DIRECTOR'S REPORT

XXV Biocontrol Workers Group Meeting
17-18 May, 2016

ICAR - National Bureau of Agricultural Insect Resources, Bengaluru 560 024

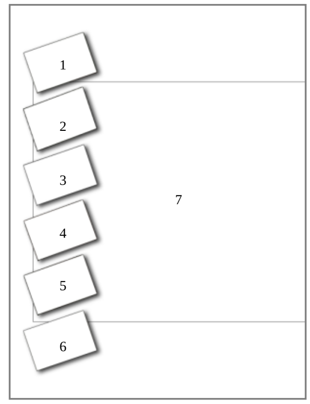
All India Co-ordinated Research Project on
Biological Control of Crop Pests

DIRECTOR'S REPORT

XXV AICRP WORKSHOP ON
BIOLOGICAL CONTROL OF CROP PESTS

17-18 May, 2016

ICAR - National Bureau of Agricultural Insect Resources
Bengaluru 560 024



Cover page

1. *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) larvae on tomato leaf
2. *Nesidiocoris tenuis* (Reuter) (Hemiptera: Miridae)
3. *Pseudonemophas versteegi* (Ritsema) (Coleoptera: Cerambycidae)
4. *Idioscopus nitidulus* (Walker) (Hemiptera: Cicadellidae)
5. *Opisina arenosella* Walker (Lepidoptera: Oecophoridae)
6. *Maruca vitrata* (Fabricius) (Lepidoptera: Crambidae)
7. Administrative block of ICAR-NBAIR, Bengaluru

Photo credits: Photographs 1 to 6 – J. Poorani; 7 – B. Manjunath

Cover design: Sunil Joshi

ACKNOWLEDGEMENTS

On behalf of the scientists of AICRP on Biological Control of Crop Pests and National Bureau of Agricultural Insect Resources (NBAIR) and on my personal behalf, I thank Dr. S. Ayyappan, former Secretary, DARE & Director General, ICAR, and Dr. Trilochan Mohapatra Secretary, DARE & Director General, ICAR, for their interest in the research work carried out at centres of AICRP on Biological Control of Crop Pests and ICAR-NBAIR. I acknowledge the support and guidance Dr. Jeet Singh Sandhu, Deputy Director General (Crop Sciences), ICAR. Dr. P. K. Chakrabarty, Assistant Director General (Plant Protection & Biosecurity), Dr. Rajan, Principal Scientist, ICAR and Dr. M.P. Singh, Chief Technical Officer, ICAR deserve our gratitude for all their positive output for this project and keen involvement in all facets of the functioning of AICRP.

All the scientists and staff of AICRP centres and ICAR-NBAIR and are to be appreciated for their hard work and cooperation in carrying out the technical programme.

The help of Dr. B. Ramanujam, Dr. Rachana, Dr. Richa Varsheny, Dr. A. N. Shylesha, Dr. S. K. Jalali, Dr. Sunil Joshi, Mr. H. Jayaram, Mr. Krishna Japur, Miss Divya & Mrs. Rekha in compilation of this document is gratefully acknowledged. Administrative support received from Ms. S. Rama, SAO and Mr. T.A. Vishwanath, FAO of ICAR-NBAIR is gratefully acknowledged.

Date: 04.05.2016
Bangalore

Abraham Verghese
Director & PC, ICAR-NBAIR

1. Introduction

AICRP in 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 in IPM.

The work under the XII plan encompasses i. Survey and collection of natural enemies belonging to insects, mites, spiders, EPN and microbial pathogens, ii. Surveillance for possible entry of potential alien invasives like *Brontispa*, *Phenacoccus manihoti*, the giant whitefly, the western flower thrips *Frankliniella occidentalis* etc. and classical biological control intervention, if needed, iii. Characterization/ Identification of natural enemies. 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 and *viz*., technologies for mass multiplication/ product development of microbes and commercialization.

Spectacular successes were achieved during the past five years in the management of the papaya mealybug, sugarcane woolly aphid; eucalyptus gall was 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. One good example is the pesticide free rice cultivation in Kerala.

2. Mandate of AICRP on Biological control of crop pests

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

- Demonstration of usefulness of biocontrol in IPM in farmers' fields.

3. Objectives

i. Development of effective biocontrol agents for use in biological suppression of crop pests and diseases.
ii. Evaluation of various methods of biological control in multi-location field trials.
iii. Development of biointensive integrated pest management strategies for cotton, rice, sugarcane, pulses, oilseeds, potato, coconut and a few selected fruits and vegetable crops.

iv. Demonstration of biocontrol agents and biopesticides as a component of IPM in farmers fields.

