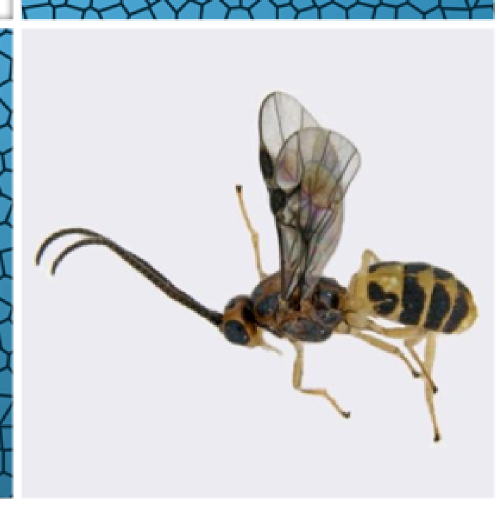
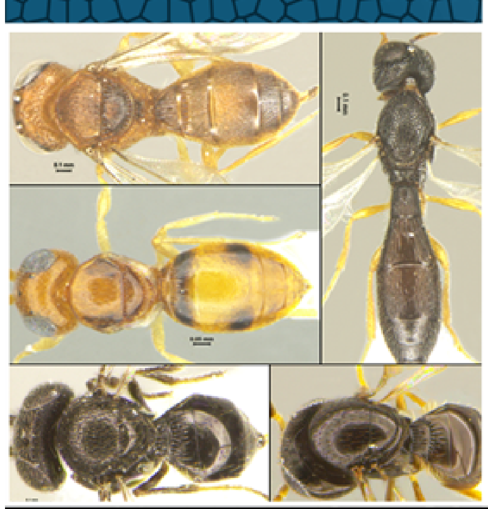
2016-17

PROJECT COORDINATOR'S REPORT

XXVI Biocontrol Workers Group Meeting

16-17 May, 2017





AICRP on BIOLOGICAL CONTROL

ICAR - National Bureau of Agricultural Insect Resources

Bengaluru - 560 024

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

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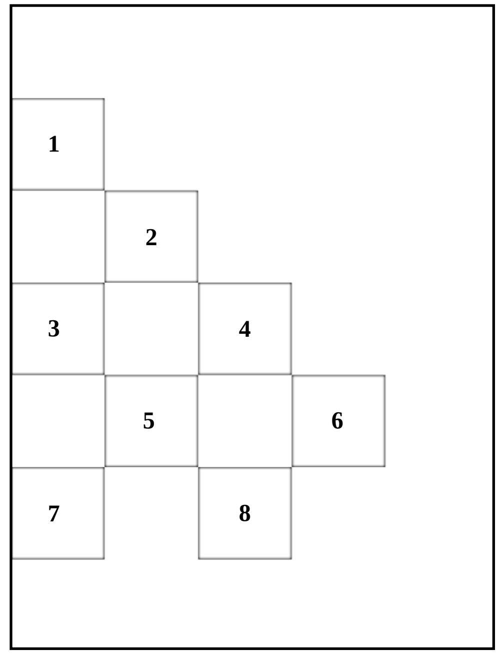

Cover page: New species described from ICAR-NBAIR

1. *Gastrozona nigrifemur* David & Hancock
2. *Tanaostigma indica* Gupta
3. *Thrips laurencei* Rachana & Varatharajan
4. *Bactrocera* (*Calodacus*) *chettalli* David & Ranganath
5. *Agiommatus thyrsisae* Gupta & Gawas
6. *Crinibracon chromusae* Gupta & van Achterberg
7. *Nyleta onge* Veenakumari, *Pardoteleia flava* Veenakumari, *Microthoron bloomsdalensis* Veenakumari, *Microthoron shompen* Veenakumari, *Oethecoctonus suryaseni* Veenakumari
8. *Cotesia trabalae* Gupta

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3 – R. R. Rachana; 7 – K. Veenakumari

Cover design: Sunil Joshi

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Date:
Bangalore

Dr. Chandish R. Ballal
Director, ICAR-NBAIR &
PC, AICRP-Biological Control

1. Introduction

AICRP on Biological Control was initiated during the year 1977 to minimize the application of chemical pesticides and to develop eco-friendly biological control methods for the sustainable management of pests. As a result, several new approaches have been made and biocontrol technologies have been improved and field-tested for wider acceptance by the end users (farmers). Efficient methods of mass multiplication of parasitoids, predators and pathogens against insect pests and antagonists against plant pathogens and plant parasitic nematodes have been developed. Similarly, biocontrol technologies for weed management have been developed. The field demonstrations through AICRP centres have increased the awareness of farmers regarding the usefulness of biological control based pest management.

The work under the XII plan encompasses – i) Survey and collection of natural enemies, *viz*., insects, mites, spiders, EPN and pathogens, ii0 Surveillance for possible entry of potential alien invasives like *Brontispa, Phenacoccus manihoti* the giant whitefly, *Frankliniella occidentalis* the western flower thrips, etc. and classical biological control intervention, if needed, iii) Characterization/ Identification of natural enemies and developing their mass production. Promising natural enemies will be taken up for further studies on bionomics, behaviour, seasonal cycles and assessment of potentials, iv).. Utilization of natural enemies: Pilot studies to assess their potential against insect pests & diseases in crops and in storage, v) Validation of established and potential natural enemies and area-wide demonstration.

Spectacular success was achieved during the past five years in the management of the papaya mealybug, sugarcane and rice borers; eucalyptus gall wasp using predators and parasitoids. Diversity of natural enemies, nematodes, entomopathogens and plant disease antagonists have been given importance and collection and cataloguing have been carried out covering vast geographical areas. Large scale demonstrations in farmers' fields were made towards facilitating the adoption of non-chemical methods of plant protection by farmers.

2. Mandate of AICRP on Biological control of crop pests

- To evolve effective biological control strategies for important insect pests, plant pathogens and nematodes.
- To co-ordinate research on biological control aspects at national level.
- To serve as nodal agency for introduction, exchange and conservation of biological control agents at national level.
- To disseminate information and impart training on biological control

3. Setup

With a view to fulfil the mandate effectively and efficiently, the Bureau is functioning in close coordination with the following State Agricultural Universities and ICAR Institutes.

State Agricultural University–based centers

1. Acharya N.G. Ranga Agricultural University, Anakapalle
2. Anand Agricultural University, Anand
3. Assam Agricultural University, Jorhat
4. Dr. Y.S. Parmar University of Horticulture and Forestry, Solan
5. Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar
6. Kerala Agricultural University, Thrissur
7. Mahatma Phule Krishi Vidyapeeth, Pune
8. Pandit Jayashankar Telangana State Agricultural University, Hyderabad
9. Punjab Agricultural University, Ludhiana
10. Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar
11. Tamil Nadu Agricultural University, Coimbatore
12. Central Agricultural University, Pasighat
13. Maharana Pratap University of Agriculture & Technology, Udaipur
14. Orissa University of Agriculture & Technology, Bhubaneswar
15. University of Agricultural Sciences, Raichur

ICAR Institute–based centres

1. Central Institute of Subtropical Horticulture, Lucknow
2. Central Plantation Crops Research Institute, Kayankulam
3. Central Tobacco Research Institute, Rajahmundry
4. Indian Institute of Rice Research, Hyderabad
5. Directorate of Seed Research, Mau
6. Indian Institute of Millet Research, Hyderabad
7. Indian Agricultural Research Institute, New Delhi
8. Indian Institute of Horticultural Research, Bangalore
9. Indian Institute of Vegetable Research, Varanasi
10. National Centre for Integrated Pest Management, New Delhi

Voluntary Centre

1. Indira Gandhi Krishi Viswavidhyalaya, Raipur
2. KAU-Regional Agricultural Rersearch Station, Kumarakom
3. Kerala Agricultural University, Vellayani
4. Dr. Y S R Horticultural University, Ambajipeta
5. Uttar Banga Krishi Vishwavidyalaya, Pundibari, West Bengal

The results from the various experiments conducted at centres across the country during the year 2016-17 are presented below.

4. Brief summary of research achievements

4.1 Basic research work at National Bureau of Agricultural Insect Resources

4.1.1 Biosystematic studies on agricultural insects

4.1.1.1 Biodiversity of oophagus parasitoids with special reference to Scelionidae (Hymenoptera)

The wasp genus *Oethecoctonus*, which consists of egg parasitoids of tree crickets (Orthoptera: Oecanthidae), was reported for the first time from the Oriental region. A new species *Oethecoctonus suryaseni* sp. n. was described and imaged. *Pardoteleia*, a monotypic genus was reported for the first time from India. A new species *Pardoteleia flava* sp. n. from India was described and imaged. The hitherto unknown male of this genus was also described and imaged for the first time. *Pardoteleia prater*, the type species was redescribed and imaged with intraspecific variations within the Indian specimens. Two new species of *Microthoron*, *viz*., *M. bloomsdalensis* sp. n. and *M. shompen* sp. n. were described. The male of *M. baeoides* Masner and its bizarre antenna were described. The monotypic genus *Nyleta* was reported for the first time from India. A new species of *Nyleta, Nyleta onge* sp. n. was now described and imaged from the remote island of Little Andaman in the Andaman and Nicobar group of Islands in the Indian Ocean. Variants of the same species were also collected from Tamil Nadu. The images of the holotype of *N. striaticeps* were also provided for the first time.

4.1.1.2 Biosystematics of trichogrammatidae (Hymenoptera)

Insects were collected, processed from Assam, Rajasthan, Karnataka, Kerala and Tamil Nadu. Additional specimens of the new species of Trichogrammatoidea were obtained from Mudigere enabling its description as a new species. *Hispidophila* and *Megaphragma* were collected from Assam and are being reported from there for the first time. Periodic surveys for hymenopteran parasitoids were conducted in a ragi field in Karnataka at fortnightly intervals for a whole year. 7711 parasitoids belonging to 18 families were collected. Scelionidae were numerically the most abundant followed by Mymaridae, Encyrtidae, Ceraphronidae and Trichogrammatidae. Trichogrammatidae were fairly evenly distributed throughout the year with one peak in April. Scelionidae peaked in July while Mymaridae peaked in September. Further analysis, in progress, will reveal the implications of the occurrence of these parasitoids. Identification services, especially for *Trichogramma* and Trichogrammatoidea were provided especially for a large consignment of over 600 specimens from Kerala.

4.1.1.3 Biodiversity of aphids, coccids and their natural enemies

A total of seven surveys were conducted for collection of aphids, coccids and their natural enemies at Udaipur, Yellagiri, Yercaud, Thandikudi and Thaditankudisai, Shimoga and Pune and 17, 21, 18, 12, 13 1nd 16 species of aphids/coccids were collected, respectively from these places. A total of 527 species were identified by making 911 slides by processing 4484 specimens. A total of 75 identification services provided to different SAUs, ICAR institutes and

Private Organisations and through which 105 species were identified. Three species of mealybugs (*Heliococcus singularis* Avasthi and Shafee, *Dysmicoccus debregeasiae* (Green) and *Planococcus nilgiricus* Williams), one soft scale (*Macoccus watti* (Green)), one aphid (*Greenidea maculata* Noordam) and one eriococcid (*Gossypariella crematogastri* Kozár & Konczné Benedicty) were added as new to existing collection of aphids and coccids at ICAR – NBAIR museum. One aphid, *Schoutedenia emblica* Patel & Kulkarni and three species of mealybugs, *viz*., *Phenacoccus parvus* Morrison, *Phenacoccus madeirensis* Green, *Pseudococcus saccharicola* Takahashi were recorded for the first time from Udaipur, Rajasthan. Similarly, one armoured scale, *Semelaspidus artocarpi* (Green), one aphid *Imaptientinum impatiens* (Shinji) and one melaybug, *Heliococcus summervillei* Brookes were recorded for the first time from South India and two mealybugs and one aphid (*Antonina thaiensis* Takahashi *Exallomochlus hispidus* (Morrison) *Uroleucon pseudoambrosiae* (Olive) were collected for the first time from India. One species of soft scale, *viz*., *Pulvinaria urbicola* was re-described. 22 species of parasitoids on 39 species of different coccids were collected and got identified. No new host association or new records could me made this year. Thirteen species of mealybugs, were deposited for molecular characterization. An identification guide to field and mounted characters of mealybug was developed. This guide includes 35 species of economically important mealybugs.

4.1.1.4 Taxonomy, diversity and host-parasitoid association of Ichneumonoidea with special reference to Braconinae, Doryctinae & Microgastrinae

In the studies of the world fauna of Microgastrinae (in total 269 species) a new species of *Cotesia* with similar shape of T1 (narrowing at midlength), together with diagnostic characters to separate it from *C. pistrinariae* from Africa was described. Further the generic placement of those two species, based on molecular and morphological analyses as well as parasitoid biology was ellaborated. To date, only two species of *Cotesia* are known to have a T1 narrowing at midlength. That represents less than 1% of all described species worldwide. In the neighbor-joining tree both species cluster more closely with other species, and in the Bayesian tree they are part of a large unresolved polytomy which provides no support for them being sister species, although it does not preclude that possibility either. However, the molecular data support the monophyly of *Cotesia*, including both *C. pistrinariae* and *C. trabalae*.

