018). Comparative efficacy of three entomopathogenic nematodes against *Pieris brassicae*. Poster presented in 13th J&K Science Congress, held from 2-4 April' 2018 in University of Kashmir, Hazratbal, Srinagar.
6. IramKhurshid, Ahmad, M.J. &Azim, M.N. (2018). First record of some pteromalids (Chalcidoidea: Pteromalidae) from Kashmir. Poster presented in 13th J&K Science Congress, held from 2-4 April' 2018 in University of Kashmir, Hazratbal, Srinagar.

Popular article in newspaper :

1. Sajad, M. Plant protection in apple crop constituting an important component of states' economy : In *Greater Kashmir:* 23rd Feb.' 2018

Dr. Y.S. Parmar University of Horticulture and Forestry, Solan

1. Nisha Devi, P.R. Gupta, K.C. Sharma, P.L. Sharma and B.R. Negi. 2018. Fertility Table Parameters of Predatory Bug *Orius bifilarus* Ghauri (Hemiptera: Anthocoridae) Preying upon *Thrips palmi* and eggs of *Corcyra cephelonica. International Journal of Current Microbiology and Applied Sciences, 7*(3): 2574-2586.**NAAS: 5.38**.
2. Brice Anjali, Verma SC, Sharma KC, Sharma PL and Mehta DK. 2017.Effect of sowing dates and IPM modules on jassid and blister beetle in okra under mid hills of Himachal Pradesh.*Journal of Entomology and Zoology Studies* 5(6): 757-761 **NAAS: 5.53**.
3. Gavkare Omkar and Sharma PL. 2017. Influence of temperature on development of *Nesidiocoris tenuis* (Reuiter) preying on *Trialeurodes vaporariorum* (Westwood) on tomato. *Entomological News*, 127 (3): 230-241.**NAAS: 6.32**.
4. Gavkare Omkar, Sharma PL and Sharma KC.2017. First record of sap beetle, *Lasiodactylus glabricola* Candeze (Coleoptera: Nitidulidae) on tomato from Himachal Pradesh. *Indian Journal of Entomology*, 79 (4): 538-539.**NAAS: 5.89**.
5. Sharma PL, Verma SC, Chandel RS, Chandel RPS and Thakur Pryianka.2017. An inventory of the predatory coccinellidae of Himachal Pradesh, India. *Journal of Entomology and Zoology Studies*, 5(6): 2503-2507.**NAAS: 5.53**.
6. Lalit Kumar, SC Verma and PL Sharma. 2017. Studies on effect of essential oils on quality characters of pea seeds (*Pisumsativum*L.) damaged by *Callosobruchus chinensis* L. (Coleoptera: Bruchidae). Journal of Entomology and Zoology Studies 2017; 5(6): 562-565.**NAAS: 5.53**

7. OmkarGavkare, Prem Lal Sharma, Juan Antonio Sanchez and Mohd Abas Shah. 2017. Functional response of *Nesidiocoris tenuis* (Hemiptera: Miridae) to the two-spotted spider mite, *Tetranychus urticae.* Biocontrol Science and Technology, 27(9): 1118 - 1122.**NAAS: 6.85**
8. SC Verma, P L. Sharma and R. K. Bhardwaj. 2017. Spatial distribution of Brevicorynebrassicae (L.) in Cabbage in mid-hills of Himachal Pradesh, India. Journal of Applied and Natural Science 9 (3): 1587 -1591**.NAAS: 4.84**.
9. Sharma Ajay and Sharma PL. 2017. Laboratory evaluation of a local isolate of *Nomuraea rileyi* (Farlow) Samson against *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae). *Agric INTERNATIONAL*, 4(1): 47-50.**NAAS: 2.25**.
10. PL Sharma and Rajender Kumar. 2017. Diversity and abundance of parasitoids of *Liriomyza trifolii* in North-Western Himalayas, India. *The Bioscan*, 12(2): 715-720.**NAAS: 5.26**.
11. PL Sharma; S. C. Verma; R. S. Chandel; M. A. Shah & O. Gavkare. 2017. Functional response of *Harmonia dimidiata* (Fab.) to melonaphid, *Aphis gossypii* Glover under laboratory conditions. *Phytoparasitica*, DOI 10.1007/s12600-017-0599-5**NAAS: 7.03**.
12. Rajender Kumar and PL Sharma. 2016. Diversity and abundance of parasitoids of *Chromatomyia horticola* (Goureau) (Agromyzidae: Diptera) in north-western Himalayas, India. *Journal of Applied and Natural Science*,8 (4): 2256-2261. **NAAS: 5.08**
13. Sharma PL and Kumar R. 2017.New Record of *Quadrastichus plaquoi* (Hymenoptera: Eulophidae) as Parasitoid of *Chromatomyia horticola* (Diptera: Agromyzidae). *National Academy Science Letters* 40(1): 9-11 **NAAS: 6.29**

UAS - Raichur

Publications:

1. Tabassum, N., Susheela, A. G. Sreenivas, A. C. Hosamani. and R. V. Beldhadi, 2017, Effect of growth regulator on sucking insect pests population in Bt cotton, *J. Cotton. Res. Dev.* 6:31 (2):322-326.
2. Tabassum, N., Susheela, A. G. Sreenivas, A. C. Hosamani. and R. V. Beldhadi, 2017, Influence of biochemical promoter in plants treatment with plant growth regulator in sucking insects pest population in Bt cotton.
3. Ambuja, H., Hosamani, A. C., Geeta, B. and Amaresh, Y. S. 2017, A case success story on efficacy of entomopathogenic fungi [*Metarhizium anisopliae* (Metchnikoff)] on sugarcane root grub [*Holotrichia serrata* (Blanch)] in Hagaribommanahalli taluka. Abstract presented in two days national seminar on "*Emerging disease relevance to microbial technology its applications prevention and eradication*" Department of Microbiology, LVD College, Raichur: 9th and 10th march 2018.
4. Ambuja, H., Hosamani, A. C., Geeta, B. and Amaresh, Y. S. 2018, Cost effective mass multiplication of entomopathogenic fungus [*Metarhizium anisopliae (*Metchnikoff)] using different cereal grains as a solid substrate. Abstract presented in two days national seminar on "Emerging disease relevance to microbial technology its applications prevention and eradication" Department of Microbiology, LVD College, Raichur: 9th and 10th march 2018.

Popular articles:

Technical bulletins on

1. Kabbina gonnehuluvina jaivika niyantrana- ondu yashogathe
2. Peede nirvahaneyalli parabhakshaka keetagala patra
3. Yerejala mattu yeregobbara utpadana tantrikate

Extension activities:

1. 20.01.2017- Aaru Kalagala Arihankaru (AKAH) on beneficial insects- AIR

MPKV, Pune

1. Galande, S. M., Pokharkar, D. S., Tamboli, N. D., Kharabde, S. B., Nakat, R. V. and Dhane, A.S. (2017) Evaluation of strains of *Sl*NPV and *Nomuraea rileyi* (Farlow) against *Spodoptera litura* (Fab.) on soybean. International Journal of Engineering Technology Science and Research, 4 (10): 1149-1152.
2. Chaudhri, C.S., **Pokharkar, D.S.,** Chaudhari. B.L. and Firke, D.M. 2017. Compatibility of insecticides with entomopathogenic fungi *Nomuraea rileyi* against tobacco caterpillar, *Spodoptera litura* (Fab.). Indian J. Ent. 79(1): 37-40.
3. Palthiya, R., **Nakat, R. V.,** Jadhav, S.S. 2017. Detrimental effect of entomopathogenic fungi on coccinellid predators in okra. Int. J. Pure App. Biosci. 5(4). 1107-1111.
4. Palthiya, R., **Nakat, R. V.,** Jadhav, S.S. 2017. Efficacy of entomopathogenic fungi against jassids on Okra. Int. J. Pure App. Biosci. 5(4). 1112-16.
5. Palthiya, R., **Nakat, R. V.,** Jadhav, S.S. 2017. Efficacy of entomopathogenic fungi against thrips on okra. Int. J. Pure App. Biosci. 5(4). 1931-36.
6. Palthiya, R., **Nakat, R. V.,** Jadhav, S.S. 2017. Efficacy of entomopathogenic fungi against aphids on okra. Int. J. Curr. Microbial App. Sci. 6(8). 2980-86.
7. Dr. Nakat R.V. ,and Dr. Pokharkar D.S. Prepared QRT Report on Research conducted in AICRP on Biological Control of Crop Pests and Weeds, during the year 2012-17 : 1-85 pp.

Popular articles/ Extension bulletin:

1. R.V. Nakat, I.G. Ghonmode, 2017. A sucess story on participation of girls surdents in Expérientiel Learning Programme on bioagents and biopesticide production module

NBAIR, Bangalore

1. Amala, U. and Shivalingaswamy. T. M. 2018. Effect of intercrops and border crops on the diversity of parasitoids and predators in agroecosystem. Egyptian Journal of Biological Pest Control DOI 10.1186/s41938-017-0015-y (NAAS Rating 6.18).
2. Ankita Gupta, K. Selvaraj, Nigel Wyatt, S. K Rajeshwari and C. R. Ballal 2017. First record of family Xenasteiidae (Diptera: Brachycera: Cyclorrhapha) from India in association with Aleurodicus rugioperculatus Martin (Hemiptera: Aleyrodidae) with cautionary notes on associated parasitoids. Journal of Biological Control.
3. Ankita Gupta, S. K. Rajeshwari & Celso O. Azevedo 2017. Biology and description of *Megaprosternum cleonarovorum* sp. nov. (Hymenoptera: Bethylidae) a gregarious larval

ectoparasitoid of *Cleonaria bicolor* Thomson (Coleoptera: Cerambycidae) from India. *Zootaxa*. 4237 (1): 078–090.