4. 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	Bhubaneshwar
15.	University of Agricultural science (Raichur)	Raichur

ICAR Institute–based centres

1.	Central Institute of Subtropical Horticulture	Lucknow
2.	Central Plantation Crops Research Institute	Kayangulam
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.	Directorate of Soybean Research	Indore
8.	Directorate of Weed Science Research	Jabalpur
9.	Indian Agricultural Research Institute	New Delhi
10.	Indian Institute of Horticultural Research	Bangalore
11.	Indian Institute of Sugarcane Research	Lucknow
12.	Indian Institute of Vegetable research	Varanasi
13.	National Centre for Integrated Pest Management	New Delhi

Voluntary Centre

1.	Indira Gandhi Krishi Viswavidhyalaya	Raipur

The results from the various experiments conducted at centres across the country during the year 2015-16 are presented below.

5. Brief summary of research achievements

5.1 Basic research work at National Bureau of Agricultural Insect Resources

5.1.1 Biosystematic studies on agricultural insects

5.1.1.1 Biodiversity of natural enemies of insect pests

Parasitoids collections were made from Karnataka, Tamil Nadu, Rajasthan, Gujarat, Himachal Pradesh, Andamans & Nicobar Islands and Mizoram. Described three new species, *viz*., *Tetrastichus thetisae*, *Sympiesis thyrsisae* and *Halticoptera indica*. First phylogenetic study resolved a diverse and geographically realistic subset of species within the genus *Glyptapanteles* (Hymenoptera: Braconidae).

5.1.1.2 Biodiversity of oophagous paraditoids with special reference to Scelionidae (Hymenoptera)

Surveys were conducted for Platygastroidea in five states, *viz*., Tripura, Andaman and Nicobar Islands, Tamil Nadu, Kerala and Karnataka. A total of 1150 parasitoids were collected, curated and preserved for future studies. So far 52 genera under four families of Platygastroidea were recorded from India under this project and an additional four genera are added raising the total to 66 genera. The five genera are *Pardoteleia, Pleistopleura, Ptiostenius, Titta* and *Nyleta.* A new species group and fifteen new species were described. The new species group *Idris adikeshavus* group has been proposed with five new species – *Idris adikeshavus, I. brevicornis, I. deergakombus, I. teestai* and *I. lopamudra.*

5.1.1.3 Biosystematics of Trichogrammatidae (Hymenoptera)

Eight states were surveyed for Trichogrammatidae. These included island ecosystems like the Andamans and the Nicobar; lowland rainforests and cultivated areas in Tripura in NE India, cultivated and natural ecosystems in Odisha; Kerala, Tamil Nadu and Karnataka, which included parts of the Western Ghats and other cultivated and non-cultivated areas. The relatively recently described *T. rabindrai*, a species so far known only from S. India was discovered in S. Andaman. It is being bar coded. A species of *Mirufens* was collected from the Nicobar Islands for the first time from leaf galls of *Dipterocarpus* sp.

A species of *Trichogrammatoidea* similar to *T. tenuigonadium* in habitus but with genitalia in males resembling other *Trichogrammatoidea* has been discovered from Karnataka. The barcode generated for this species is distinct unlike any other species in the genus thus validating its status as a new species.

5.1.1.4 Biodiversity of aphids and coccids

Aphid species, *viz*., *Aphis* (*Bursaphis*) *solitaria* McVicar Baker and *Brachycaudus* (*Brachycaudina*) *napelli* (Schrank); mealybug, *viz*., *Formicococcus formicarii* (Green) and scale, *Anomalococcus crematogastri* (Green) were recorded for the first time in the country. Similarly, *Trionymus townesi* Beardsley and *Dysmicoccus carens* Williams were recorded for the first time from Karnataka. Eleven species of aphids, a species of mealybug and a species of soft scale were added as new to the existing collection of aphids and coccids at NBAIR.

5.1.1.5 Documentation, production and utilisation of predatory anthocorids and mites

Anthocorid predators such as *Montandoniola bellatula* Yamada 2007 and *Xylocoris cerealis* Yamada and Yasunaga 2006 (from Karnataka) were new records for India. Two new species of *Orius* were recorded, one from coconut and rose and another from *Clerodendrum infortunatum*, all from Karnataka. Four anthocorid predators, *viz*., *Cardiastethus exiguus, Bilia castanea, Orius maxidentex* and *Buchananiella pseudococci pseudococci* were recorded on thrips infested mulberry in Salem (Tamil Nadu) and *O. maxidentex* from Karnataka. A new species of *Orius* was recorded on *Clerodendrum infortunatum.*

Four to six releases of *Blaptostethus pallescens* against broad mites (*Polyphagotarsonemus latus*) infesting capsicum could significantly reduce the pest incidence and curling symptoms and improve the plant height.