A new species, *Crinibracon chromusae* Gupta & van Achterberg parasitic on pupae of *Hasora chromus* (Cramer) (Hesperiidae) on *Millettia pinnata* (L.) Panigrahi (Fabaceae) was described from India and compared with *C. sinicus* (Yang, Chen & Liu, 2008) from China, the only other species known with a similar general appearance. For the first time biological information for the genus *Crinibracon* Quicke, 1988, is given. Three species of hyperparasitoids, *Philolema braconidis* (Ferrière) (Hymenoptera: Eurytomidae), *Nesolynx javanica* Ferrière (Hymenoptera: Eulophidae), and an *Eupelmus* sp. (Hymenoptera: Eupelmidae) emerged along with *C. chromusae* from pupae of *H. chromus*.

Recently, *Cotesia dictyoplocae* (Watanabe) (Hymenoptera: Braconidae) was fortuitously reared from *A. assamensis* in Assam, India, on the host plant *Persea bombycina* (King ex Hook. f.) Kosterm. (Lauraceae). This is the first report of *C. dictyoplocae* parasitizing larvae of *A. assamensis* in India. Previously, *C. dictyoplocae* was known from China, Japan, and Korea.

Cotesia dictyoplocae is a gregarious larval parasitoid, and females lay on an average 30 eggs per host larva.

In rearing of *Gangara thyrsis* (Fabricius) (Lepidoptera: Hesperiidae) from Karnataka and Goa, India, six species of parasitoids were observed. One new species of parasitic wasp is described and illustrated: *Agiommatus thyrsisae* (Hymenoptera: Pteromalidae), a solitary parasitoid reared from the egg of *G. thyrsis* on the natural host plant *Dypsis lutescens* (H. Wendl.) Beentje & Dransf. Three additional species of parasitic wasps were also reared: *Anastatus ramakrishnai* (Mani, 1935) (Hymenoptera: Eupelmidae), a solitary hyperparasitoid of *A. thyrsisae*; *Sympiesis thyrsisae* Gupta, Gawas & Bhambure (Hymenoptera: Eulophidae), a gregarious parasitoid reared from the caterpillar of *G. thyrsis* on the host plant *Cocos nucifera* L., and *Brachymeria lasus* (Walker) reared from pupa of *G. thyrsis* on the host plant *D. lutescens*. Additionally, two species of tachinid flies were also reared from the pupae of *G. thyrsis*: *Exorista sorbillans* (Wiedemann, 1830) and an innominate species close to *Blepharella* spp. *Gangara thyrsis* is a new host record for the genus *Agiommatus* and for *A. ramakrishnai* and *B. lasus*. The mean percent parasitism in *G. thyrsis* eggs was 26.58% with an incubation period of 6-7 days. Amongst the egg parasitoids, 57.14–73.08% were females and 23.08% were males. Hyperparasitism ranged from 3.85 to 42.86%. *Dypsis lutescens*, a member of Arecaceae, is a new host plant record for *G. thyrsis*.

Tanaostigma Howard (Hymenoptera: Tanaostigmatidae) is recorded for the first time in the fauna of the Old World, with *T. indica* Gupta described and illustrated from southern India, reared from *Millettia pinnata* (Fabaceae).

The banana skipper *Erionota torus* Evans has recently emerged as a serious pest of banana. In the present study for the first time egg parasitism of *E. torus* by *Ooencyrtus pallidipes* (Ashmead), a gregarious parasitoid, is reported from India. The natural percent parasitism observed was 80−82% in the banana field located at Komanal, Shivamogga district, Karnataka. Since this parasitoid has served as an effective biological control agent for *E. torus* in Mauritius and Taiwan, possibilities are there that it can establish as a potential biological control agent in India as well.

Rearing data on parasitism of seven butterfly species in six genera belonging to three Lepidoptera families (Hesperiidae, Lycaenidae and Papilionidae) are presented for the first time from Kerala, India. Four species of parasitic wasps along with two possibly unnamed species, collectively from three Hymenoptera families (Braconidae, Chalcididae and Ichneumonidae), were discovered. *Dolichogenidea hasorae* (Wilkinson, 1928) **n. comb**. (Hymenoptera: Braconidae) is reassigned from the traditionally defined genus *Apanteles*. The following host associations are recorded: *Brachymeria lasus* (Walker) (Chalcididae) from pupa of *Hasora chromus* (Cramer) (Hesperiidae); *Casinaria ajanta* Maheshwary & Gupta (Ichneumonidae) from caterpillars of two hesperiid species − *Ampittia dioscorides* (Fabricius) (Hesperiidae) and *Parnara* sp. (Hesperiidae); *Dolichogenidea hasorae* (Wilkinson) **n. comb**. from caterpillar of *Hasora taminatus* (Hübner); *Glyptapanteles aristolochiae* (Wilkinson) from caterpillar of *Troides minos* (Cramer) (Papilionidae); *Apanteles* sp. (Braconidae) from caterpillar of *Telicota bambusae* (Moore) (Hesperiidae); and *Cotesia* sp. from caterpillar of *Udara akasa* (Horsfield) (Lycaenidae). The majority of these records are the first reports except *C. ajanta* from *Parnara* sp. Host range extension and varied host association of parasitoids are discussed based on newly acquired and previously published data. Brief diagnosis of wasps and illustrations of wasps along with their respective hosts are provided.

Identified *Encarsia guadeloupae* Viggiani for the new invasive rugose spiraling whitefly (RSW) *Aleurodicus rugioperculatus* Martin 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 recorded and maximum parasitism was recorded by *Encarsia guadeloupae* Viggiani. This communication is the first report of the rugose spiraling whitefly, its host plant range and associated natural enemies in India.

4.1.1.5 Biosystematics and diversity of entomogenous nematodes in India

Samples were collected randomly with a hand shovel. Each soil sample (approximately 500 g) was a composite of 5–7 random sub-samples taken at a depth of 0–15 cm in an area of approximately 25 m2. In total 189 soil samples were collected randomly from vegetables, banana, rubber, sugarcane, and forest land of Karnataka, Tamil Nadu, Kerala, Andhra Pradesh, Goa and Maharashtra. 20 *Steinernema* sp and 11 *Heterorhabidtis* sp were from these places.

First record of *Heterorhabditis pakistanense* (Nematoda: Heterorhabditidae) from India. A total of 11 soil samples were collected from the walnut and apple cultivated lands in Kargil district of Jammu and Kashmir. A soil sample drawn from walnut rhizosphere of Adul Gund of Kargil district and positive sample was anticipated with *Heterorahbditis* nematode, this nematode was identified as *H. pakistanense* through morphological and molecular characterization and named as *Heterorhabditis pakistanense* strain NBAIIH05. The genomic DNA of NBAIIH05 was extracted from single first generation hermaphrodite and successfully amplified using Internal Transcribed Spacer (ITS) region of rDNA gene by PCR amplification and then subjected to sequencing. The ITS region of rDNA of isolate *H. pakistanense* NBAIIH05 was successfully amplified and was found to have 816 base pairs. Sequence alignment of ITS region of *H. pakistanense* NBAIIH05 showed maximum identity with *H. pakistanense* Shahina et al. 2016 (99.0%) and formed a highly supported clade. The base sequence (1-795 bp) of this isolate has been deposited in GenBank, NCBI and accession number was obtained GenBank: KX954218.

Influence of soil texture and soil moisture on *Heterorhabditis pakistanense* (Rhabditida: Heterorhabditidae) activity. In this study we investigated the effect of soil texture (Sandy clay loam, Sandy clay and Clay soil) and soil moisture 1-20% (wt/wt) on activity of *H. pakistanense* infective juveniles (IJs). The horizontal soil column assay results revealed that, in sandy clay loam soil IJs migrated at a distance of 25cm in 5days and caused 100% mortality to *Galleria mellonella* larvae whereas, in sandy clay and clay soil mortality was 10% and 70%, respectively. At 45cm, *H. pakistanense* NBAII05 caused 60% mortality in only sand clay soil. In vertical soil column assay *H. pakistanense* NBAII05 caused 100% mortality in 45cm at 5days of after inoculation in sandy clay loam soil, but at 45cm we could not find mortality in sandy loam and clay soil. The effect of soil moisture on *H. pakistanense* NBAIIH05 infectivity indicated that, except 1% moisture in rest, 100% larval mortality was recorded. IJs penetration to *G. mellonella* larvae varied significantly with different soil types, depth and soil moisture. Based on this study we conclude that soil texture and moisture should be considered critical factor while using *H. pakistanense* NBAIIH05 in biological control programme.

The efficacy of two species of entomopathogenic nematodes (EPN), *Steinernema abbasi* and *Heterorhabditis indica*, against *H. consanguinea* was tested under laboratory and field conditions. In a laboratory assay, *H. indica* caused significantly greater mortality (25-100%) than

S. abbasi (20-80%) against second instars and *H. indica* caused 17.5-82.5% mortality in third-instar grub larvae, while *S. abbasi* caused (10-60%) mortality. These results revealed that second-instar grubs were more susceptible than third-instar grubs and efficacy of EPN against *H. consanguinea* varies with nematode species. The penetration and multiplication rate for *H. indica* was significantly higher than those of *S. abbasi*. Infective juveniles (IJ) of both nematode species and a commonly used insecticide (phorate) were tested against this insect in a field experiment. Field trail data showed that the percentage reduction in *H. consanguinea* grub population was significantly higher using *H. indica* at a dose of 2.5×10^9 IJ ha^{-1} than *S. abbasi* and phorate application. Phorate application was more efficient in reducing the grub population than both nematode species at the lower application rate (1.25×10^9 IJ ha^{-1}). Overall, these experiments suggest that *H. indica* may be a promising biocontrol agent against *H. consanguinea*.

4.1.2 Monitoring of invasive pests

4.1.2.1 New Invasive rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin

The invasive rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin has invaded our country and reported on coconut, banana, custard apple, sapota and several ornamental plants in Tamil Nadu, Andhra Pradesh and Kerala. This is the first report of this pest in India as well as oriental region. It was initially noticed to feed on coconut in Pollachi and Coimbatore (Tamil Nadu) during August, 2016 and later on recorded from other parts of peninsular India. The severity of infestation reached an alarming situation causing extensive damage to coconut and banana and thus has assumed major pest status. This pest is highly polyphagous and expected to extend its host range in India.

4.1.2.2 Studies on Papaya mealybug

In Karnataka, infestation papaya mealybug on mulberry was surveyed in the districts of Maddur, Hassan, Tumkur, Mandya, Chamarajnagar, Ramanagar, Kollegal, Kolar and Chikballapur area. The occurrence of papaya mealybug was nil in the surveyed areas. No sericulture farmer requested for parasitoids in the entire year showing the complete suppression of papaya mealybug in mulberry. Incidence of papaya mealybug was very low 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. Survey in about 65 orchards of papaya in Nelamangala, Devanahalli, Kunigal, Mandya, Bangalore, Kollegal, Maddur, Kanakapura, Mysore, Chamarajanagar, Kolar, Tumkur road, and Hassan revealed not a single tree with papaya mealybug. In the homesteds >85% parasitization by *Acerophagus papayae* and also 15-25 per cent by *Pseudleptomastix mexicana* was found in all the places where ever papaya mealybug was observed. On request 18 shipments of *Acerophagus papayae* was received this year by papaya growers out of fear only and no orchard recorded severe incidence of papaya mealybug.

Hibiscus was 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*, on tapioca it was found associated with *P. madeirrensis*. Parasitism by *A. papayae* was very high (>82%). Several weeds which were previously found to harbor

Papaya mealybug, *viz*., *Parthenium, Sida acuta, Acalypha*, *Abutilon* and crotons were free from papaya mealybug.

4.1.2.3 Erythrina Gall wasp managment

Erythrina Gall wasp *Quadrastichus erythrinae* was found in very low populations in Kolar, Mandya, and Ramnagar districts. *Aprostocetus gala* was found to be the major parasitoid of *Q. erythrinae*. 15-35% parasitization observed in field. It was clearly established that *Aprostocetus gala* was always found associated with *Q.erithrinae*.

4.1.2.4 Establishment of *C. connexa* gall fly

Chromolaena weed biocontrol agent *C. connexa* released at different places has established upto 15 galls per 5 minutes search in 450 m around the released spot. In Puttur area it has spread around 22-25 km from the released spot and in Tataguni estate it has sprad to the nearby foresest area, whereas in GKVK it has been localised because of the availability of host insects. *Ormyrus* sp. parasitization was recorded upto 7% in GKVK.

4.1.2.5 Invasive whitefly *Aleurocanthes bangalorensis*

Aleurocanthes bangalorensis was observed to be severe on jamun trees in and around Bangalore. The species identity was confirmed by Dr. Sundarraj of IWST. Two encyrtids and one eulophid parasitoid collected has been handed over for identification. *Acletoxenus indicus* Malloch, a dipteran maggot was found feeding on the whitefly. Two encyrtids and one eulophid parasitoid collected has been handed over for identification.