4. Ankita Gupta. 2018. A new species of Uniclypea Bouček, 1976 (Hymenoptera: Pteromalidae) parasitic on Apoderus tranquebaricus Fabricius (Coleoptera: Attelabidae) from India with notes on biology. Systematic Parasitology, 95:115–120. DOI 10.1007/s11230-017-9766-9 (published online 30th November 2017).
5. Archana, M. D'Souza, P. E. and Patil, J. 2017. Efficacy of entomopathogenic nematodes (Rhabditida: Steinernematidae and Heterorhabditidae) on developmental stages of house fly, *Musca domestica. Journal of Parasitic Diseases*, :782–794.
6. B. Ramanujam, B. Poornesha, S. Renuka, A. N. Shylesha and R. Rangeshwaran. 2017. Colonization and Persistence of Different Strains of *Beauveria bassiana* (Balsamo) Vuillemin as Endophytes in Sorghum bicolor (L.) Moench. Biopesticides International.13 (1): 43-50.
7. B. Ramanujam, Krishna Japur, B. Poornesha, A. N. Shylesha and R. Rangeshwaran. 2017. Field evaluation of endophytic entomopathogenic fungi against maize stem borer, *Chilo partellus* (Crambidae: Lepidoptera). Indian Journal of Agricultural Sciences. 87 (8): 1099–1103.
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26.13 Participation in seminars / Symposia / Workshops, etc.

AAU – Anand

1. Dr Raghunandan B.L. participated in 21 days training programme on 'Production protocol for biocontrol agents, microbial biopesticides and quality analysis of microbial biopesticides from 1-21 June 2017 held at National Institute of Plant Health Management (NIPHM), Hyderabad.

2. Dr Raghunandan B.L. participated in one day national seminar on 'Plant Protection: Problems and solutions' organized by Plant Protection Association of Gujarat (PPAG), Junagadh chapter on 19-07-2017.
3. Dr Raghunandan B.L. participated in three days training programme on 'Improving e-Governance in Agriculture' sponsored by MANAGE, Hyderabad from 05-09-2017 to 07-09-2017 held at Anand Agricultural Univeristy, Anand.
4. Dr Raghunandan B.L. participated in Special symposium on 'Microbial Antagonists and their role in Biological Control of Plant Diseases and West Zone Meet of Indian Phytopathological Society (IPS) (2017) on October 5- 7, 2017 held at Anand Agricultural Univeristy, Anand.
5. Dr DM Mehta & Dr Raghunandan BL participated in 14th Plant Protection Subcommittee (PPSC) meeting held at AAU Anand on 11-12 March 2018.
6. Dr DM Mehta & Dr Raghunandan BL participated in 14th Joint Agricultural Research committee meeting held at AAU, Anand on 21-22 March 2018

ANGRAU, at RARS, Anakapalle

1. Attended XXVI annual group meet on AICRP on Biological control of crop pests at Solan, Himachal Pradesh from 16-17, May, 2017; presented achievements of AICRP centres on biological contol of maize and sorghum pests; participated as rappoteur for session on tribal sub plan programme.

Diagnostic Field Visits: Eighteen

1. Dr.M.Visalakshi conducted field visit on 4.7.17 in Chodavaram division, Visakhapatnam district , monitored problems in paddy, groundnut, sesame , greengram, sugarcane and advised remedies to farmers.
2. Dr.M.Visalakshi conducted field visit on 14.7.17 in East Godavari district , monitored white grub , early shoot borer in sugarcane and advised remedies to farmers.
3. Dr.M.Visalakshi conducted field visit on 26.8.17 in Vizianagaram division, Vizianagaram district , monitored problems in paddy, ragi, groundnut and advised remedies to farmers.
4. Dr.M.Visalakshi conducted field visit on 21.9.17 in Vizianagaram division, Vizianagaram district , monitored problems in paddy and advised remedies to farmers.
5. Dr.M.Visalakshi conducted field visit on 12.10.17 in Anakapalle, Yelamanchili division, Visakhapatanam district, monitored problems in paddy and advised remedies to farmers.
6. Dr.M.Visalakshi conducted field visit on 30.10.17 in Narsipatnam divisiondivision, Visakhapatanam district, monitored problems in paddy and advised remedies to farmers
7. Dr.M.Visalakshi conducted field visit on 6.11.17 in Chodavaram division, Visakhapatanam district, monitored problems in paddy and advised remedies to farmers.
8. Dr.M.Visalakshi conducted field visit on 13.11.17 in Chodavaram division, Visakhapatanam district, monitored problems in paddy and advised remedies to farmers.
9. Dr.M.Visalakshi conducted field visit on 14.11.17 in Anakapalle, Yelamanchili divisions, Visakhapatanam district, monitored problems in paddy and advised remedies to farmers.