Xylocoris flavipes and *Blaptostethus pallescens* were evaluated against *Sitophilus oryzae* infested maize seeds. This result indicates that anthocorid predators are potential bio-agents of *Sitophilus oryzae* and would be very effective if introduced as soon as seeds are stored as they would deter adult oviposition.

At NBAIR, the production of *Corcyra cephalonica* has been scaled up by optimising the dosage of charging and installing temperature humidity maintenance system in the rearing room in 2013. The production increased from 19.8 cc per month in 2010 to 48 cc in 2016.

Trichogramma chilonis was exposed in large 3 ft cages @ of 8 tricho cards / per one nucleus card and maximum of 104 cards could be exposed at a time and parasitism reached up to 99.0%. By adopting a similar method, *T. japonicum* was exposed @ of 4 tricho cards / per one nucleus card and maximum of 97 cards could be exposed at a time and up to 85.0% parasitism could be recorded.

The interaction between two parasitoids of litchi stink bug, *Anastatus acherontiae* and *Anastatus bangalorensis* was studied. In sequential and simultaneous exposures, overall parasitism (26.7 to 90.0%) was significantly higher than or on par with the parasitism by individual species indicating that the parasitoids are complementary to each other.

5.1.2. Molecular characterization and DNA barcoding of agriculturally important parasitoids and predators

Different parasitoids, predators and other insects were collected from Andaman & Nicobar Islands, Srinagar, Pune, Anand, Varanasi, Dharmapuri and Bangalore and were used for DNA barcoding studies. The parasitoids belong to Braconidae, *viz*., *Glyptapanteles* sp. (Barcode: ACZ3549) (Genbank Acc. No. KR260984), *Glyptapanteles* sp. (AAI5405) **(**KT284335), *Glyptapanteles* sp. (ACZ3433) (KT25318), *Microplitis maculipennis* (ACV9232) (KP759295), *Glyptapanteles creatonoti* (AAH1199) (KR021154), *Glyptapanteles* sp. (ACZ3493) (KT254316), *Glyptapanteles obliquae* (Wilkinson) (ACS3730) (KR021152), *Glyptapanteles aristolochiae* (Wilkinson) (ACZ3726) (KR021156), *Glyptapanteles cf. Spodopterae Ahamad (*ACS3730) (KR260983), *Glyptapanteles spodopterae* (ACS3730) (KR260976), *Glyptapanteles* sp. (AAH1199) (KT284334), *Glyptapanteles* sp. (ACZ3303) (KT254319), *Glyptapanteles bliquae* (Wilkinson) (AAH1199) (KR021152), *Glyptapanteles cf. amprosemae* Ahmad (ACZ3016) (KT284342) were characterized and barcodes generated. Phylogenetic analyses were performed on 38 based on mitochondrial cytochrome oxidase subunit I (COI) nucleotide sequences. Maximum likelihood and Bayesian inference methods displayed three and four major discrete *Glyptapanteles clades*, respectively. Furthermore, molecular characterization and DNA barcodes were generated for 103 agriculturally important parasitoids, predators and other insects based on COI gene & ITS-2 and deposited in GenBank and BOLD and obtained accession numbers.

5.1.3. Monitoring of invasive pests

5.1.3.1 New invasive Tomato pinworm, *Tuta absoluta*- Monitoring and management

Tuta absoluta (Meyrick 1917), a lepidopteran tomato leaf miner also called as pin borer belongs to the family Gelichiidae. It is considered as one of the most devastating tomato pests in the countries it has invaded so far. It has originated from Peru (South America) and then invaded many other countries in South America, Europe, Africa and Asia. *T. absoluta* larvae completely destroy the tomato leaves by mining leaves, stems and buds and burrowing tunnels in the fruits, causing unmarketability of fresh tomatoes and yield losses up to 100%. The pest was detected and identified in October 2014 from Pune, Maharashtra in India by the Scientists of ICAR and now poses most serious threat to tomato cultivation in the country. The damage of this pest on tomato crops has been reported from Gujarat, Maharashtra, Telangana, Andhra Pradesh, Karnataka and Tamil Nadu. *T. absoluta* can be easily recognized on tomato plants by the presence of large blotch or mine on the leaves with dark frass inside and pinhead size holes on the developing fruits. On the leaves, the larvae feed on the mesophyll tissue, forming large mines or extensive galleries. In case of serious infestation, leaves die completely. The larval entry and exit holes on the fruits are small and pin-head sized. Sometimes the entry and exit holes are used by secondary pathogens, leading to fruit rot. Multiple holes and presence of many larvae in a fruit can be noticed. The other potential host plants for *T. absoluta* in India are brinjal and potato apart from other solanaceous weed hosts.