4.1.2.6 *Anagyrus amnestos* a parasitoid of Madeira mealybug

Anagyrus amnestos was collected from parasitized nymph and adult Madeira mealybugs of both male(Nymphs) and female which collected from *Abutilon* plants during the survey. *A. amnestos* is a koinobiont, gregarious, super parasitoid, in which, adults laid eggs inside the body of the mealybug. Thus larval period was completed within the body of the mealybug. Hence time from the egg laid upto the formation of pupa was considered as larval period. Larval period ranged from 10-11 days (Mean = 8.59 ± 0.50), pupal period ranged from 8-10 days (Mean = 8.59 ± 0.5). Adult male lived for 3-4 days (Mean = 2.86 ± 0.15) with honey and for 1-2 days (Mean = 1.3 ± 0.57) without honey. Adult female lived for 12-14 days (Mean = 11.01 ± 0.68) with honey and 3-4 days (Mean = 3.55 ± 0.19) (without honey), thus duration of life cycle of male and female with honey was, 18.66 days (Mean = 2.86 ± 0.15) and 26.81 days (Mean = 11.01 ± 0.68) respectively and for male 17.12 days (Mean = 1.30 ± 0.90), female 19.37 days (Mean = 3.55 ± 0.19) without honey, respectively.

4.1.2.7 Surveillance for alien invasive pests

At Gujarat, surveillance for alien invasive pests was carried out to record some of likely invasives such as *Brontispa longissima*, *Aleurodicus dugesii*, *Phenacoccus manihoti*, *Phenacoccus madeirensis*, alien invasive pests of fruits and vegetables in the market yards and *Tuta absoluta*. Periodic surveys revealed that none of the invasive pest listed above was recorded except *Tuta absoluta.*

At Himachal Pradesh, different vegetable and fruit ecosystems at Solan, Kandaghat, Nainatikkar, Deothi, Subathu, Sarahan, Una, Bilaspur,Ghumarwinn Rekongpeo, Ribba, Akpa, Moorang, Tabo, 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 at Nauni, Dharja, Solan, Kandaghat, Nainatikkar, Deothi, Subathu, and Sarahan locations of the state. Under open conditions the leaf miner was recorded infesting tomato and potato, whereas, in a polyhouse the pest was found to infest tomato, brinjal and potato.

4.1.3 Exploitation of *Beauveria bassiana* for management of stem borer, *Chilo partellus* in maize and sorghum through endophytic establishment

A field trial was conducted to evaluate the promising endophytic isolates of *Beauveria bassiana* (ICAR-NBAIR-Bb-5a, 23 and 45) through foliar applications of oil formulations against stem borer, *Chilo partellus* in maize (Var. Nithyashree) and sorghum (var. Maldandi M-35) at ICAR-NBAIR, Yelahanka Research Farm, Bengaluru, during *kharif* and *rabi* seasons of 2016-17.

In maize field experiment, Bb-5a isolate showed significantly lower dead hearts (2.7 and 2.53 in kharif and rabi, respectively), lowest no. of exit holes (3.38 and 2.05 /plant in kharif and rabi), lesser no. of galleries (1.98 and 1.40 /plant in *kharif* and *rabi*) and lower stem tunnelling (6.73 and 3.38 cm/plant in kharif and rabi), as compared to untreated control which showed higher number of dead hearts (5.83 and 7.13), exit holes (6.78 and 6.65 /plant), galleries (3.05 and 3.40 no./plant) and stem tunnelling (10.83 and 7.03 cm/plant) during kharif and rabi season respectively. Significantly higher cob yield was obtained in the plots treated with Bb-5a (11.8 and 13.0kg/10plants in *kharif* and *rabi*) compared to the lower yield of control plot (10.0 and 9.0 kg/10plants in *kharif* and *rabi*).

In sorghum field trial, Bb-23 and Bb-5a isolates showed significantly lesser dead hearts of 6.78 and 9.33 % respectively, lowest exit holes of (0.38 and 0.73/plant) and stem tunnelling (3.75 and 4.32 cm/plant) respectively as compared to untreated control, which recorded higher dead hearts of 19.78 %, exit holes 2.10/plant and stem tunnelling of 10.18 cm/plant. The grain yield obtained in Bb-5a treated plot (151gm/10plants) and Bb-23 treated plot (147gm/10plants) were significantly higher compare to untreated control (105gm/10plants).

4.1.4 Mapping of the cry gene diversity in hot and humid regions of India

Analysis of cry gene diversity was determined for the three North-eastern states like Meghalaya, Tripura and Assam. Cry16 was most abundant accounting for 43% of the samples and it is dipteran specific. Cry10A accounted for 30% of the samples. Cry1 and cry2 was abundant and was present in 40% of the samples cry1 and cry2 occurred together. Cry1 is lepidopteran specific whereas cry2 is dipteran specific. Other cry genes included cry4 (dipteran) and cry12 (nematicidal) and were present in 23% of the samples. Cry3 the coleopteran toxin occurred in 16% of the samples. Since many of the cry genes occurred together the percentage calculation varied.

NBAIR-BtAN4 a new indigenous organism for control of both lepidopteran and coleopteran pests was identified. It expresses cry1, cry2, cry8 and vip3a toxins. Transcriptome analysis was done to understand the range of toxins expressed by this organism. The isolate was found toxic to the coleopteran pests like *Oryctes rhinoceros, Papillio* sp., *Callosobrochus chinensis* and *Sitophilus oryzae*. NBAIR-BtAN4 showed very high toxicity against *Callosobrochus chinensis* and was better than the standard exhibiting an LC_{50} of 6.8 μg/ml. Against *Sitophilus oryzae* same was gave least LC_{50} value (89.65 μg/ml) compared to the standard (85.26 μg/ml) and was the most toxic among the indigenous isolates tested.

NBAIR-BtAN4 was also tested against the important lepidopteran pests like *Helicoverpa armigera* and *Plutella xylostella*. It was found to be toxic to both and the LC_{50} was determined as 414.59 ng/ml for *H. armigera* and 545.15 ng/ml for *P.xylostella*. Liquid formulation of NBAIR-BtAN4 was prepared and sent to Dr. Chandrika Mohan, Principal Scientist, CPCRI, Kayangulam for evaluation against red palm weevil and *O. rhinoceros*.

4.1.5 Studies on insect viruses

Nucleopolyhedrosis viruses (NPVs) have been isolated from Bihar hairy caterpillar *Spilosoma obliqua*, semi looper *Achaea janata*, armyworms *Spodoptera mauritia*, *Spodoptera litura* and borer *Helicoverpa armigera*. Under light microscopy, occlusion bodies of SlNPV, HaNPV, AjNPV and SpobNPV were appeared as irregular. Under Scanning Electron Micrscopy (SEM), occlusion bodies appeared as tetrahedral, rod, oval, and irregular in shape. SEM studies revealed that the polyhedral particles of size approximately 0.6-2.0 μm. Some OBS were having pits and protrusions. The LC_{50} values observed for second instar larvae were 2.5×10^4 OBs/ml for HaNPV, $3.5x10^4$ OBs/ml for SlNPV , 3.6×10^4 OBs/ml for AjNPV and 3.6×10^4 .OBs/ml for SpobNPV. The efficacy of SpobNPV was demonstrated on potato Bihar hairy caterpillar.

4.1.6 DNA barcoding and genomics studies on natural enemies

Forty parasitoids, predators and insect pests had been characterised using cytochrome oxidase I gene and ITS-2 region and GenBank accession numbers and DNA barcodes had been generated for the same. New invasive spiraling whitefly *Aleurodicus rugioperculatus* and its parasitoid *Encarsia guadeloupae* was characterized using CO1 and ITS-2 and barcode generated. Transcriptome analysis of DBM and validation of expression of insecticide resistant genes had been done using RT-PCR, Transcriptome sequencing of *Trichogramma chilonis* and *Chrysoperla zastrowi sillemi* had been done.

4.1.7 Diversity and predator-prey interactions in predatory mirids & geocorids

Surveys for mirids and geocorids were made from different places of Karnataka. There were more than 100 specimens were collected. Two species of predatory mirid, *Termatophylum* spp. from mango leaf web were collected from Kanakpura. Other mirid species collected is *Chimairacoris lakshmiensis* from *Ficus* from Bangalore. Among Geocorids, one species identified was *G.* sp. near to *jucundus*.

A protocol to rear *Geocoris ochropterus* was standardized. *G. ochropterus* was reared on beans and *Sitotroga cerealella* eggs. One oviposition container (500 ml) can accommodate 6 pairs. A female on an average laid 176 eggs with 68% hatchability. So from one container 714 newly emerged nymphs can be harvested. They can be multiplied in same container till 3rd instar. After that they can be separated to other containers as more space is required with growing size. Approximately 83% nymphs develop into adults. So with 6 pairs nearly 593 adults can be harvested in 32-35 days. It was found that *S. cerealella* eggs can be effectively utilized for continuous rearing of *G. ochropterus*.

Feeding potential of *G. ochropterus* on *S. cerealella* eggs was studied. The total number of eggs fed was about 586 during the nymphal period. Total feeding by one female was 3372 eggs and feeding per day was 51.25 eggs. Adult male fed upon 2306.5 eggs and mean feeding per day was 50 eggs.

Geocoris ochropterus fertility table was studied in laboratory on *Sitotroga cerealella* eggs. The net reproductive rate was 28.60, The approximate duration of a generation, Net generation time of the predator when reared on *S. cerealella* were 51.9 and 56.77, respectively, finite rate of increase, Hypothetical F2s and Weekly multiplication rate were 1.06, 817.96 and 1.50, respectively when reared on *S. cerealella.*

Laboratory studies were conducted to check the feeding preference of geocorid predator, *Geocoris ochropterus* for unparasitized eggs of *Corcyra cephalonica* (Stainton) and *Helicoverpa armigera* (Hubner) and those parasitized by *Trichogramma chilonis* Ishii. In a no-choice situation, *G. ochropterus* nymph and adult devoured 64 and 91 per cent of the unparasitized *Helicoverpa* eggs provided and both nymph and adult fed only 3.3 and 1.3 percent, parasitized eggs respectively. Given a choice of parasitized and un parasitized *H. armigera* eggs, nymphs and adults of this species preferred to feed on unparasitized eggs. Same result obtained with *Corcyra cephalonica.* It indicates that it may be possible to integrate releases of geocorids and trichogrammatids for biological control of lepidopteran pests in different crop ecosystems.

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

4.2.1 Biodiversity of biocontrol agents from various agro ecological zones

AAU-A: The activity of biocontrol agents were 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 crops *i.e.*, tomato, groundnut, maize, cotton, castor, okra and observed for egg parasitism. The diversity of *Chrysoperla*, coccinellids, spiders, antagonistic bacteria-*Bt*, entomopathogenic nematodes (EPN) was studied.

- *Trichogramma chilonis* was the only trichogrammatid recorded.
- *Chrysoperla zastrowi sillemi* (Esben-Peterson) was found in all the populations.
- The natural population of *Cryptolaemus montrouzieri* was observed.
- Total 23 spider specimens were collected from cotton ecosystem
- Total 24 *Bt* isolates were isolated and preserved for further studies.
- Two soil samples were found positive for the presence of EPNs.
- Periodic surveys were carried out but none of the invasive pest listed above was recorded except *Tuta absoluta.*

ANGRAU: In sugarcane ecosystem, *Chilo infuscatellus* as early shoot borer and two species of internode borer i.e., *Chilo infuscatellus* and *Chilo sacchariphagus indicus* were observed. Natural parasitization of *Trichogramma* by using sentinel cards showed variation in sugarcane, maize and rice ecosystems. Sugarcane crop recorded maximum parasitization at RARS, Anakapalle during last week of July, 2016 (10.8%); august, 2016 (18.6%) and Munagapaka village (6.1%) in fields adopting *Trichogramma chilonis* release in sugarcane. *Trichogramma chilonis* parasitization recorded in paddy during last week of august, 2016 (5.23%) and rabi maize during first week of February, 2017 (1.15%). Abundance of coccinellid predators and spiders observed high in *rabi* maize crop.

IGKV: Plastic containers with *Corcyra* larvae sandwiched on the top with the help of muslin cloth and tied firmly with the help of rubber band were placed in fields of different agro-ecosystems. Parasitoids collected from parasitized larvae were identified as *Goniozus* sp., *Elasmus* sp., *Bracon bravicornis*, *Bracon sp.*

PJTSAU: Regular collections were made from important crops of Telangana state to know the natural occurrence of the parasitoids and predators in different crop ecosystems. The results of the pooled data in *Kharif* & *Rabi*, 2016-17, revealed that *Trichogramma* parasitization ranged from Nil in chilli to a maximum of 9.3 per cent in rice. Rice crop recorded maximum of 9.3 per cent while in maize it was 5.7 percent and in cabbage it was as low as 0.8 per cent. The abundance studies pertaining to *Chrysoperla* suggested that *Kharif* recorded more predatory presence than in *Rabi*. In *Kharif,* Bitter gourd recorded maximum population (12.0) and minimum was recorded in Red gram (2.0). *Chrysoperla* population in *Rabi* was maximum (9.0) in brinjal while it was least (5.0) in bitter gourd.

SKUAST: A total of twenty three species of parasitoids and predators belonging to the orders Hymenoptera and Coleoptera were collected from different fruit crops in Kashmir during 2016-17. Two coccinellid predators, *viz*., *Aiolocaria hexaspilota,* ?*Serangium* sp. and three pteromalid parasitoids (Hymenoptera), *viz*., *Cheiropachus* sp*., Macromesus* sp., and *Raphitelus* sp. were reported first time. Among parasitoids, *Aphelinus mali* and *Encarsia perniciosi* displayed an average of 0.0 - 23.0 and 0.0 - 16.0 per cent parasitism of Woolly apple aphids and San Jose scale respectively, in samples collected from unmanaged orchards. Hyper parasitism by *Marietta* sp. and *Azotus* sp. was noticed during July- August which displayed an upward swing during September' 2016. Parasitism by *Cheiropachus* sp*., Macromesus* sp., and *Raphitelus* in xylophagus grubs infesting almonds, was observed from September to December 2016.