10. Dr.M.Visalakshi conducted field visit on 13.12.17 in Lakkavaeram, Chodavaram mandal, Visakhapatnam district, monitored problems in greengram, blackgram and advised remedies to farmers.
11. Dr.M.Visalakshi conducted field visit on 27.12.17 in Chodavaram division, Visakhapatanam district, monitored problems in rice fallow pulses and advised remedies to farmers.
12. Dr.M.Visalakshi conducted field visit on 30.12.17 in vizianagaram division, Vizianagaram district, monitored problems in maize and advised remedies to farmers.
13. Dr.M.Visalakshi conducted field visit on 12.1.18 in Bheemili division, Visaklhapatnam district , monitored problems in maize and advised remedies to farmers.
14. Dr.M.Visalakshi conducted field visit on 24.1.18 in Bheemili division, Visaklhapatnam district , monitored problems in maize and advised remedies to farmers.
15. Dr.M.Visalakshi conducted field visit on 19.2.18 in Vizianagaram division, Vizianagarm district, monitored problems in maize and advised remedies to farmers.
16. Dr.M.Visalakshi conducted field visit on 21.2.18 in Ranasthalam division, Srikakulam district, monitored problems in maize and advised remedies to farmers.
17. Dr.M.Visalakshi conducted field visit on 17.3.18 in Anakapalle division, Visakhapatanam district, monitored problems in maize and advised remedies to farmers.
18. Dr.M.Visalakshi conducted field visit on 20.3.18 in Anakapalle division, Visakhapatanam district, monitored problems in maize and sugarcane and advised remedies to farmers.

Meetings

1. Dr.M.Visalakshi participated in Mid term review meeting on 24.101.17 at ICAR-NBAIR, Bangalore and presented workdone report of experiments, experiments to be initiated constraints in execution of technical programme and budget allocation.
2. Dr.M.Visalakshi participated in QRT meeting at PJTSAU, Hyderabad on 28.2.18 and presented workdone report of ANGRAU cntre for the period from 2015- 2017.

GBPUAT, Pantnagar

1. **A. K. Tewari, Roopali Sharma and Manju Sharma** (2017). 26th Annual Group Meeting of AICRP on Biological control of crop pests held at YSPUHF, Nauni, Solan w.e.f. 16-17 May, 2017

2. **Dr A.K. Tewari, Dr Roopali Sharma and Dr Manju Sharma (2017).** National Symposium on Sustainable Disease Management Approaches and Applications & IPS-MEZ Annual Meeting, 21-23 Dec.2017.

3. Action taken report on the recommendations of XXVI AICRP Bio-control workshop May 16-17, 2017-18.
4. A status paper on role of zero tillage vis-à-vis pests out breaks based on available information is being prepared
5. *In-vitro* testing of compatibility of different combinations of potential bioagents has been done. Field experiments would be conducted during next year (2018-19 & 2019-20) to generate bio-efficacy data for microbial consortia.

6. All the centres were offered Pantnagar isolates for testing in their locations during the workshop but no request could be received from any centre, which may be due to lack of Plant Pathologist in this group.

KAU, Thrissur

1. Dr. Madhu Subramanian, Professor attended XXVI Biocontrol Workers Group Meeting held on 16th to 17th May, 2017 at Y.S. Parmar University of Horticulture & Forestry, Solan.
2. Dr. Madhu Subramanian, Professor attended midterm review of the AICRP on BCCP at NBAIR, Bengaluru held at October 24th 2017.
3. Dr. Madhu Subramanian, Professor and Dr. Smitha M.S., Assistant Professor attended QRT of AICRP on BCCP held at NBAIR, Bengaluru on 27th February 2018.
4. Dr. Smitha M.S., Assistant Professor participated in ICAR sponsored short course on 'Nanotechnological approaches in pest and disease management' held from 15th to 24th November, 2017 at NBAIR, Bengaluru.

PAU, Ludhiana

1. Drs K S Sangha, Neelam Joshi, Parminder Singh Shera and Sudhendu Sharma participated in 26th Biocontrol Workers' Group Meeting of AICRP- Biological Control of Crop Pests held on May 16-17, 2017 at YSPUHF, Solan
2. Drs K S Sangha, P S Shera and Sudhendu Sharma participated in Research and Extension Specialist's Workshop for Vegetables, Horticulture and Sericulture along with Post-harvest Management, Farm Power and Machinery, Food Technology and Agricultural Economics held on 31st May and 1st June, 2017 at PAU Ludhiana
3. Drs K S Sangha, Neelam Joshi, Parminder Singh Shera, Rabinder Kaur and Sudhendu Sharma participated in Research and Extension Specialists Workshop for *Rabi* crops held on 31st August and 1st September, 2017 at PAU Ludhiana
4. Dr Sudhendu Sharma participated in Regional *Kisan Mela* held on September 8, 2017 at Ballowal Saunkhari
5. Drs K S Sangha and Parminder Singh Shera participated in Regional *Kisan Mela* on September 8, 2017 at Gurdaspur.