5.1.3.2 Extent of damage on tomato crop by *T. absoluta* in different states between (March 2015 -February 2016)

Severe incidence was recorded in Dharmapuri and Krishnagiri districts of Tamilnadu (5.7-55.5%), Chitamani and Kolar districts of Karnataka (1.5-64.3%), Chittur district of Andhra Pradesh (13-36.7%) and Junagadh district of Gujarat (5.5-17%).

5.1.3.3 Natural enemies of *Tuta absoluta*

Cage studies were conducted to evaluate *Trichogramma* species against eggs of *Tuta absoluta* infesting tomato plant. Three species of *Trichogramma* could successfully parasitize *T. absoluta*. Parasitism by *Trichogramma achaeae* was 28.8% followed by *T. pretiosum* (thelytokous) (22.7%) and *Trichogrammatoidea bactrae* (12.5%). No parasitism was recorded in the cages where *T. chilonis* was released. Anthocorid predators, *Amphiareus constrictus* and *Blaptostethus pallescens* were observed to be efficient predators of *Tuta absoluta* eggs, feeding on 90 to 100% of the eggs when released in a ratio of 1 predator: 10 eggs.

5.1.3.4 Bioassay against *Tuta absoluta* with NBAIR *Bt* anf fungal isolates of *Beauveria bassiana* and *M. anisopliae* isolates

Four NBAIR *Bt* isolates along with standard MTCC-8997 expressing the coleopteran specific proteins were tested against early second instar larvae of *Tuta absoluta* by tomato leaf dip methodology. The most toxic isolate was NBAIR-4 with LC_{50} 301.3 ppm, followed by NBAIR-1with LC_{50} as 373.7 ppm Laboratory bioassay with three isolates each of *B. bassiana* (Bb-5a, Bb-19 and Bb-23) and *M. anisopliae* (Ma-4, Ma-6 and Ma-35) against *T. absoluta* indicated very low mycosis (6.7 to 26.7%).

5.1.3.5 Rapid action management plan advocated to farmers

i. Destruction of infested tomato plants and fruits by burying deep inside the soil or by burning.
ii. Crop rotation with non solanaceous crops.
iii. Nursery with pest proof net covering and use of pest free seedlings for transplantation
iv. Preservation / augmentation of natural enemies like *Nesidiocoris tenuis*, *Necremnus* sp., *Orius* sp. and *Trichogramma* spp.
v. Installation of *T. absoluta* pheromone baits for monitoring and mass trapping male moths both in nursery and main field (40 traps /ha)
vi. Initiate the use of insecticide both in nursery and main field, if the moth catches in the pheromone trap is exceeding 20-30 moths/trap / week.
vii. Recommended the following insecticides Chlorantriniliprole (Rynaxypyr) 10.26% OD @ 0.3 ml/lit or Flubendiamide 20% WG @ 0.3 ml/lit or Indoxacarb 14.5% SC @ 0.5 ml/lit or Neem formulation (Azadirachtin @ 1% or 5%) @ 2-3 ml/lit) for managing the pest on tomato crop.

5.1.3.6 Studies on papaya mealybug

Incidence of papaya mealybug was recorded below pest level in all the areas surveyed in Karnataka and Tamil Nadu Andaman islands. However, in the summer of 2016, it was recorded in Andaman Islands causing 25-30% damage on papaya and other vegetable crops. Three consignments of parasitoids were sent for managing the same.

Parasitism: A high level of parasitism was recorded from all the samples collected. *Acerophagus papayae* was the predominant parasitoid exercising control in addition *Pseudleptomastix mexicana* was recorded in all the samples with parasitism ranging from 5.0 to 20.0%. None of the samples recorded from any area was free from parasitoids showing their wide spread presence and their adaptability to Indian conditions.

Hyper parasitism: Parasitism of *Acerophagus papayae* by hyper parasitoids was recorded to the extent of 6-7% by *Chartocerus* sp. and 2-3% by *Marietta leopardina*.

Supply of natural enemies: *Acerophagus papayae* and *Pseudleptomastix mexicana* cultures were sent to OUAT Bhubaneswar, Andaman Islands, Hosur, Madurai, New Delhi, Gujarat, Pondicherry, Ananthpur, in addition to local supplies in Karnataka.

5.1.3.7 Invasive whitefly *Aleurothrixus trachoides*

The association between the invasive pest solanum whitefly *Aleurothrixus trachoides* (Back) and the predator *Axinoscymnus puttarudriahi* Kapur and Munshi on capsicum under natural conditions was studied. The variance to mean ratio being greater than unity indicated an aggregated distribution of the pest and the predator.

5.1.3.8 Host range of invasive mealybug, *Pseudococcus jackbeardsleyi* Gimpel and Miller (Jack Beardsley mealybug) in Karnataka and Tamil Nadu

Survey for occurrence of *P. jackbeardsleyi* in Tamil Nadu and Karnataka indicated no major incidence of the pest.