UAS-R: To record the incidence of natural enemies in cotton ecosystem, Sentinel cards of *Corcyra* were uniformly released in cotton at every fifteen days interval and these cards were brought to the laboratory for emergence of parasitoids.

YSPUHF : Coccinellid beetles like *Adalia tetraspilota, Coccinella septempunctata, Hippodamia varigieta, Cheilomenes sexmaculata, Propylea lutiopustulata, Chilocorus infernalis, Stethorus sp, Priscibrumus uropygialis, Platynaspis saundersii, Harmonia eucharis, Oenopea sauzetii, Oenopia kirbyi, Oenopia sexareata, Illeis* spp*, Coelophora bisselata, Pharoscymnus flexibilis*

Scymnus posticalis, *Stethorus aptus,Harmonia dimidiata,* and *Adalia tetraspilota* were collected from different cropping systems preying on aphids, whiteflies, scales mites, etc. Green lace wing, *Chrysoperla zastrowi sillemi* was collected from cucumber, okra, brinjal and apple associated with aphids and whiteflies. Syrphid flies namely *Episyrphus balteatus, Eupeodes frequens, Melanostoma univitatum, Betasyrphus serarius, Sphaerophoria indiana, Ischiodon scutellaris Metasyrphus corollae* and *Scaeva pyrastri* were collected from different crops at different locations of the state. *Dinocalpus coccinellae* was recorded and collected as parasitoid of *Hippodamia variegata* and *Coccinella septempunctata* under mid-hills of Himachal Pradesh. Parasitoids such as *Diadegma semiclausum*, *Cotesia vestalis* and *Diadromus collaris* were collected from larvae and pupae of the diamondback moth, *Plutella xylostella* feeding on cauliflower and cabbage. Anthocorid bugs like *Orius* sp. and *Anthocoris* sp. were found associated with peach leaf curl aphid and thrips in peaches. During survey, *Nesidiocoris tenuis* and *Neochrysocharis formosa* were found associated with the American pin worm, *Tuta absoluta* in tomato under mid hills of the state. *Baryscapus galactopus* was collected as hyperpasitoid of*Cotesia glomerata* parasitizing *Pieris brassicae* in cauliflower. *Campoletis chloridae* was reared from field collected larvae of *Helicoverpa armigera.*

CISH: Population of coccinellid predators which feeds on mango hopper and mealy bug was recorded during 11^{th}-17^{th} SMW, and the highest number of beetles (2.5/panicle) recorded at 13^{th} SMW. The most abundant species was *Coccinella septempunctata.* Reduviid predators were observed in mango orchard during 39^{th} SMW, egg masses & neonates also found during 40^{th}-43^{rd} SMW.

KAU: Surveys for natural enemies of banana pseudostem weevil and banana aphid were conducted in four districts, namely, Thrissur, Ernakulam, Calicut and Wayanad districts.Three different species of earwigs were collected from banana plants infested by pseudostem weevils at Kannara and Vellanikkara. They were identified as *Auchenemus hinksi* Ramamurthi , *Paralabis dohrini* Kisby and *Euborellia shabi* Dohrn by comparing with identified specimens available with the centre. Survey for the natural enemies of pepper root mealy bug *Formicoccus polysperes* at both Wayanad and Calicut districts did not yield any natural enemies.

MPKV: The natural enemies inclusive of coccinellids (*Coccinella septempunctata* L., *Menochilus sexmaculata* F., *Scymnus* sp.), *Dipha aphidivora* Meyrick, *Micromus igorotus* Bank. and syrphid *Eupeodes confrater* and parasitoid *Encarsia flavoscuttellum* were recorded on SWA in sugarcane, *Coccinella transversalis* F., *Menochilus sexmaculata* F*., 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 mealybugs.

The natural parasitism of *Trichogramma* was not noticed in the crops like cotton, maize, soybean, sugarcane, tomato and brinjal in Pune region. The chrysopid, *Chrysoperla zastrowi sillemi* Esben. was observed in cotton, maize, bean, jowar, okra and brinjal, and *Mallada boninensis* Okam. on cotton, beans, mango, papaya and hibiscus. The *Cryptolaemus* adults were recovered from the custard apple and papaya orchards and on hibiscus. The cadavers of *S. litura a*nd *H. armigera* infected with *Nomuraea rileyi, Metarhizium anisopliae, Sl*NPV, *Ha*NPV were collected from soybean, jawar, maize, cabbage, pigeon pea, tomato crops in farmers' fields. The mealybug, *Paracoccus marginatus* W. & G. was observed in papaya orchards along with encyrtid parasitoid, *A. papayae* and *S. epius* in Dhule and Pune region.

4.2.1.1 Surveillance for alien invasive pests

The alien invasive pests, *viz*., *Brontispa longissima, Aleurodicus dugesii, Phenacoccus manihoti, Phenacoccus madeirensis* were not recorded in any of the centre during the year 2016-2017. In Tamil Nadu the incidence of papaya mealybug *P. marginatus* was observed in crops like papaya, tapioca, guava, cotton, mulberry, brinjal and the Jack Beardsley mealy bug *Pseudococcus jackbeardsleyi* in papaya and tapioca were also observed. In all the places of occurrence of *Paracoccus marginatus* the parasitoid *Acerophagus papayee*, *Anagyrus lockii* and predator *Cryptolaemus montrouzieri*, *Spalgius* and *Mallada* were noted. Random surveys were also carried out in Ernakulam, Thrissur, Palghat, Wayanad and Calicut districts of Kerala. Isolated infestation of papaya mealy bug was observed in Thrissur district. The encyrtid *Acerophagus papayae* was observed at both the locations. In Maharashtra *Pseudococcus jackbeardsleyi* and *Paracoccus marginatus* were recorded on custard apple and papaya respectively, in Pune region. While, *Tuta absoluta* Meyrick was recorded on tomato in Pune district during January to May 2016 and again from January to March, 2017. It was also reported in the Solapur district in the month of March, 2017.

In coconut, the occurrence of rugose whitefly *Aleurodicus rugioperculatus* was observed from second week of August 2016 in Anamalai and Pollachi block of Coimbatore district. The natural enemies observed were *Encarsia* sp, *Mallada* sp, *Cryptolaemus montrouzieri* and *Chrysoperla zastrowi sillemi*.

Survey for occurrence and incidence of the American pin worm, *Tuta absoluta* in solan revealed that the pest was present in almost all the tomato growing areas (Nauni, Dharja, Nainatikkar, Deothi, Subathu, Kandaghat, Dharampur and Sarahan) of mid-hills of Himachal Pradesh. At these locations 42 to 89 per cent of the tomato plants were infested with *T. absoluta* with the number of mines/leaf/infested plant varying from 1-11 and fruit damage varying from 0-6 per cent at different locations. The severity of the pest was more on tomato than on brinjal and potato.

4.2.2 Pest outbreak

In **UAS Raichur** the pink boll worm moth activity was noticed from second week of August and continued till harvest of the crop. Maximum moth catches were noticed during second week of December (28.75 moths /trap) and it also coincided the highest number of larvae (12.28/25 bolls). Maximum locule damage of of 28.08 per cent was noticed at second week of November.

KAU: A massive outbreak of army worms was noticed in the rice at Kuttanad, Kerala. With a day or two more than 2000 ha were completely lost by the attack.

TNAU: The occurrence of whitefly was registered in coconut gardens of Kottur, Malayandipattinam, Aliyar, Pollachi, Angalakurichi, Naikkenpalayam, Samipalayam areas of Coimbatore district. Coconut whitefly problem was reported from II week of August 2016 onwards. The population of whitefly was severe in Deejay hybrids and medium to low in other varieties. The natural parasitization of whitefly nymphs was also observed based on the presence of emergence hole of adult parasitoid. The field samples collected are under observation for the emergence of adult parasitoid. In addition, the grubs of predator *Mallada* sp. was also noted besides the eggs present amongst the whitefly population.

AAU-J: A survey was conducted covering 10 villages, *viz*., Allengmora, Sengeliati, Sonarigaon No. 1, Sonarigaon No. 2, Majiabheti, Gorumora, Upor Deuri, Bahphola, and Dhodang Chapori of Jorhat district and Bahir Kolia village of Majuli district of Assam. Two species namely nut grass armyworm, *Spodoptera mauritia* and tobacco caterpillar *S. litura* were found to attack *Sali* rice (Var. Ranjit, Bahadur, Doria, Bora, Komal and Joha etc.) with the intensity of low to severe attack (50-90%). *S. mauritia* is sporadic in nature, while *S. litura* is a regular pest of castor, okra, crucifers, colocasia and others, young instars are gregarious in nature, but from 3rd instar onwards it feeds singly. As high as 34-62 numbers of larvae per hill were observed in certain locations. Control measures were explained to farmers.

4.2.3 Biological suppression of plant diseases

4.2.3.1 Biological control of diseases of rice, lentil and chickpea

GBPUAT: In rice among different bio-agents tested, Th-14, PBAT-3 and TCMS-36 were found most promising in reducing diseases, and in increasing yield. In Chickpea among all the isolates **PBAT-3, Psf-173 and *Bacillus*** were found very promising in reducing pre and post emergence seed and plant mortality in field**.** In lentil among all the isolates **PBAT-3, Psf-173, and *Bacillus*** were found very promising in reducing pre and post emergence seed and plant mortality in field**.**

4.2.3.2 Biological control of chilli anthracnose diseases

GBPUAT: Among different treatments, *viz*., *Trichoderma harzianum* (Th-3), *Pichiaguillier mondii* (Y-12) and *Hanseniaspora uvarum*(Y-73) and Carbendazim, significantly minimum number of diseased fruits was observed with Carbendazim (100.0) followed by Th-3 (126.6) as compared to control (166.6). Significantly maximum fruit yield was observed with Carbendazim (21.2 q/ha) followed by Y-12 (19.8 q/ha) and Th-3 (18.8 q/ha) as compared to control (15.5 q/ha).

PAU: Lowest per cent of fruit rot (3.02%) was recorded in chemical control, which was followed by *Trichoderma harzianum* (3.97%). The latter was further at par with *Pichia guilliermondii* (4.67%) and *Hanseniaspora uvarum* (4.37%). Yield varied from 47.62 to 50.0q/acre and was non-significant.

AAU-A: Seed treatment, seedling dip and foliar spray of *Pichia guilliermondii* (Y12) resulted in low anthracnose disease intensity (6.23 %) and higher yield (83.27 q/ha) and this treatment was found at par with the treatment of *Pseudomonas fluorescens* with disease intensity (6.58 %) and yield (79.99 q/ha).

4.2.3.3 Management of pre and post emergence damping off diseases of vegetables

GBPUAT: In tomato, Psf-173, Psf-2 PBAT 3 and TCMS-36 were found effective in reducing pre-and post-emergence seedling mortality. Maximum plant vigour index was observed with Psf-173 (5172.12) followed by Psf-2 (4916.34), PBAT-3 (4653.01) and TCMS-36 (4461.89) as compared to Metalaxyl (3021.75) and control (3313.48). In onion, PBAT 3 and Psf-173 were found very promising in reducing pre and post emergence respectively. Maximum plant vigour index was observed with Psf-173 (2218.24) followed by PBAT3 (2096.25) as compared to Metalaxyl (1480.22) and control (1386.54). In chilli minimum pre-emergence mortality was observed in *Bacillus* and minimum post- emergence mortality (30-45DAS) was observed with Th-14. *Bacillus* sp. is coupled with maximum plant vigour index.

4.2.4 Biological suppression of sugarcane pests

4.2.4.1 Monitoring of sugarcane woolly aphid and its natural enemies

PJTSAU: In Telangana, only scanty presence of Sugarcane woolly aphid (SWA) was noticed in some area. The incidence of SWA, despite being patchy, was noticed only in July & August, 2016 and again in February & March, 2017 while SWA incidence was not evidenced from September 2016 to January 2017. Sporadic Incidence was noticed in Bodhan, Kamareddy, Sadasivpet and adjoining areas of Medak.

MPKV: The SWA incidence was recorded along riverside and a canal area, followed by its natural enemies in most of the sugarcane fields in Western Maharashtra and it was relatively high during this year. The SWA incidence and intensity rating were 1.90 per cent and 2.43, respectively. The natural enemies recorded in SWA infested fields were mainly *D. aphidivora* (0.55-3.20 larvae/leaf), *M. igorotus* (1.16-8.66 grubs/leaf), *Eupeodes confrater* (0.66-1.80 larvae/leaf) and spider (0.13-0.52 /leaf) during July, 2016 to March, 2017. The parasitoid *Encarsia flavoscutellum* found well distributed and established in almost all the sugarcane fields and suppressed the SWA incidence in Western Maharashtra.

4.2.4.2 Bioefficacy of entomopathogenic fungi and entomopathogenic nematodes in suppression of termite incidence in sugarcane

ANGRAU: Entomopathogenic fungi, *Metarhizium anisopliae* and entomopathogenic nematode, *Heterorhabditis indica* were effective in reducing bud damage , seedling mortality in sugarcane due to termites resulted in higher cane yield compared to untreated control . Seed cane yield was recorded significantly high in *Heterorhabditis indica* (67.21 t/ha) followed by *Steinernema sp.* (65.3 t/ha) and *Metarrhizium anisopliae* (57.1 t/ha) compared to low cane yield in control (37.74 t/ha) and chemical insecticide, chlorpyriphos 50 TC (49.72 t/ha).