MPKV, Pune

Research Meetings

1. Dr. S. M. Galande attended 75th Board of Studies meeting in Agril. Entomology held at Rahuri on 25th and 26th April, 2017.
2. Dr. D.S. Pokharkar and S.M. Galande attended XXVI Annual workshop of AICRP on Biocontrol held at Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, (H.P.) on 16th and 17th May, 2017and presented the research report of the work done under AICRP on Biological Control of Crop Pests and Weeds, AC, Pune centre during the year 2016-17.
3. Dr. D. S. Pokharkar attended Joint Agresco Meeting held at VNMKV Parbhani during 29.5.2017 to 31.5.2017 and presented the report of Agril. Meteorology.

4. Dr. S. M. Galande attended synopsis of M.Sc. (Agri.) students of Entomology on 29.5.2017.
5. Dr. U. B. Hole, Entomologist, participated and attended one day training programme on, "Scientific Bee Keeping" on the eve of World Honey Bee Day celebration programme on 19.8.2017, Dept. of Entomology, MPKV, Rahuri.
6. Dr. U. B. Hole, Entomologist, participated in the "Agri-Tech Fest-2017' organized at College of Agriculture, Pune, w.e.f. 10th to 13th September 2017 and demonstrated the use of different bicontrol agents against pests of various crops.
7. Galande, S. M. attended 3rd International Conference on Science, Technology and Management- 2017, and presented the paper at Maratha Chamber of Commerce Industries and Agriculture Pune on 5th Nov 2017.
8. Dr. U. B. Hole, Entomologist, being of member of Zonal Committee for, "Creation of awareness about care during handling of agricultural pesticides", participated and attended the meeting on 09.10.2017 under the chairmanship of Joint Director of Agriculture, Pune Division, Pune.
9. Dr. U. B. Hole, Entomologist, participated in the visit of ICAR monitoring team of AICRP on Cotton, Central Zone and shown the incidence of pink bollworm on BG- II cotton genotypes on 10.10.2017 at Cotton Improvement Project, MPKV, Rahuri.
10. Dr. R. V. Nakat Entomologist attended RRC meeting of Agril. Entomology section at DOR office, MPKV, Rahuri on 11.12.2017 and presented the research report of AICRP on Biocontrol and one research recommendation.
11. Dr. R.V. Nakat attended the Regional workshop on preventing Grain losses: the scientific approach on 29-30th Jan, 2018 which was jointly organized by MPKV, Rahuri and Entomological society of India, New Delhi. The live demonstration on grain fumigation for farmers is also organized on 30/01/2018 where around 350 farmers and 200 students participated in fumigation demonstration programme. India storage Forum is launched at Hotel Pride on 30/01/2018 by the Entomological society of India.
12. Dr. R.V. Nakat attended the meeting of finalizing the specification of the lab equipments required for biocontrol lab at Directorate of Quality Control and Inputs, Govt.of Maharashtra, Pune on 10.1.2018.
13. Dr. R.V. Nakat attended the farmers seminar and demonstration on "Safe use of pesticides" at IARI, Regional station, Baner, Pune on 31/01/2018.
14. Dr. R.V. Nakat, Entomologist attended the QRT meeting at NBAIR on 26th Feb, 2018. Prepared the QRT report on the research experiment carried out during the period 2012-17 and presented the QRT report before QRT Team which is appreciated by the QRT members.
15. Dr. R.V. Nakat, Entomologist, AICRP on Biocontrol attended research planning meeting at Directorate of Research, MPKV, Rahuri on 3rd march, 2018, prepared and presented the Research experiment planning for the year 2018-19 of AICRP on Biocontrol, A.C. Pune.

Training

The practical training on 4 months duration on mass production of biopesticides imparted to 30 students of VIII th semester of B.Sc.Agri under Experiential Learning programme during

Dec.2017 to March 2018. They have mass produced bioagents and biopesticides sold out to the farmers and earned the revenue.

PJTSAU

Dr. S. J. Rahman, Principal scientist & University Head (Ento):

1. Participated in Bio Safety Conference organized by Ministry of Env., Forests & Climate Change at different parts of country during 2017-18
2. Participated in ZREAC (*Kharif &Rabi*) meetings in Telangana during 2017-18

25.14 Biocontrol agents maintained

AAU, Anand

1. *Trichogramma chilonis*
2. *T. achaeae*
3. *T. pretiosum*
4. *Trichogrammatoidea bactrae*
5. *Beauveria bassiana (Bb-5)*
6. *Lecancillium lecanii (Vl-8)*
7. *Metarhizium anisopliae (Ma-1)*
8. *Bacillus thuringiensis (PDBC-BT1, NBAII BTG-4)*
9. *Trichoderma harzianum (Th-3)*
10. *Pseudomonas fluorescens (Pf-1)*