5.1.3.9 Establishment of *Cyclophora connexa*, gall fly of *Chromolaena*

Chromolaena weed biocontrol agent *C. connexa*, which was released at different places has established causing up to 15 galls per 5 minutes search in 2 km in and around released spots in Kanakapur Road. In Puttur, it has spread around 6-9 kms from the released spot and in Tataguni estate it has spread to the nearby forest area, whereas in GKVK campus, it has been localised because of the availability of host plants year round. Burning of the dried plants either manually or by forest fire has become the major factor for low level of spread in forest area. The gall fly has also established in Kerala and as well as in Tamil Nadu in the places of release.

5.1.3.10 Survey for invasive thrips, *Frankliniella occidentalis*

Examination of the samples of flowers of tomato and chilli from Karnataka Tamil Nadu and Gujarat did not yield the western flower thrips, *Frankliniella occidentalis*.

5.1.3.11 Mass production of *Aenasius* (=*bambawalei* Hayat) *arizonensis* (Girault) (Hymenoptera: Encyrtidae)

Adult females showed preference to parasitize third instar nymphs. Reddish brown cocoons scattered in the mealybug colony indicates the parasitism by *A. arizonensis*. Mass production of parasitoids using *Parthenium hysterophorus* as host revealed that the total developmental period of 16 to 20 days and pupal period of 6 to 8 days. Adult longevity of females 13 to 30 days and males 8 to 10 days with fecundity of 130-150 eggs. Females were more in number compared to males (Around 30 males to 100 females in *Parthenium* host plant).

5.1.3.12 Erythrina gall wasp managment

Erythrina gall wasp, *Quadrastichus erythrinae* was found in low populations in Kolar, Mandya, and Ramnagar districts. *Aprostocetus gala* was found to be the major parasitoid of *Q. erythrinae* 10.0 to 15.0% parasitism observed in the field. The native species collected and identified as *Aprostocetus* sp. was found to be a potential parasitoid of erythrina gall wasp, *Quadrastichus erythrinae* in India. Its molecular characterization and sequences matched >80.0% with the *A. gala* submissions.

5.1.3.13 Incidence of invasive leaf miner, *Chromatomyia syngenisiae*

Severe outbreak of invasive leaf miner, *Chromatomyia syngenisiae* was recorded in chrysanthemum in poly houses from Coonor, Ooty and nearby areas including Nilgiri hills and Coimbatore. The incidence occurred in > 80.0% of the plants in the sampled area and the yellow traps were full by the end of the day of installation with adult flies. No parasitoids were recorded from the area. Release of *Diglyphus* sp. also did not bring down the damages. *Herbertia* sp. (Hymenoptera: Pteromalidae) was collected from the mummified puparium of the leaf miners.

5.1.3.14 New invasives and host extensions

- Banana skipper, *Erionota thrax* (Lepidoptera: Hespiridae) severity has come down.
- Root mealybugs on pepper, *Formicococcus polysperes* Williams and other species have become severe in Coorg and Chickmagalur area.
- The skipper, common banded awl, *Hasora chromus* (Cramer) (Lepidoptera: Hesperiidae), upsurge was recorded on *Pongamia pinnata* in and around Bangalore. In some localities the caterpillars entered houses creating panic among people (Bengaluru). High incidence was also noticed in ICAR-NBAIR research farm. The trees were entirely defoliated. Many insectivorous birds were seen feeding on the caterpillars.

- A looper (*Cleora* sp.) (Lepidoptera: Geometridae) was found to feed extensively on neem trees in a few villages of Samsthan Narayanpur Mandal of Nalgonda district in Telangana during October/November 2015. Similar damage was found in the nearby villages also. Previously this was recorded as a pest of pigeon pea from Hyderabad.

5.1.4. Biosystematics and diversity of entomogenous nematodes in India

Three insect associated nematodes (*Steinernema* sp., *Heterorhabidtis* sp. and *Oscheius chromogenesis*) were isolated from the soils collected from Kerala, Karnataka, Andhra Pradesh, Maharastra and Nicobar islands.

5.1.4.1 Efficacy of EPN (Rhabditida: Steinernematidae and Heterorhabditidae) on house fly, *Musca domestica*

Among the EPN species tested, *S. carpocapsae* caused significantly greater mortality (81.2 to 100.0%) than the *H. indica* (62.5 to 100.0%), *S. glaseri* (25.0 to 100.0%), *S. abbasi* and *S. feltiae* (6.3 to 100.0%) against second instars of *M. domectica*, whereas *H. indica* caused significantly greater mortality (18.8 to 100.0%) than the *S. carpocapsae*, *S. glaseri*, *S. abbasi* and *S. feltiae* against third instars of *M. domestica* @ 50-10000 IJs/maggot.