4.2.4.3 IPM module for the sustainable management of early shoot borer (*Chilo infuscatellus*) and internode borer (*Chilo infuscatellus Chilo sacchariphagus indicus*) in sugarcane

ANGRAU: Study revealed that Trash mulching + *T. chilonis* release @ 50,000/ha from 30 DAP for 6 times and 2 releases after node formation and Trash mulching + *T. chilonis* release @ 75,000/ha from 30 DAP for 6 times and 2 releases after node formation are effective in managing shoot borers in sugarcane with high incremental benefit cost ratio.

4.2.4.4 Management of White grub, *Holotrichia consanguinea* Blanch in sugarcane using Bioagents

ANGRAU: Soil application of entomopathogenic nematode, *Heterorhabditis indica* / *Steinernema sp*.; entomopathogenic fungi, *Metarrhizium anisopliae* / *Beauveria bassiana* in sugarcane after the onset of mansoon rains were found effective with high per cent reduction in white grub damage resulted in higher yield increase over phorate and untreated control.

4.2.5 Cotton

4.2.5.1 Monitoring of whitefly and its natural enemies in cotton including Sirsa

PAU: Regular surveys conducted in cotton growing areas of Punjab (Fazilka, Bathinda, Mansa and Muktsar) and Haryana (Sirsa, Fatehabad) to monitor whitefly population and its natural enemies on cotton crop revealed that whitefly remained below ETH level (6 adults/ leaf) in almost all the cotton growing districts of Punjab except in some villages of Khuhian Sarvar block of Fazilka district. 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 population of coccinellids, *Chrysoperla*, spiders and *Zanchius* sp. varied from 0.0 to 1.0, 0.0 to 13.0, 0.0 to 7.5 and 0.0 to 1.0 per 10 plants, respectively. The population of predators were maximum till end July, but declined thereafter.

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

PJTSAU: The *Bt* cotton growing areas of Telangana were surveyed and Jassids incidence was found higher followed by whiteflies and thrips. The associated natural enemies of sucking pests were noticed to be coccinellids followed by chrysopids and spiders.

UAS-R: The peak activity of mirid bug was noticed during second fortnight of October (3.00 mirid bugs /plant) and thereafter the decline in population was noticed. The incidence of mirid bug was noticed on second fortnight of September and continued till second fortnight of November. The predator population, *viz*., coccinellids, chrysoperla and spiders activity had no direct effect on the activity of mirid bug population.

MPKV: The incidence of aphids (12.32-31.40), jassids (3.20-7.12), thrips (5.75-15.32) and white flies (3.40-8.32) per three leaves per plant found relatively high from 1st week of August till end of October, 2016. The natural enemies, *viz.,* coccinellids, *M. sexmaculata* and *C. septempunctata* were recorded from 3rd week of July to 4th week of December, 2016.

4.2.5.3 Bioefficacy of microbial insecticides against sucking pests in *Bt* cotton

AAU: Significantly lower number of jassids (2.13), whiteflies (2.96), aphids (6.55) and thrips (4.37) were recorded in the application of *L. lecanii* (40g/10 l of water) followed by *L. lecanii* (30g/10 l of water), *B. bassiana* (40g/10 l of water) and *B. bassiana* (30g/10 l of water).

4.2.5.4 Monitoring of mealybugs and other sucking pests in *Bt* cotton

MPKV: Maximum number of mealybugs (1.60/twig) was recorded during 3rd week of November, 2016. No natural enemies observed in the mealybug colonies. However, the coccinellids *M. sexmaculata, C. septempunctata* and chrysopid *Chrysoperla zastrowi sillemi* were noticed on the plants. The sucking pests, *viz.,* aphids (12.32-31.40), jassids (3.20-7.12), thrips (5.75-15.32) and white flies (3.40-8.32) per three leaves per plant found relatively high from 1st week of August till end of October, 2016. The peak incidence of aphids and jassids recorded during 1st week of September (35th MW), while highest population of thrips and white fly observed in 3rd (37th MW) and 4th week of September (39st MW), respectively. The natural enemies, *viz.,* coccinellids *M. sexmaculata*, *C. septempunctata,* chrysopid *Chrysoperla zastrowi sillemi* and spiders recorded from 3rd week of July till December, 2016. Maximum population of coccinellids (6.32 grubs and/or beetles/plant) and chrysopids (2.68 grubs/plant) were recorded in the middle of September, 2016.

4.2.5.5 Monitoring biodiversity and outbreaks for invasive mealy bugs on cotton

PJTSAU: Fortnightly surveys were conducted in fields /orchards for mealy bug incidence in Adilabad, Warangal, Rangareddy and Mahbubnagar districts of Telangana. Four species of Mealy bugs, *viz.*, *Paracoccus marginatus, Maconellicoccus hirsutus*, *Phenacoccus solenopsis,* and *Ferrisia virgata* were recorded. Among all, *P. solenopsis* was the predominant species recorded on cotton. Papaya mealybug, *P. marginatus* was observed on papaya, tapioca, mulberry, parthenium and other host plants. Natural enemies, *viz., Acerophagus papayae, Cryptolaemus montrouzieri, Scymnus coccivora, Coccinella septumpunctata* and *Chrysoperla* recorded on different species of mealybugs.

UAS-R: The incidence of mealy bug was noticed during second week of October (0.08 mealy bugs per 10 cm apical shoot length) and continued till harvest of the crop. The peak activity was noticed first fortnight of January (82.25 mealy bugs per 10cm apical shoot length) and the associated natural enemies population was also more with the incidence of mealybug. The primary parasitoid, *Anesius arizonesis* has successfully suppressed the mealybug population. Similarly, the peak activity of *A. dactylopi* was noticed during first week of January and thereafter decline in population was noticed. Coccinellid activity was coincided with the peak activity of mealy bugs.

4.2.5.6 Habitat manipulation for the management of *Bemisia tabaci* (Gennadius) on cotton

PAU: The BIPM practices involving cultivation of Bt cotton crop following recommended agronomic practices, growing sorghum as a barrier crop, installation of yellow sticky traps, augmentative releases of chrysopids and application of botanicals/biopesticides rendered significantly lower whitefly population than untreated control. The predator population was significantly more in BIPM (1.36/ plant) as compared to chemical control (0.39/ plant) and untreated control (0.98/ plant). Seed cotton yield in BIPM (22.80 q/ha) was at par with chemical control (23.70 q/ha) and was significantly better than untreated control (21.30 q/ha).

4.2.5.7 Field evaluation of biopesticides for the management of whitefly, *Bemisia tabaci* (Gennadius) on Bt cotton

PAU: Study revealed significantly lower population in chemical treatments (spiromesifen 240 SC @ 500 ml/ha & diafenthiuron 50 WP @ 500g/ha) followed by application of botanical (Neem baan 1% @ 1250 and 1500 ml/ha) and biopesticides (*Lecanicillium lecanii* 2% AS and *Metarhizium anisopliae* 1% WP @ 1200 ml/ha). However, the effect of different treatments on seed cotton yield was insignificant.

4.2.5.8 Biological suppression of pink bollworm, *Pectinophora gossypiella*

UAS-R: Minimum larvae of pink bollworm, minimum locule damage were noticed in continuous release of *Tr. bactrae.* Maximum seed cotton yield of 22.40 q/ha was noticed in continuous release of *Tr. bactrae.*

4.2.6. Rice

4.2.6.1 Seasonal abundance of predatory spiders in rice ecosystem

PAU: Regular surveys to study the diversity of spiders from rice growing areas. A total of nine species were recorded from the rice fields. *Neoscona* sp. was the predominant species (74.48%) at all the locations followed by *Tetragnatha javana* (13.54%). Species diversity (0.929) was calculated as per Shannon-Weiner index of diversity. Species evenness (0.404) and dominance index (0.596) was worked out as per formulae given by Krebs and Southwood, respectively.

4.2.6.2 Diversity of insect pests and their natural enemies in organic and conventional rice

PAU: The overall incidence of rice stem borer (4.06% dead heart, 2.82% white ears) and leaf folder (0.94%) was less in conventionally managed fields as compared to organic fields (4.60% dead heart, 5.11% white ears, 2.29% leaf folder). The population of plant hoppers was less in organic fields (4.36/hill) as compared to conventionally managed fields (4.87/hill). The population of natural enemies was high in organic fields (spiders 6.33/plot, dragonflies 1.67/plot and damselflies 3.26/plot) than in conventional fields (spiders 4.07/plot, dragonflies 0.24/plot and damselflies 0.98/plot. Natural parasitism in the eggs, larvae and pupae of stem borer and leaf folder ranged from 1.97 to 20.18 and 0.31 to 2.44 per cent in organic and conventional rice, respectively.

4.2.6.3 Field evaluation of fungal pathogens for management of gundhi bug, *Leptocorisa oratorius*

KAU Trichur: Two entomopathogenic fungi, namely, *Beauveria bassiana* (local isolate) and *Metarhizium anisopliae*, were evaluated along with NBAIR strain of *B.bassiana* against the rice bug, *Leptocorisa oratorius* in a farmer's field at Velliyode, Vadakkenchery in Palghat District. The results did not bring out any significant differences between the different treatments, although plots treated with the NBAIR strain of *B. bassiana* consistently recorded mean bug population that were identical to that of insecticide treated plots.

4.2.7 Maize

4.2.7.1 Bio suppression of *Chilo partellus* with *Trichogramma chilonis* on *rabi* maize

ANGRAU: Field release of *Trichogramma chilonis* (at the rate of 75,000 and 100,000 parasitoids per ha) at 15 Days after seedling emergence, three times at weekly interval was found effective in reducing maize stem borer damage with higher cob yields.

4.2.7.2 Evaluation of NBAII entomopathogenic strains against maize stem borer

ANGRAU: NBAII entomopathogenic strains Bb5a, Bb19 were effective against maize stem borer with less damage caused by *Chilo partellus* resulted in higher cob yields

4.2.8 Sorghum

4.2.8.1 Field evaluation of NBAII entomopathogenic strains against sugarcane stem borer, *Chilo partellus* (Swinhoe) in *Kharif* sorghum

UAS-R: *Beauveria bassiana* -7 @ 1.5 ml/l recorded minimum population of larvae and pupae, minimum tunnelling, low number of entry holes, minimum dead hearts and higher yield and it is at par with *Metarhizium anisopliae* - 35 @ 1.5 ml/l

4.2.9 Pulses

4.2.9.1 Evaluation of microbial agents for management of Lepidopteran pests on Moong bean (*Spodoptera litura, Helicoverpa armigera*)

PAU: Formulations of *Bacillus thuringiensis* PDBC Bt1 (1%), Bt 1(2%), NBAII BT G4 (1%), NBAII Bt G4 (2%), Delfin @1 Kg/ha, Delfin @ 2.0 Kg/ha, *Beauveria bassiana* (Mycojaal) 1.5 Kg/ha, *Beauveria bassiana* (Mycojaal) 2.0 Kg/ha, chlorpyriphos 20EC @ 3.75 litre/ha and untreated control were evaluated against lepidopteran pests in moong bean. Among all these bioagents, higher dose of PDBC Bt1 (2%) and both doses of Delfin were at par with each other and recorded the lowest pod damage.

4.2.9.2 Evaluation of biocontrol agents against pod borers of cowpea

KAU Thrissur: *B. thuringiensis* sprayed at 15 days interval recorded the lowest mean infestation of 12.25 per cent, followed by *Beauveria bassiana* sprayed at 15 days interval with 16.59 per cent mean infestation.

4.2.10 Tropical Fruits

4.2.10.1 Effect of biopesticides for the management of Mango hopper, pests *Idioscopus* spp in field condition

KAU Vellayani: Field studies conducted on management of mango hoppers revealed that all the treatments, *viz*., *B. bassiana* (ITCC 6063) 2 per cent, malathion 0.1 per cent, and azadirachtin 1% were significantly superior to the untreated control. *B. bassiana* (ITCC 6063) 2 per cent and azadirachtin 1 per cent were superior to control in reducing the population of hoppers.

4.2.10.2 Effect of biopesticides for the management of Mango webber, *Orthaga* spp. in field condition

KAU Vellayani: Significant reduction in the damage by the leaf Webbers was observed at 3rd, 5th, 10th and 15th day of intervals, when azadirachtin @ 1 ml/l and biopesticides, *Beauveria bassiana* ITCC 6063 @ 20g /l were applied. Insecticide Malathion 50% EC @ 2ml/L was also found effective against the mango webber pest.

4.2.10.3 Survey and monitoring of papaya mealybug, *Paracoccus marginatus*

MPKV: The incidence of papaya mealybug was noticed to the extent of 1.0 to 9.33 per cent in all the ten districts of Western Maharashtra which was relatively very low during this year. However, the pest incidence noticed maximum in Shahada (Nandurbar), followed by Shirpur (Dhule) and Chopada (Jalgaon) areas. There was record of ten predatory species, and the parasitoid, *Acerophagus papayae* (0.6 to 4.8 adults/leaf) found parasitizing mealybugs in papaya orchards surveyed.