AAU, Jorhat

1. *Trichogramma japonicum*
2. *T. chilonis*
3. *T. mwanzai*
4. *T. pieridis*
5. *Blaptostethus pallescens*
6. *Trichogramma pretiosum*
7. *Telenomus sp* recovered from tea
8. *Neochetina eichhorniae and N. bruchi*

The biocontrol agents (parasitoids and predators) produced and maintained in the laboratory are being utilized for teaching and training of farmers, extension workers, entrepreneurs and also students of U.G. (ELP) and P.G. Research. Cultures of parasitoids (*Trichogramma japonicum, T. chilonis, T. pieridis)* and water hyacinth beetle *Neochetina eichhorniae and N. bruchi* have been supplied to different regional research stations of AAU, KVKs and Agricultural officers, Govt. of Assam for their field demonstration against pests of rice, sugarcane and vegetables. As per request from Deputy Director, CPIMC, Guwahati we had provided Coryra culture to the institute.

ANGRAU, Anakapalle

1. Mass multiplication of *Trichogramma chilonis with* new protocol (2010) developed by NBAIR, Bangalore.

2. Mass multiplication of *Trichogramma japanicum.*

KAU, Thrissur

1. **Entomopathogenic micro organisms:** *Pseudomonas fluorescens, Trichoderma viride, Metarhizium anisopliae var. anisopliae, Lecanicillium lecanii, Beauveria bassiana, Bacillus thuringiensis, Pochonia chlamydospora, Paecilomyces lilacinus*

2. **Parasitoids:** *Trichogramma chilonis, T. japonicum*

3. **Predators:** *Cryptolaemus montrouzieri*, *Blaptostethus pallescens*

PAU, Ludhiana

1. *Trichogramma chilonis* (temperature tolerant strain)
2. *T. japonicum* (temperature tolerant strain)
3. *T. brassicae*
4. *Bracon hebetor*
5. *Chrysoperla zastrowi sillemi*
6. *Coccinella septempunctata*
7. *Cheilomenes sexmaculatus*
8. *Blaptostethus pallescens*
9. *Aenasius arizonensis*
10. *Cotesia glomerata*
11. PAU Bt

Host insects

1. *Helicoverpa armigera*
2. *Spodoptera litura*
3. *Galleria mellonela*
4. *Corcyra cephalonica*
5. *Phenacoccus solenopsis*
6. *Plutella xylostella*

SKUAST, Kashmir

The culture of following bio agents (obtained from NBAII, Bangalore) including parasitoids and predator, along with their actual/ fictitious hosts, was maintained for the purpose of mass production mainly for distribution to farmers/ experimental purposes, teaching, training to P.G.students, farmers, FCLAs, extension workers and exhibitions in Kisanmelas etc.

S.No.	Hosts and bio agents	Source
1.	*Trichogramma brassicae*	from NBAIR
2.	*T. chlionis*	-do-
	T. chlionis (MITS)	-do-
3.	*T. cacoeciae*	-do-

4.	*T. embryophagum*	-do-
5.	*T. pretiosum*	-do-
6.	*Blaptostethus pallescens*	-do-
7.	*Quadraspidiotus perniciosus*	Local strain
8.	*Corcyra cephalonica*	NBAIR
9.	*Heterorhabditis indica*	-do-
10.	*H. pakistanensis*	-do-

Dr. Y.S. Parmar University of Horticulture and Forestry, Solan

1. Entomopathogeic fungi: *Metarhizium anisopliae, Beauveria bassiana, Lecanicillium lecanii*
2. Entomopathogenic nematodes: *Steinernema* sp. and *Heterorhabditis* sp (These are maintained by the Nematology section of the Department)
3. Parasitoids: *Trichogramma chilonis. T. pretiosum, T. achaeae* and *T. pieridis, T. embryophagum*
4. Predators: *Neoseiulus longispinosus, Chrysoperla zastrowi sillemi, Blaptostethes pallescens*

Host/prey insects:

- *Corcyra cephalonica, Tetranychus urticae, Plutella xylostella, Tuta absoluta*

MPKV, Pune

Following cultures of bioagents and host insects were maintained in the Biocontrol laboratory, and used for experimental purposes as well as supplied to other Biocontrol laboratories in the State. Besides, *Trichogramma* spp., *Cryptolaemus montrouzieri, Ha*NPV, *Sl*NPV, *Metarhizium anisopliae* and *Nomuraea rileyi* were mass cultured and used for action research demonstrations on research farms of the University, and farmers' fields. These were also distributed to needy farmers.

Parasitoids: *Trichogramma chilonis* Ishii
Trichogramma chilonis TTS
Trichogramma chilonis SAS
Trichogramma japonicum Ashmead
Trichogramma achaeae
Trichogrammatoidea bactrae
Chelonus blackburni Blanchard
Acerophagus papayae Noyes & Schauff
Predators: *Cryptolaemus montrouzieri* Mulsant
Chrysoperla zastrowi sillemi (Esben-Petersen)
Microbial agents: *Nomuraea rileyi*
Metarhizium anisopliae
Beauveria bassiana
Lecanicillium lecanii
Laboratory host : *Phthorimaea operculella* Zeller

Corcyra cephalonica Stainton
Maconellicoccus hirsutus Green
Paracoccus marginatus W. and G.