5.1.4.2 Pathogenicity of *Oscheius* sp. on *Bactrocera cucurbitae* pupae

A dose of 200 IJs/pupae of *Oscheius* sp. on *Bactrocera cucurbitae* resulted in 80.0% pupal mortality after 48th inculcation.

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

A total of 86 soil and insect samples collected from Western Ghats were analysed during the year and 25 isolates of *Bacillus thuringiensis* isolates expressed bipyrmadal crystals. Soil samples from Greater Nicobar Islands yielded 4 isolates of *Bt* expressing bipyramal and spherical crystals.

The trypsin activated Vip3A protein (4 hrs IPTG induction) at 500 µg concentration caused 100% mortality of *Plutella xylostella* after 48 hours. The LC_{50} value was calculated as 53.676 µg/ ml.

Cry8A expressing *B. thuringiensis* (NBAIR-BTAN4) was tested against the potato grub and 100.0% mortality recorded in 48 hrs.

Liquid formulations of NBAIR-BTG4 and standard HD-1 at 1 and 2% concentrations did not show mortality of two natural enemies *Cryptolemus montrouzieri* and *Chrysoperla zastrowi sillemi* indicating their safety.

5.1.6. Exploitation of *Beauveria bassiana* for management of stem borer (*Chilo partellus*) in maize and sorghum through endophytic establishment

Field evaluation of endophytic *B. bassiana* against maize and sorghum stem borer

Field trials were conducted to evaluate the endophytic isolates of *Beauveria bassiana* (NBAIR-Bb-5a, 7, 14, 19, 23 and 45) through foliar applications of oil formulations against stem borer, *Chilo partellus* in maize and sorghum at ICAR-NBAIR, Attur Research Farm, Bengaluru.

In maize, Bb-5a isolate showed significantly lower dead hearts (10.2 and 7.1% during kharif and rabi seasons respectively), lowest no. of exit holes (1.80 and 1.07/plant) and stem tunneling (1.23 and 2.21 cm/plant) as compared to untreated control which showed higher dead hearts (23.6 and 26.8%), exit holes (7.2 and 4.07/plant) and stem tunneling (5.2 and 7.8 cm/plant).

In sorghum, Bb-23 and Bb-5a isolates showed significantly lesser dead hearts of 6.8 and 9.3%, respectively, lowest exit holes of (0.4 and 0.7/plant) and stem tunneling (3.7 and 4.3 cm/plant), as compared to untreated control with 19.8% of dead hearts, 2.1/plant exit holes and 10.2 cm/plant of stem tunneling.

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

5.2.1 Biodiversity of biocontrol agents from various agro ecological zones

AAU-A: The populations of the biocontrol agents, *viz*., *Trichogramma, Chrysoperla, Cryptolaemus,* spiders and entomopathogenic nematodes (EPNs) were collected from different crop ecosystems in Anand district. Among the predators, *Chrysoperla zastrowi sillemi* (Esben-Peterson) was found in alllocations. Similarly the activity of coccinellids and *Cryptolaemus* was studied. Hardly any anthocorids was recorded during the period. Seventeen species of spiders were collected from paddy ecosystem. *Bt* isolates were obtained from 58 soil samples out of the 300 samples collected from Panchamahal district.

AAU-J: Coccinellids collected on different *rabi* vegetables infested by aphids, mealybugs and whiteflies were identified as *Coccinella septempunctata*, *C. transversalis*, *Brumoides suturalis* and *Micraspis* spp. Different types of spiders were collected from different habitats such as grasses, moist places, under stones, pebbles, dead leaves, humus, bushes, on the bark and branches of trees, houses and huts. The most dominant spider species collected from rice ecosystem were *Oxyopes* sp., *Tetragnatha* sp., *Lycosa pseudoannulata* and *Argiope catenulata*.

PJSTAU: Natural enemy populations, *viz., Trichogramma chilonis*, coccinellids, *Chrysoperla*, predatory earwig, *Euborellia sp.* and spiders were recorded from different ecosystems during Rabi, 2015.

IARI: Field collected strains of *Trichogramma chilonis* were maintained under laboratory conditions on *Corcyra cephalonica* eggs. Test and back crosses were made between different strains of *Trichogramma chilonis* AAA10 (relatively temperature tolerant) with other high fecundity strains, *viz.*, FFF1, FFF2 and FFF3 and mortality was high among the individuals in each generation. The crosses with high fecundity strains were relatively more susceptible to test temperature regimes coupled with higher percentage of arrhenotoky. Per cent arrhenotoky among the progenies also increased with increase in temperature.