TNAU: The incidence of papaya mealybug was recorded in Coimbatore, Erode, Tiruppur, Salem, Karur, Theni, Vellore, Dindigul, Perambalur, Tiruvannamalai, Villupuram, Namakkal, Nagapattinam, Trichy, Cuddalore districts of Tamil Nadu in crops like papaya, tapioca, mulberry, guava, cocoa, Coccinea, brinjal, cotton, tomato and hibiscus crops. The prevalence was high in Erode, Tiruppur and Coimbatore. In all the places of occurrence of *Paracoccus marginatus* the parasitoid *Acerophagus papayee*, *Anagyrus lockii* and predator *Cryptolaemus montrouzieri*, *Spalgius* and *Mallada* were noted.

AAU-A: Survey was conducted in Anand, Kheda, Vadodara, Chhotaudepur and Sabarkantha districts and only trace incidence of papaya mealy bug was observed during the entire year.

KAU Thrissur: Random surveys were carried out in Ernakulam, Thrissur, Palghat, Wayanad and Calicut districts of Kerala. Isolated infestation of papaya mealy bug was observed in Thrissur district. The encyrtid *Acerophagus papayae* was observed at both the locations.

4.2.10.4 Survey for pest incidence in mango ecosystem in coastal Andhra Pradesh and field evaluation of bio pesticide formulations against mango hoppers, *Idioscopus* sp.

DRYSRHU, Ambajipet: The survey was carried out in mango growing mandals of East Godavari, West Godavari and Krishna districts of A.P. A high incidence of thrips and hooper population on mango was recorded in the months of January and February in the mango gardens. Among biopesticides the four sprays of *Lecanicillium lecanii*, *Beauveria bassiana* and *Metarhizium anisopliae* were effective in suppressing mango hoppers. The chemical insecticide treatment imidacloprid was most effective and was followed by *L. lecanii* treatment

4.2.10.5 Field evaluation of *Beauveria bassiana* W/P formulation against tea mosquito bug in Guava

TNAU: Field evaluation of *Beauveria bassiana* (IIHR formulation) against tea mosquito bug showed that *Beauveria bassiana* at 10g/litre of water had a maximum reduction of fruit damage (81.1%) closely followed by *Beauveria bassiana* at 5g /l.

4.2.10.6 Survey and monitoring of mealy bugs and their natural enemies on fruit crops

IIHR: In Annona predominant melaybug species observed was *Maconellicoccus hirsutus* followed by *Ferrisia virgata* and *Planoccocus citrii* during 216-17. The predominant predator was predatory gall midge *Triommata coccidivora,* followed by lycaenid butterfly, *Saplgis epius* and lady bird beetle, *Cryptolaemus montrouzeri.*

4.2.10.7 Bio-efficacy of EPNs against Citrus trunk borer, *Pseudonemophas* (=*Anoplophora*) *versteegi*

CAU: Among the EPN treatments, CAU-1 stem injection (34.00 % reduction) was observed as the best treatment and it was closely followed by CAUH-1 stem injection (27.50% reduction), CAUH-2 stem injection (26.50% reduction) and NBAII-01 stem injection (26.19 % reduction) at Pasighat. However, at Rengging, CAUH-1 stem injection gave the highest reduction in trunk borer infestation among the EPNs with 32.68% reduction and it was closely followed by NBAII-01 stem injection (31.25% reduction) and CAU-1 stem injection (30.20% reduction). The stem injections of the EPNs were found more effective than their respective cadaver treatments.

4.2.10.8 Biodiversity of natural enemies of banana weevil, aphid and root mealybug of pepper

KAU Thrissur: Three different species of earwigs were collected from banana plants infested by pseudostem weevils at Kannara and Vellanikkara. They were identified as *Auchenemus hinksi* Ramamurthi , *Paralabis dohrini* Kisby and *Euborellia shabi* Dohrn.

4.2.10.9 Field evaluation of entomopathogenic fungi against banana pseudostem borer *Odoiporus longicollis*

KAU Thrissur: Preliminary results suggest that spraying with *B. bassiana* (10^8 spores/ ml) was the most effective treatment among those involving entomopathogenic fungi.

4.2.10.10 Field evaluation of *Lecanicillium lecanii* against pineapple mealy bug *Dysmicoccus brevipes*

KAU Thrissur: The fungus *L. lecanii* @10^9 spores/ml was found to be as effective as Imidacloprid (0.3 ml/l) in reducing the root mealy bug after two rounds of spray.

4.2.11 Temperate Fruits

4.2.11.1 Evaluations of entomopathogenic fungi and EPNs for the suppression of apple root borer, *Dorysthenes hugelii*

YSPUHF: For the management of apple root borer, *Dorysthenes hugelii,* although chlorpyriphos (0.06%) was the most effective treatment resulting in 83.2 per cent mortality of the root borer grubs, *Metarhizium anisopliae* was equally effective resulting in 68.3 per cent mortality of the pest.

4.2.11.2 Survey for identification of suitable natural enemies of Codling moth, *Cydia pomonella*

SKUAST: Natural parasitism of larvae/ pupae of Codling moth, *Cydia pomonella* ranged 1.0 to 4.0 per cent. Parasitism, although negligible, but was recorded from all the villages.

4.2.11.3 Field evaluation of *Trichogramma embryophagum* and *T. cacoeciae* against codling moth, *Cydia pomonella* on apple

SKUAST: Two year investigation confirmed the superiority of *Trichogramma cacoeciae* over *T. embryophagum* with increased reduction in fruit damage. Integrated management involving one spray of Chlorpyriphos 20 EC @ 1.5 ml/lit. + sequential releases of *T. cacoeciae* + one spray of NSKE + trunk banding + disposal of infested fruits + pheromone traps resulted in 37.65% reduction in damage over control.

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4.2.11.4 Evaluation of predatory bug, *Blaptostethus pallescens* against European red mite, *Panonychus ulmi* on apple

SKUAST: Per cent reduction in mites' population over check was high in case of two field releases of bugs @ 200/plant than 100/plant. In laboratory condition, 70.00, 92.22, 80.00 and 68.66 per cent mortality of eggs of European red mites in response to 1:10, 1:15, 1:20 and 1:25 predator: prey ratio indicated overall performance of predator though statistically on par but 1:15 predator: prey ratio as best.

4.2.11.5 Laboratory evaluation of feeding potential of *Chilocorus infernalis* against *Lecanium* scale on plum

SKUAST: A third instar grub of *C. infernalis* was found to consume an average of 90.0, 86.66 and 66.65 per cent *Lecanium* scale, when 10 (T1), 15 (T2) and 20 (T3) prey was supplied to a single grub.

4.2.11.6 Field evaluation of predatory bug, *Blaptostethus pallescens* against two spotted spider mite, *Tetranychus urticae* on apple

SKUAST: Two releases of anthocorid bugs @ 200 per plant resulted in less mite populationa and higher Per cent reduction in mites' population (43.23) over check. In laboratory condition, at predator: prey ratio of 1: 10, 1: 15, 1: 20 and 1: 25 *B. pallescens* caused total mortality (failure of hatching) of the eggs of spider mites as 93.33, 86.66, 63.33 and 51.0 per cent. Performance of the predator at 1: 10 and 1: 15 was found best, though statistically on par.

4.2.12 Oilseed

4.2.12.1 Biological suppression of mustard aphid, *Lipaphis erysimi* Kaltenbach

AAU-A: Among all entomopathogenic fungi, pooled aphid index count over period over spray was recorded lower in the treatment *B. bassiana* + *L. lecanii* @ 5g/ liter (1.37) which was at par with the treatment *L. lecanii* + *M. anisopliae* @ 5g/ liter (1.40). Higher seed yield was obtained in the treatment *B. bassiana* + *L. lecanii* @ 5g/ liter (9.66 q/ha) followed by *L. lecanii* + *M. anisopliae* @ 5g/ liter (9.28 q/ha).

PAU: Chemical control (Dimethoate @ 4 ml/litre of water) significantly reduced the aphid population from 53.06 to 0.67 aphid per plant. Among commercial biopesticide formulations (*Beauveria bassiana*, *Lecanicillium lecanii*, *Metarhizium anisopliae*) and Neem oil, none was found effective against mustard aphid

OUAT: Among all the Biopesticides, three sprays of *Metarrhizium anisopliae* (2×10^8 spores/g)+ *Lecanicillium lecanii* (2×10^8 spores/g) @ 5 ml/l at 15 days interval proved to be the best treatment in reducing the aphids and producing the highest yield (8.23 q/ha) with highest B: C ratio (1.55).

4.2.13 Vegetables

4.2.13.1 Survey and surveillance of tomato pinworm, *Tuta absoluta.*

TNAU: Maximum moth collection of pinworm, leaf damage and fruit damage in tomato was observed in October (3-23), November (5-25) and December (3-17 adult moths trap) as compared to rest of the cropping period.

UAS-R: The incidence of tomato pinworm, *T. absoluta* noticed during last week of October and continued till first week of April. The peak activity of moths was noticed during second week of January (1060.07 moths /trap) and later the decline in moth trap catches.

YSPUHF: *Tuta absoluta* was recorded from tomato at Nauni, Dharja, Solan, Kandaghat, Nainatikkar, Deothi, Subathu, and Sarahan locations of the state. Under open conditions the leafminer was recorded infesting only tomato and potato, but, in a polyhouse the pest was found to infest tomato, brinjal and potato. At these locations 42 to 89 per cent of the tomato plants were infested with *T. absoluta* with the number of mines/leaf/infested plant varying from 1-11 and fruit damage varying from 0-6 per cent at different locations. The severity of the pest was more on tomato than on brinjal and potato.

IIVR: Occurrence of pin worm on leaf and fruit were first recorded during second week of January (2 SMW), 2017 at the experimental farm of the institute. Both leaves and fruits were affected by this borer.

MPKV: The incidence of American pinworm, *Tuta absoluta* was observed in Yedagaon, Umbraj, Pipmpalwandi and Manjarwadi villages of Junnar tahasil and Avasari village of Ambegaon tahasil in Pune district. The leaf damage was ranged from 20 to 40 per cent and the fruit damage in the range of 18 to 29 per cent. Maximum incidence of the pinworm was noticed in the month of March, 2016. Similarly, it was also observed in Chaudeswadi village of Malshiras tahasil in Solapur district on newly transplanted tomato crop in March, 2017.
PJTSAU: The marginal incidence of the pest was observed.

4.2.13.2 Biological control of brinjal mealy bug *Coccidohystrix insolitus*

TNAU: Two releases of *Cryptolaemus* @1500 /ha caused mealybug reduction 91.5 per cent sustaining the predator population of 10.4 nos./10 plants realising the fruit yield of 63.4 t/ha.

4.2.13.3 Bio-efficacy evaluation of EPN formulations of NBAIR against ash weevil in brinjal

TNAU: The application of EPN (NBAIR formulation) 20kg/ha along with *Metarhizium anisopliae* (NBAIR formulation) 5kg/ha mixed with 250 kg FYM/ha resulted 87.74 per cent reduction of ash weevil with minimum leaf damage of 8.37 per cent and it was on par with EPN (NBAIR) + *Metarhizium anisopliae* IPM formulation + 250 kg FYM and soil drenching of chlorpyriphos 0.1 per cent.

4.2.13.4 Evaluation of BIPM against major pests of curry leaf

TNAU: By adopting BIPM module leaf roller population was reduced by 78.94 per cent and psyllid population upto 59 per cent. The leaf yield was also high in BIPM plot 7.75 t/ha with the cost benefit ratio of 1:3.99.

4.2.13.5 Biological suppression of American pinworm, *Tuta absoluta* on tomato

AAU-A: Lower leaf and fruit damage by *Tuta absoluta* was observed in the treatment Azadirachtin 1500ppm @ 2ml/liter (2.67 %, 0.58 %) followed by the treatment *Beauveria bassiana* @ 4g/ liter (2x10^8cfu g^{-1}) (4.00 %, 0.69 %) and (*Trichogramma achaeae* @ 50000/ha release - 6 releases) (5.33 %, 1.12 %).

UAS-R: Among all the entomopathogenic fungi, minimum number of larvae, per cent fruit damage and high yield was observed in *Metarhizium anisopliae* @ 1.5 ml/l followed by *Lecanicillium lecanii* @ 1.5 ml/l and *Beauveria bassiana* @ 1.5 ml/l.

YSPUHF: Azadirachtin (1500ppm; 3ml/L), *T. achaeae, T. pretiosum* (each @ 50000/ha) and Bt (1L/Ha) were equally and more effective (56.8 - 69.6% reduction) than *M. anisopliae, L. lecanii* and *B. bassiana* (32.5 - 33.9% reduction), but, less effective than indoxacarb (2ml/L) seven days after the second treatment.

MPKV: Six releases of *Trichogramma achaeae* @ 50,000 parasitoids per ha at weekly interval, followed by *Metarhizium anisopliae* @ 10^8 conidia/ ml and azadirachtin 1000 ppm @ 2 ml/lit, being on par with each other and were the next promising treatments after chemicals.

4.2.13.6 Effect of biopesticides for the management of shoot and fruit borers *Earias vittella* in Bhindi

KAU, Vellayani: per cent fruit infestation was less in *Beauveria bassiana* @20gml/land followed by *Metarhizium anisopliae* @ 5g/l.