TNAU

Sl.No	Organisms produced	Quantity sold	Amount (Rs.)
1	*Trichogramma sp.*	855CC	42,750
2	*Acerophagus papayae*	12100 Nos.	6,050
3	*Bracon brevicornis*	21250 Nos.	10,625
4	*Goniozus nephantidis*	3700 Nos.	3,330
5	*Cryptolaemus montrouzieri*	1560 Nos.	2,340
6	*Chrysoperla zastrowi sillemi*	6,88,750 Nos.	1,86,375
7	*Corcyra* eggs	147cc	7,350
	Total		**2,79,070**

MPUAT

S. No.	**Particulars**	**Production**	**Area covered**	**Used in Crops**	**Target pests**
1.	*Trichogramma chilonis*	1900 cards	103 ha.	Maize,	Maize stem borer
			1.0 ha.	Tomato,	Fruit borers
			1.0 ha.	Brinjal	Shoot and fruit borer
			1.0 ha.	Okra	Fruit borers
2.	*Verticillium lecanii*	500 gm	1.0 ha.	Cabbage	Mustard aphid
3.	*Metarhizium anisopliae*	500 gm	1.0 ha.	Groundnut	White grub
4.	*Beauveria bassiana*	500 gm	1.0 ha.	Green gram	Semiloopers
5.	HaNPV	500 ml	2.0 ha.	Tomato and Okra	Fruit borer

PJTSAU

Sl.No.	**Bio Agent being cultured and mass produced**	**Type of Bio Agent**
1.	*Trichogramma japonicum*	Egg parasitoid
2.	*Trichogramma pretiosum*	Egg parasitoid
3.	*Trichogramma chilonis*	Egg parasitoid
4.	*Trichogramma achae*	Egg parasitoid
5.	*Trichogramma brasilensis*	Egg parasitoid
6.	*Trichogrammatoidea bactre*	Egg parasitoid
7.	*Chelonus blaclburni*	Egg larval parasitoid
8.	NPV of *Helicoverpa*	Bio Pesticide
9.	NPV of *Spodoptera*	Bio Pesticide

26.15 Technology assessed/ transferred

AAU, Anand

The following recommendation has been approved for scientific community during research council meeting on 10-11th March 2018

1. Following treatments of either *Pichia guilliermondii* (Y12) OR *Pseudomonas fluorescens* (Pf-1) in sequence found effective for the management of chilli fruit rot/anthracnose disease.
2. Seed treatment (10 g or ml/kg seeds),
3. Seedling root dip (20 g or ml/litre water for 5 minutes)
4. Four foliar sprays (10 g or ml/litre, 1% AS, $2x10^8$ cfu/g) at fortnightly interval starting from the initiation of fruit ripening.
5. These bioagents could be included as components of IDM strategy.

PAU, Ludhiana

1. Large scale demonstrations for the management of borers in sugarcane, stem borer in maize, stem borer and leaf folder in rice using bioagents, *Trichogramma chilonis* and *T. japonicum*. A total of 11074, 404 and 212 acres were covered in sugarcane, maize and organic basmati rice, respectively.
2. Provided *Corcyra* eggs, *Trichogramma* culture and technical guidance to different biocontrol labs at sugar mills and Regional Stations (PAU).
3. Provided *Corcyra* eggs, *Trichogramma* culture to Division of Entomology, SKUAST-Jammu, Jammu and Kashmir

SKUAST, Kashmir

1. Supply of bioagents *Trichogramma cacoeciae, T. embryophagum, T. chilonis* and *T. brassicae* to farmers against Codling moth, *Cydia pomonella*, maize stalk borer, *Chilopartellus*, Diamond back moth, *Plutella xylostella* and cabbage butter fly, *Pieris brassicae.*
2. *T. chilonis* (MITS) was assessed against Brinjal shoot and fruit borer in Srinagar.
3. Trunk banding of apple at Ladakh to trap and kill overwintering larvae of Codling moth, *Cydia pomonella*
4. Field performance of anthocorid bug, *Blaptostethus pallescens* was assessed against European red mite, *Panonychus ulmi* and spider mite, *Tetranychus urticae.*
5. Laboratory performance of anthocorid bug, *Blaptostethus pallescens* was assessed against pear psylla on pear
6. Laboratory performance of *Chilocorus infernalis* was assessed against *Parthenolecanium corni* on plum
7. Laboratory performance of *Coccinella septempunctata* and *C. undecimpunctata* was assessed against pear psylla on pear
8. *Hetererhabditis pakistanensis* was assessed against Codling moth, *Cydia pomonella* at Ladakh and *Pieris brassicae* on kale in Shalimar campus, Srinagar.