MPKV: The natural enemies recorded were coccinellids, *Coccinella septempunctata*, *Menochilus sexmaculata*, *Scymnus* sp, parasitoids and predators on sugarcane woolly aphid, *Encarsia flavoscuttellum, Dipha aphidivora*, *Micromus igorotus* and syrphids; *Coccinella transversalis, M. sexmaculata, Brumoides suturalis*, *Scymnus coccivora* and *Triomata coccidivora* on custard apple mealybug colonies and *Acerophagus papayae*, *Pseudleptomastix mexicana, Mallada boninensis*, *Spalgis epius, Scymnus nubilus*, *Phrynocaria perrotteti* on papaya mealy bug. The chrysopid, *Chrysoperla zastrowi sillemi* was recorded in cotton, maize and French bean, while *M. boninensis* on French beans, mango, okra, papaya and sunflower. The *Cryptolaemus* adults were recovered from the pre-released plots of custard apple and papaya. Cadavers of *Helicoverpa armigera* and *Spodoptera litura* infected with EPNs were collected the fields of soybean, potato and tomato.

PAU: Five different entomopathogenic fungi were isolated from 31 soil samples of various crop ecosystems in Fatehgarh Sahib, Sangrur, Pathankot and Barnala districts. Five *Bacillus* bacteria were isolated from soil samples of various crop ecosystems in Barnala, Patiala, SAS Nagar, Amritsar and Ludhiana districts. EPNs have been recovered from 10 soil samples out of fifty samples collected from different locations of Punjab.

SKUAST: Surveys on different horticultural crops including apple, apricot, plum, pear, peach, cherry, walnut and almonds were conducted in Kashmir valley and Ladakh. Among important natural enemies, aphelinid parasitoids, *Encarsia perniciosi*, *Aphytis proclia*, *Ablerus* sp. and coccinellid predator, *Chilocorous infernalis* were found on San Jose scale exclusively in unmanaged orchards. *Aphelinus mali* was found actively associated with apple woolly aphid, *Eriosoma lanigerum.* Nine natural enemies were recorded for the first time from Kashmir in association with different fruit pests.

TNAU: The predators, *viz.*, *Cryptolaemus montrouzieri* and *Chrysoperla zastrowi sillemi* were recorded on mealybugs, scales and psyllids infesting brinjal, curry leaf, guava, papaya and tapioca.

UAS-R: *Trichogramma* spp. and *Chrysoperla* sp. were collected from different crop ecosystems at regular intervals. Parasitoids of tomato pinworm, *Tuta absuluta* were collected.

5.2.1.1 Surveillance for alien invasive pests

No alien invasive insect pests like *Aleurodicus dugesii*, *Brontispa longissimi*, *Phenacoccus manihoti*, *Phenacoccus madeirensis* and *Frankliniella occidentalis* were observed in any of the centres. Mealybugs recorded on papaya in Tamil Nadu were *Paracococcus marginatus* and *Pseudococcus jackbeardsleyi*; in Maharastra, *Pseudococcus jackbeardsleyi* was recorded on custard apple, *P. marginatus* was observed in the papaya orchards of western Maharashtra along with the encyrtid parasitoid *A. papayae* and *P. mexicana*. A new parasitoid, *Aprostocetes* nr. *purpureus* reported for the first time from PMB colonies in Rahuri region of Maharashtra. Tomato pinworm, *Tuta absoluta* was recorded from Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra, Gujarat and Himachal Pradesh.

5.2.2 Biological suppression of plant diseases

5.2.2.1 Biological control of diseases of rice, pea and chickpea

GBPUAT: In rice among different *Trichoderma* isolates tested, TCMS 9 and PBAT 3 were found effective in improving plant health, reducing sheath blight and brown spot diseases and in increasing yield. In pea, TCMS 9, PBAT 3 and PSF 173 reduced seed and plant mortality in field. In chickpea, PSF 2 and PBAT 3 were found very promising in reducing seed as well plant mortality in the field.

5.2.2.2 Biological control of chilli anthracnose diseases

AAU-A: Among the different biocontrol treatments tested, *Pichia guilliermondii* (Y12) seed treatment, seedling dip and foliar spray ($2x10^8$cfu ml^{-1}) was found superior to all with the minimum disease intensity (13.6%) and the maximum yield (38.2 q/ha).

PAU: Lowest per cent of fruit rot (19.2%) was recorded in chemical control, which was followed by *P. guilliermondii* (22.1%) and *Trichoderma harzianum* (24.2%) treatments. Highest yield of 67.7 q/acre was recorded in chemical treatment followed by *P. guilliermondii and T. harzianum* treatments with a yield of 58.5 and 56.7 q/acre respectively.