MPKV: Three sprays of chlorpyriphos 0.04 per cent at fortnightly interval was found at par with *B. thuringiensis* @ 1 kg/ha in terms of shoot damage, fruit damage and yield.

OUAT*: Metarrhizium anisopliae* @ 2×10^8 cfu application followed by Bt spray @ 1 kg/ha proved to the best treatment in reducing the sucking and fruit borer pests and producing the highest yield (8.38 t/ha) next to insecticidal check (9.31 t/ha).

4.2.13.7 Effect of biopesticides for the management of sucking pests in Brinjal Crop

KAU, Vellayani: *Beauveria bassiana* (ITCC KAU culture) 20gm/l was found superior in controlling the sucking pests with minimum pest population. The yield was also high in the plots treated with *Beauveria bassiana* 20gm/l compared to the check plot.

4.2.13.8 Development of Biocontrol based IPM module against *Leucinodes orbanalis* of brinjal

AAU J: The damage of shoots (9.03%) and fruits (16.43%) was the minimum in BIPM package as compared to chemical control plots (11.50 and 19.71, respectively). The yield of BIPM package was 263.78 q/ha as against 260.09 q/ha in chemical control plot and both were found to be on par with each other.

PAU: Two releases of *T. chilonis* as well as application of Neem oil (2 sprays) and *B. thuringiensis* (2 sprays) was found best, recording 7.03 per cent shoot damage and 8.48 per cent fruit damage. The yield was significantly higher in chemical control (328.3 q/ha) followed by BIPM module (262.1 q/ha).

4.2.13.9 Effect of biopesticides for the management of sucking pests in chilli Crop

KAU, Vellayani: *Beauveria bassiana* 20gm/l and Dimethoate 600g ai/ha found superior in controlling the sucking pests with minimum pest population. The yield was also high in the plots treated with *Beauveria bassiana* 20gm/l compared to the check plot.

IIVR: *Beauveria bassiana* (Bb-83) IIVR strain was found most promising against the yellow mites in chilli with highest per cent mite reduction (56.57 PROC) over the control followed by *Metarhizium anisopliae* (Ma-35) NBAIR strain (53.60 PROC). *B. bassiana* (Bb-83) IIVR strain treated plots registered significantly highest green chilli yield (6175 kg/ha) as compared to other entomopathogens.

4.2.13.10 Biointensive management of insect pests of tomato under field conditions

YSPUHF: Among bio-agents/biopesticides, *Neoseiulus longispinosus* (10 mite/plant) and azadirachtin (1500 ppm; 3ml/L) were the best treatments for the control of *Tetranychus urticae* in tomato resulting in 60.3 and 51.2 per cent reduction in the mite population over control. Both these treatments, however, were significantly less effective than fenazaquin (0.0025%) which caused 91.1 per cent over control.

4.2.13.11 Demonstration of BIPM package for management of key pests of tomato

AAU-J: Per cent fruit damage and the population of sucking pests were less in BIPM compared to chemical treated plot. The yield of BIPM package recorded 242.83q/h, which was superior to yield of 234.7q/ha in chemical control plot

4.2.13.12 Development of bio-intensive IPM package for the suppression of insect pests of capsicum under field conditions

YSPUHF: *Chrysoperla zastrowi sillemi* (1 larva/plant), *Lecanicillium lecanii* (5g/L of 10^8 conidia/g) and azadirachtin (1500ppm; 3ml/L) were statistically equally effective against green peach aphid, *Myzus persicae* resulting in 54.8 to 61.2 per cent reduction of the aphid population over control, but, were less effective than imidacloprid (0.0075%) was the most effective treatment resulting in 87.2 per cent reduction of the aphid population over control.

4.2.13.13 Evaluation of entomopathogenic fungi against sucking pests of *Bhut Jolokia* (*Capsicum sinensis*)

AAU-J: Among the different entomopathogenic fungi, Bb 5a (NBAIR strain) was the next best treatment after chemical in reducing the population of *A. gossypii* (5.10/ 3 leaves) and *S. dorsalis* (3.13/ 3 leaves) with next higher yield of 44.35 q/ha.

4.2.13.14 Biological control of *Myllocerous subfasciatus* on brinjal

IIHR: Among the different concentrations tested 10^8 recorded highest mortality in all the treatments It was observed that *Beauveria* sp recorded 93% followed by *Pseudomonas* sp SK3b recording 86% mortality after 72 hours.

4.2.13.15 Management of bacterial wilt an isolate of *Pseudomonas florescence*

CAU: The lowest incidence of bacterial wilt with 12.16% wilted plant, the highest average plant height (68.00cm), highest average number of fruit per plant (8.30 fruits) and average fruit weight (112.00g/fruit) were recorded in the plot treated with seedling root dip + soil drenching with CHF*Pf*-1.

4.2.13.16 Survey, collection and identification of mealy bug infesting major vegetable crops and its natural enemies

IIVR: *Phenacoccus solenopsis* (Tinsley) was found to be infesting major vegetables namely tomato, brinjal, *Capsicum* and okra and their peak period of incidences were also recorded. This mealy bug infested almost thorough out the year. Another species *Centrococcus insolitus* (Green) was also recorded to infest brinjal during the study. The prominent endoparasitoid *viz*., *Aenasius arizonensis*(Girault) (Encyrtidae: Hymenoptera) of *Phenacoccus solenopsis* were noted. Highest cumulative recovery was obtained from tomato (27.56%) followed by okra (19.33%) whereas lowest recovery (7.75%) was in case of brinjal.

4.2.13.17 Role of habitat manipulation on natural enemies of cabbage pests

AAU-J: Cabbage intercropped with mustard and cowpea was found to be the best (1.03 larvae/plant) harvouring lesser the *Plutella* larval population, and *Brevicoryne brassicae* population (3.41/plant) with higher coccineliids (3.34/plant) and syrphid (3.01/plant). Maximum yield of 175.52 q/ha was also obtained in this treatment.

4.2.14 Biological suppression of polyhouse crop pests

4.2.14.1 Monitoring diversity of pests and diseases of yard long bean (*Vigna unguiculata*) under polyhouse conditions and their management.

RARS Kumarakom: In survey incidence of Tetranychid mite *Tetranychus truncatus* Ehara (population ranging from 2-5/cm ^{2}) and white fly *Bemisia tabaci* (0-5/plant) were observed in majority of polyhouses. Infestation of serpentine leaf miner, *Liriomyza trifolii* and *Spodoptera litura* could also be seen. Incidence of powdery mildew (30 %), sooty mould (20%) and *Cercospora* leaf spot (10 %) were also recorded. *Beauveria bassiana* 1% (10^{8} spores/ml and 10^{9} spores/ml) and *Lecanicillium lecanii* 1% (10^{9} spores/ml) to be to be on par with insecticide Spiromesifen@ 96 g ai ha^{-1} in reducuing aphid population.

4.2.14.2 Monitoring the diversity of pests and natural enemies in Chrysanthemum under polyhouse condition

TNAU: In survey, whitefly population was maximum (4.2 /plant) in Hosur whereas maximum incidence of leaf miner 14.6 nos/plant was noticed in Kothagiri area followed by Hosur (10.2 no/plant). Regarding the mite incidence all the three locations showed a population range of 2.7 to 3.5 no./ 2 sq.m.

4.2.14.3 Evaluation of biocontrol agents against sap sucking insect pests of ornamental / vegetables in polyhouses

YSPUHF: Against rose aphid, *Macrosiphum rosaeiformis,* azadirachtin (1500ppm; 3ml/L), *Hippodamyia variegata* (10beetles/plant) and *Lecanicillium lecanii* (5g/L of 10^{8} conidia/g) were equally effective resulting in 50.8 to 69.1 per cent reduction in the aphid population over control. These bio-agents were, however, significantly less effective than imidacloprid (0.0075%) which reduced the aphid population to the tune of 96.6 per cent over control.

4.2.15 Large scale adoption of proven biocontrol technologies

4.2.15.1 Large scale demonstration of BIPM technology for management of *Helicoverpa armigera* in tomato

AAU-A: In the year 2016-17 (*Kharif*) demonstration experiment was carried out at Sarangpur Goshala Trust, Sarangpur. There were three treatments, *viz*., BIPM module, Chemical Control/Farmer's practice and absolute control. Lowest number of *H. armigera* / plant and fruit damage was recorded in BIPM module (1.15, 10.25%) followed by farmers practice (1.51, 12.74%). The same trend has been observed with respect to yield. The Highest yield was recorded in BIMP module (16.84t/ha) followed by farmers practice (15.06 t/ha) treatment and found at par with each other

4.2.15.2 Rice

AAU-J: Large scale adoption of proven bio control based BIPM package in rice was carried out in the farmer's field at three locations in Jorhat district on variety Ranjit covering an area of 30 ha. The result revealed that the population of *Cnaphalocrocis* sp, *Scirpophaga* spp. was least in BIPM package as compared to farmers practice. The BIPM package contributed higher yield (43, 83.93kg/ha) and higher net returns (53,025.00). The population of natural enemies was high in BIPM package than farmers practice.

GBPUA&T: Large scale field demonstrations of bio-control technologies on rice crop were conducted at the field of 30 different farmers in Nainital district (Halduchur and Golapar area) covering an area of approximately 50 acre with per farmer's acreage ranging from 0.50-4.0 acre. Four kg of PBAT-3 (Th-14 + Psf-173) was distributed to each adopted farmer. An average yield of 70q/ha was recorded from the farmers who had applied bio-control technologies under IPM programme, however an average yield of 58q/ha was recorded from the farmers who applied conventional farmers practices.

PAU: Large scale demonstrations of biocontrol based IPM (six releases of *T. chilonis* and *T. japonicum* each @ 100,000/ha) conducted at Nabha (Patiala), Samrala (Ludhiana), Kheri (Sangrur) in organic *basmati* rice (*var*. Pusa 1121) over an area of 165 acres rendered lower incidence of dead hearts in biocontrol field (2.25 %) as against untreated control (4.93 %) resulting in a reduction of 53.67 per cent. Similarly, leaf folder damage in release field was significantly lower in biocontrol fields (2.20%) as compared to untreated control (5.25%) with a mean reduction of 57.92 per cent. The mean incidence of white ears was significantly lower in biocontrol field (3.38%) as against untreated control (6.93%) resulting in a reduction of 51.23 per cent.

OUAT: BIPM (Biointensive Pest Management) module was demonstrated in 100ac of farmers' field in paddy crop (Swarna sub 1, Pooja) during *kharif* 2016 at village Otarakera of Satyabadi block in Puri district among 33 beneficiaries. There was significant reduction in stem borers, foliage feeders and sucking pests with higher B: C ratio in BIPM plots (1.8) as compared to farmers own practice (1.6) of spraying chemical insecticides.

KAU Thrissur: Large scale validation of IPM practices in rice was carried out in an area of 13 ha at Palla Road Padasekharam in Vadekkenchery Panchayat of Palghat District. Plots where IPM practices were adopted registered 40 per cent more yield than that obtained from non IPM plots. The cost of cultivation was also 10 per cent lower in the former. The increased yield as well as reduced cost resulted in an increase in profit by Rs 32,626/ha. The cost benefit ratio, at 2.15 was higher than the 1.45 obtained in case of non IPM fields.

4.2.15.3 Pigeon pea

UAS-R: Large scale demonstration of NBAII BTG 4 *Bt* was done in a Askihal village of Raichur taluka over an area of 10 ha. Totally ten farmers were selected to demonstrate the effectiveness of NBAII BTG 4 *Bt* in comparison with farmers practice. The results indicated that NBAII BTG

4 *Bt* recorded 9.04 per cent damage compared to farmers practice which recorded 8.26 per cent pod damage. Similarly the grain damage was 1.64 was noticed in NBAII BTG 4 *Bt* compared to farmers practice (1.23%). NBAII BTG 4 *Bt* recorded 10.36 q/ha grain yield and in farmers practice it was 11.42 q/ha grain yield

4.2.15.4 Brinjal

OUAT: BIPM module comprising of erection of pheromone trap @ 25/ha, release of *Trichogramma chilonis* @ 50,0000/ha at weekly interval and two sprays of Bt at peak flowering stage was demonstrated in 58 ac of brinjal crop in four villages of Cuttack district during *rabi* 2016-17 among 56 beneficiaries. This practice significantly reduced the shoot and fruit borer infestation with higher B: C ratio as compared to farmers own practice. Net return over farmers practice was observed as Rs. 60,060-64,545/= / ha.

4.2.15.5 Sugarcane

OUAT: The egg parasitoid *Trichogramma chilonis* @ 1 lakh/ha against ESB and internode borer (IB) and *T. japonicum* against TSB were released at 10 days interval starting from 30 DAG in the farmers field on sugarcane (87A-298, CO-86032) crop of 105 ac grown during *rabi* 2015-16 among 37 beneficiaries. Low borer incidence with higher cane yield (128.7 t/ ha) and remuneration was noticed in BIPM plots as compared to non BIPM plots (102.6 t/ha).

PAU: Large-scale demonstrations of effectiveness of *T. chilonis* against stalk borer, *C. auricilius* were carried out on an area of 456 acres at eight villages. The incidence of stalk borer in release fields (3.1 %) was significantly lower than untreated control (7.7 %). The reduction in incidence over control was 59.7 per cent. 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.