PJTSAU

1. *In situ* culturing & production of imported parasitoid, *Acerophagous papayae* through potato seedling technique by using papaya mealy bug, *Paracoccus marginatus* as host. - This method was followed by several farmers to maintain *Acerophagous papayae* populations in local areas of requirement across the state. The parasitoid was released in the infested fields and mealy bug management through Biological Control was achieved.
2. A case history of successful management of Papaya Mealy Bug through imported parasitoid, *Acerophagous papayae* has been celebrated at National level where in PJTSAU Centre was invited along with the two successful farmers to share their experiences at national level in the presence of DG, ICAR.
3. Standardized Bio suppression of aphids, *Uroleucon carthami* in safflower by using Entomo Pathogenic Fungi (EPF) *Verticillium (Lecanicillium) lecanii* - Two sprays of *Verticillium (Lecanicillium) lecanii* @ 5gm/litre at vegetative stage with 10 days interval is standardized as recommendation at national level to manage safflower aphid, *Uroleucon carthami* in non spiny safflower. – This recommendation was presented as an achievement of the PJTSAU centre at International Conference of Safflower held at Directorate of Oilseeds Research (now IIOR)
4. Developed Conservation protocols based on Pest Predator Ratios for Sugarcane Woolly Aphid (SWA), *Ceratovacuna lanigerum* and predators, *Dipha aphidivora* & *Micromus igoratus*- These protocols were discussed and passed on to the managements of three leading Sugar mills in Telangana viz., Gayatri Sugar Mills, Kamareddy; Nizam Deccan Sugars, Medak and Ganapathi Sugars, Sangareddy. - As a result of effective conservation of both *Dipha aphidivora* and *Micromus igoratus*, the populations of SWA continued to be under check as per the present data being obtained through SWA monitoring.
5. Developed Mass Production Protocols for *Trichogramma*, *Chrysoperla*, *Ha*NPV, *Sl*NPV, *Trichoderma* & *Pseudomonas* amenable for the state of Telangana and they have been officially passed on to stake holders through Department of Agriculture, Govt. of Telangana on the basis of which several decentralized Bio Control Units are being run by rural youth besides nine State owned Bio Control Labs *viz*, Adilabad, Nizamabad, Karimnagar, Sadasivpet (Medak), Mahbubnagar, Rajendranagar (Hyderabad), Warangal, Nalgonda and Khammam.
6. Upliftment of livelihoods of rural women groups by upscaling NPV production units through active support from NGOs such as Centre for Sustainable Agriculture (CSA) and Centre for peoples forestry (CPF).
7. Feedback analysis of yield gaps in several Horticultural Crops in reference to with or without State Horticulture Mission (SHM) was done to evaluate the programmes of SHM in capacity of member of Technical Support Group (TSG).

ACRONYMS

AICRP-BC	All India Coordinated Research Project of Biological Control of Crop Pests, Bangalore
NBAIR	National Bureau of Agricultural Insect Resources, Bangalore
AAU-A	Anand Agricultural University, Anand
AAU-J	Assam Agricultural University, Jorhat
ANGRAU	Acharya N.G.Ranga Agricultural University, Anakapalle
GBPUAT	Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar
KAU	Kerala Agricultural University, Thrissur
MPKV	Mahatma Phule Krishi Vidyapeeth, Pune
PAU	Punjab Agricultural University, Ludhiana
PJTSAU	Pandit Jayashankar Telangana State Agricultural University, Hyderabad
SKUAST	Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar
TNAU	Tamil Nadu Agricultural University, Coimbatore
YSPUHF	Y.S. Parmar University of Horticultural and Forestry, Solan
CAU	Central Agricultural University, Pasighat
MPUAT	Maharana Pratap University of Agriculture & Technology, Udaipur
OUAT	Orissa University of Agriculture & Technology, Bhubaneswar
UAS-R	University of Agricultural Sciences, Raichur
IGKV	Indira Gandhi Krishi Viswavidhyalaya, Raipur
KAU RARS	KAU-Regional Agricultural Research Station, Kumarakom
KAU RARS	KAU-Regional Agricultural Research Station, Vellayani
YSRUH	Dr. Y S R Horticultural University, Ambajipeta
UBKV	Uttar Banga Krishi Vishwavidyalaya, Pundibari, West Bengal
CISH	Central Institute of Subtropical Horticulture, Lucknow
CPCRI	Central Plantation Crops Research Institute, Kayamkulam
CTRI	Central Tobacco Research Institute, Rajahmundry
IIHR	Indian Institute of Horticultural Research, Bangalore
IIRR	Indian Institute of Rice Research, Hyderabad
IIMR	Indian Institute of Millet Research, Hyderabad
IIVR	Indian Institute of Vegetable Research, Varanasi
NCIPM	National Centre for Integrated Pest Management, New Delhi