Large-scale demonstrations on the effectiveness of *Trichogramma chilonis* (Biocontrol based IPM technology) against stalk borer @ 50,000 per ha at 10 days interval over an area of 7910 acres conducted at farmers' fields in collaboration with six sugar mills of the state reduced the incidence of stalk borer, *Chilo auricilius* by 56.6 per cent.

Large scale demonstrations on the effectiveness of *T. chilonis* @ 50,000 per ha at 10 days interval (eight releases) over an area of 1550 acres conducted at farmers' fields in collaboration with three sugar mills, for the management of early shoot borer, *Chilo infuscatellus* indicated 54.3 per cent reduction of shoot borer incidence.

Large-scale demonstrations on the effectiveness of *T. chilonis* @ 50,000 per ha against early shoot borer, *C. infuscatellus* over an area of 365 acres conducted at villages indicated reduction in shoot borer incidence over control in release fields and chemical control (Coragen 18.5 SC @ 375 ml/ ha) by 56.9 and 86.5 per cent, respectively. However the cost: benefit ratio (1: 17.88) was higher in biocontrol as compared to chemical control (1: 9.48).

Large scale demonstrations on the effectiveness of *T. japonicum* against top borer, *Scirpophaga excerptalis* @ 50,000 per ha at 10 days interval (eight releases) over an area of 100 acres were carried out in collaboration with Doaba Co-operative Sugar Mills Ltd., Nawanshahar, reduced the incidence of top borer by 53.4 per cent.

Large-scale demonstrations of effectiveness of *T. japonicum* against top borer, *S. excerptalis* were carried over an area of 195 acres at villages reduced its incidence over control by 55.7 and 78.6 per cent in release fields and chemical control (Ferterra 0.4 GR @ 25 kg/ha), respectively. The cost benefit ratio was higher in biocontrol (1: 18.47) as against chemical control (1: 10.61).

4.2.15.6 Maize

PAU: Large scale demonstrations of using *T. chilonis* in farmer's fields was carried out in area of 355 acres in Hoshiarpur, Nawashahr, Roop Nagar and Pathankot districts of Punjab in collaboration with Maize Section, Department of Plant Breeding & Genetics, KVK Pathankot, KVK Ropar, FASS Hoshiarpur and KVK Hoshiarpur. Single release of *T. chilonis* @ 100,000/ ha on 15 day old crop provided effective control of maize stem borer, *Chilo partellus* as against untreated control. The reduction in incidence over control was 52.51 and 69.24 per cent in biocontrol and chemical control, respectively. The net returns over control in biocontrol package were Rs. 5036.75/- as compared to Rs.8239.25/- in chemical control.

4.2.16 Tribal Sub plan programme (TSP)

AAU-A: Biocontrol technologies for the management of *Fusarium* wilt and pod borer (*H. armigera*) in pigeon pea and chick pea

100 tribal farmers (50 Pigeon pea growers and 50 chick pea growers) were selected from Dahod district and distributed bio-inputs to the tribal famers and gave demonstration and training on use of bio-inputs in farming. There was a significant reduction in the incidence of *Fusarium* wilt and *Helicoverpa armigera* in pigeon pea to the tune of 60-65%. 10-12% increase in yield was observed. In chick pea 62-65% reduction in *Fusarium* wilt disease incidence and 10-15% increase in yield was observed.

Biological interventions to enhance the production and productivity of okra in tribal areas of Tapi district in Gujarat

200 tribal farmers (okra growers) were selected from Tapi district and distributed bio-inputs and gave demonstration and training on use of bio-inputs in the cultivation of okra. Increased adoption of biocontrol practices in cultivation of okra. Reduction (65-70%) in pests and disease incidence. 12-15% increase in yield was observed.

ANGRAU: Organic farming in paddy, rajmah, ginger

Total 143 acres area of Araku valley and Chinthapalli area, Visakhapatnam district was covered. Inputs were distributed to 45 paddy farmers; 50 Rajma farmers and 67 ginger farmers.

Organic farming in Paddy

Conducted front line demonstrations in organic farming paddy in three villages, *i.e*., Naduguda, Ramguda of Araku valley and Idulabailu of Chinthapalli areas. All biological inputs were distributed among farmers. Organic farming paddy farmers recorded higher yields (4500 kg/ ha) compared to traditional tribal farmers (2300 kg / ha) without any fertilizer application and plant protection measures. Enhancement of yield levels by 95% with improved quality benefitting 45 paddy farmers covering 43 acres.

Organic farming in Rajmah

Front line demonstrations on organic farming of Rajmah were conducted in two villages i.e, Gunjariguda (Araku valley) and Asarada (Chinthapalli). Around 20-30% of yield increment along with improved quality suitable for export benefiting 50 tribal farmers covering around 50 acres of tribal agricultural acreage.

Organic farming in Ginger

Front line demonstrations on organic farming of ginger were conducted in three villages, *i.e*., Gunjariguda , Kothavalasa (Araku valley) and Asarada (Chinthapalli). Around 15-20% of yield increment with export oriented quality produces benefiting 67 tribal farmers covering around 50 acres of tribal agricultural acreage.

Tribal farmers acquired knowledge on importance of organic farming through cultvation of suitable high yielding paddy varieties, usage of Bio-pesticide (*Pseudomonas flourescens),* Liquid Bio-fertilizers (*Azospirillum, Azatobacter* and *Phosphobacteria)* and Biocontrol agent - *Trichogramma chilonis* and *T. japanicum* as Tricho cards; proper harvesting, post harvesting techniques like drying and seed storage methods. Farmers realized the advantages of biocontrol agent; biofertilizers and improved varieties in paddy cultivation. Organic farming FLD tribal farmers of Araku valley and Chinthapalli regions of Visakhapatnam district, Andhra Pradesh, recorded higher yields by adopting biofertilizers, biopesticides and biocontrol agents in paddy , rajmah and ginger crops .

SKAUST: Tribal Sub Plan on Integrated Pest Management of Codling moth in Ladakh

Six tribal areas of Kargil have been selected for benefiting the farmers with IPM technologies of Management of Codling moth. Six core groups of literate orchardists have been made to implement the programme and help a total of 150 farmers under 10 groups. Each core group will be provided basic training related to IPM of Codling moth, including timing of chemical spray, use of Tricho cards and pheromone traps, trunk banding of apple for trapping and killing of larvae, debarking of old trees and disposal of infested fruits etc. Instructions and guide lines for IPM of Codling moth will be distributed to farmers in their local language.

MPKV: The village Dalpatpur and Harsul in Trimbakeshwar Tahasil of Nashik district is a Tribal (ST) dominating areas in Maharashtra. The TSP was implemented in collaboration with Bharatiya Agro Industries Foundation (BAIF), Maharashtra Institute of Technology Transfer for

Rural Areas (MITTRA), Nashik. Fifty fruit orchards (*Wadis*) of tribal farmers established by BAIF, MITTRA at Dalpatpur and Harsul villages were selected for carrying out operation under TSP. The *wadi* of 0.40 ha consisting 9-10 years old plantation of fruit crops of 40 mango trees, 30 Cashew nut trees, 10 plants of Amla, 5 plants of Drumstick and forest species, *i.e*., *Teak* and *Bamboo* planted on border. One-day training programme on IPM of fruit crops to tribal youth and tribal farmers was organized. In IPM training, pests of mango and cashew nut and their management strategies were presented to 25 tribal youth farmers and 50 tribal farmers. Thereafter, demonstration was organized for enrichment of FYM with biofertilizer and biopesticides. The information on 3 P Mission programme was illustrated to protect parasitoids, predators and pollinators in ecosystem. Inputs were provided to farmers. Due to proper and timely application of enriched FYM and spraying of entomopathogenic fungi (EPF) to control mango hopper and tea mosquito bug, the yield of mango and cashew nut was increased. Ultimately tribal farmers are satisfied with TSP project.

TNAU: Under the TSP, three trainings to tribal farmers were organised during the period under report. First training was organised Jawathu hills, Polur block, Tiruvannamalai district. Under the training programme sixty tribal farmers were enriched with knowledge on organic cultivation using biofertilizers, growth regulators, antagonists, biopesticides, entomofungal agents and entomophages and establishment of homestead vegetable cultivation. In addition, demonstrations on the use of nimbicidine, egg parasitoid *Trichogramma* spp. predators like green lace wing, *Chrysoperla* and *Cryptolaemus* were also conducted. One hundred and twenty tribal farmers of Sembukarai and Thumanoor villages of Periyanaickkan Palayam block, Coimbatore district and Manjavadi village, Pappireddipatti block of Dharmapuri district got exposed for one day training about the production of pesticide residue free crop produce.

YSPUHF-Solan: Eco-friendly management of pests of apple, almond, peas, beans, cauliflower and cabbage.

TSP was implemented was implemented in four villages (Moorang, Akpa, Nichar & Sungra) in Himachal Pradesh. 200 tribal farmers cultivating apple, almond, peas, beans, cauliflower and cabbage in area of 200 ha were benefited. Inputs like, *Metarhizium anisopliae, Beauveria bassiana,* Yellow sticky traps, Blue sticky traps, Neem Baan, *Trichoderma viridae* and *Pseudomonas* were provided. 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 2-3 sprays of chemical pesticides. In case of apple, farmers saved about Rs 15000/- per hectare by avoiding chemical treatment for the control of apple root borer.

5. Director and monitoring team visits to AICRP centers during 2016-17

Sl. No.	Dates	Visit of Director/ NBAIR Scientist	Place of visit	Highlights of visit
1.	23.8.2016 to 24.8.2016	Dr. Chandish. R. Ballal Director & Project Coordinator AICRP BC, NBAIR	AAU, Anand	Reviewed the progress of AICRP–BC work at AAU, Anand centre.
2.	04.07.2016 to 06.07.2016	Dr. S. K. Jalali, PS (Ento) and HOD NBAIR Dr .Shylesha, PS (Ento) NBAIR	PAU, Ludhiana	Reviewed the progress of AICRP–BC work at PAU, Ludhiana centre and visited the experimental plots.
3.	2.9.2016	Dr. Chandish R. Ballal, Director & Project Coordinator AICRP BC, NBAIR	PJTSAU, Hyderabad	Reviewed the progress of AICRP–BC work at PJTSAU, Hyderabad centre and visited the experimental plots.
4.	11.11.16 to 12.11.16	Dr. Chandish R. Ballal, Director & Project Coordinator AICRP BC, NBAIR	TNAU, Coimbatore	Review of AICRP biocontrol of crop pests scheme
5.	24.11.16	Dr. S.K. Jalali and team of scientists from NBAIR	TNAU, Coimbatore	Visited the biocontrol lab and survey on cotton whitefly incidence
6.	22.01.2017 to 23.01.17	Dr. M. Mohan Principal Scientist and Dr. K. Selvaraj, Scientist	AAU, Anand	Reviewed the progress AICRP–BC work at AAU-A and also attended farmers' day (*Trichogramma* day) at Devagadhbaria, on 23.01.2017.
7.	10.01.2017 to 11.01.2017	Dr. S. K. Jalali PS (Ento) and HOD and Dr. T. Venkatesan PS(Ento)	AAU, Jorhat	Review the progress of the research programme at AAU, Jorhat
8.	21.02.2017 to 25.02.2017	A group of scientist led by Dr. P. Mohanraj	AAU, Jorhat	Reviewed the progress of work of AICRP on Biocontrol at AAU, Jorhat
9.	24.2.2017	Dr. Sunil Joshi, Principal Scientist (Ento)	MPKV, Pune	Visited the Biocontrol laboratory as well as experimental plots on 24.2.2017 and took review of the progress of research work.
10.	20.03.2017 to 21.03.2017	Dr. Chandish R. Ballal, Director, NBAIR, and the team of scientists	TNAU, Coimbatore	Brain storming session on rugose whitefly

7. Publications: During the year 2016-17, a total of 217 Research papers/symposium papers/reviews/technical bulletins, etc. were published by the different centres.

Centre	Research papers in journals	Papers in Symposia/Seminars	Books/ Book Chapters /Tech. Bulletins/ Popular articles/ Newsletters/Proceedings articles	Total
NBAIR, Bangalore	38	-	-	38
AAU, Anand	-	-	1	1
AAU, Jorhat	8	-	14	22
GBPUAT, Pantnagar	9	10	8	27
KAU, Thrissur	1	-	2	3
MPKV, Pune	13	-	2	15
PAU, Ludhiana	14	7	9	30
PJTSAU, Hyderabad	1	-	-	1
SKUAST, Srinagar	5	-	-	5
TNAU, Coimbatore	5	19	1	25
YSPUHF, Solan	11	-	-	11
OUAT, Bhubaneshwar	2	6	-	8
DRYSRHU, A.P	6	-	-	6
IGKV , Raipur	-	5	7	12
IIHR , Bangalore	4	-	9	13
Total	**117**	**47**	**53**	**217**

8. Profile of experiments and demonstrations carried out during 2016-17

Crop/Insect	Experiments	Large Scale Demonstrations
Biodiversity of biocontrol agents	2	0
Antagonists of crop disease management	4	2
Sugarcane	4	7
Cotton	10	0
Tobacco	1	0
Rice	4	5
Maize	2	2
Sorghum	1	0
Pulses	4	0
Oilseeds	1	0
Tropical Fruits	12	0
Temperate Fruits	6	0
Vegetables	21	2
Polyhouse crops	4	0
TSP	9	0
Total	**85**	**18**