GBPUAT: *T. harzianum* (Th-3) and *P. guilliermondii* (Y-12) were found significantly better in reducing fruit rot with increased yield.

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

GBPUAT: In tomato, PSF-2, PSF-173 and PBAT 3 were found effective in reducing pre- and post-emergence seedling mortality with increased plant vigour. In onion, PBAT 3 was found very promising in reducing pre and post emergence mortality coupled with better plant vigour.

5.2.3 Biological suppression of sugarcane pests

5.2.3.1 Monitoring of sugarcane woolly aphid and its natural enemies

MPKV: Monitoring of sugarcane woolly aphid (SWA) incidence and impact assessment of natural enemies on its bio suppression was carried out in Maharashtra. The average pest incidence and intensity were 1.5 per cent and 1.6, respectively. The natural enemies recorded in the SWA infested fields were mainly predators like *Encarsia flavoscutellum* (5.1 adults/leaf), *Dipha aphidivora* (0.6 to 3.0 larvae/leaf), *Micromus igorotus* (1.2 to 5.2 grubs/leaf), syrphid, *Eupeodes confrator* (0.4 to 1.0 larvae/leaf) and spider (0.1 to 0.3 /leaf) during July to March, 2016. The parasitoid, *Encarsia flavoscutellum* was distributed and established well in sugarcane fields and suppressed the SWA incidence in Solapur, Pune and Satara districts.

TNAU: The SWA was noted in patches in Erode, Karur, Coimbatore and Namakkal areas of Tamil Nadu. The incidence of SWA was noted from November 2015 and the population escalated from January 2016 and the maximum population ranged up to 18.4 SWA/2.5 sq.cm leaf area during March 2016 in Erode district followed by Namakkal district (12.6 SWA/2.5 sq. cm).

PJTSAU: In Telangana, patchy appearance of SWA was noticed in a few fields of Nizamabad and adjoining areas of Medak.

5.2.4 Cotton

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

AAU-A: Significantly minimum number of jassids (0.6/leaf), whiteflies (2.5/leaf), aphids (5.2/leaf) and thrips (1.2/leaf) were registered in the treatment *Lecanicillium lecanii* @ 40 g/ 10 litre. However, none of the tested microbial insecticides found superior to chemical pesticide.

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

MPKV: The mealybug and other sucking pests incidence was recorded in cotton from 1st fortnight of August 2015 till January, 2016 in the experimental plot. However, the incidence of mealybug was not observed on cotton till December, 2015 and incidence of sucking pests started from August, 2015 onwards. The natural enemies generally present in cotton ecosystem were predatory coccinellids, *Coccinella*, *Menochilus* and *Scymnus*, chrysopids, *Brumoides* and spiders. The highest seed cotton yield (18.01 q/ha) was recorded in chemical treatment and it was at par with *L. lecanii* treated plots.

PJTSAU: In Telangana, survey for infestation and intensity of sucking pest incidence showed incidence of jassids to a greater extent followed by whiteflies and thrips.

5.2.4.3 Monitoring biodiversity and outbreaks for invasive mealybugs on cotton

PAU: Regular surveys of mealybugs and its natural enemies in Ludhiana and major cotton growing areas of Punjab revealed only one mealybug species, *Phenacoccus solenopsis* on cotton. There was no major outbreak of pests on cotton. However, coccinellid predators such as *C. sexmaculata*, *C. septempunctata* and *B. suturalis* and green lace wing, *Chrysoperla zastrowi sillemi* were noticed feeding on mealybug. The parasitism by parasitoids under field conditions varied from 40.0 to 68.2%, out of which endoparasitoid, *Aenasius arizonensis* (73.2%) was predominant, which in turn was hyperparasitised by *Promuscideaun fasciativentris* to the extent of 26.8%.

UAS-R: The activity of mealybug appeared during second fortnight of October and continued till the harvest of the crop. The peak activity was noticed during second week of February with an average population of 85.42 mealybugs/plant, which also coincided with the peak activity of its primary parasitoid, *Aenasius arizonensis* (18.05/plant). The peak activity of *Anagyrus dactylopii* was noticed during second fortnight of January.

TNAU: Survey conducted in Coimbatore, Erode and Tiruppur districts of Tamil Nadu on cotton host plants indicated the incidence of five species of mealybugs and *Phenacoccus solenapsis* and *Nipaecoccus viridis* were predominant.

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

PAU: Regular observations of diversity of sucking pests, bollworms and their natural enemies in transgenic *Bt* and non-*Bt* cotton in Ludhiana showed that the incidence of sucking pests was less in sprayed condition as compared to unsprayed condition. Bollworm incidence was not observed on Bt cotton. However, on non-Bt cotton the mean larval population, damage in freshly shed fruiting bodies, green boll damage was comparatively more under unsprayed condition as against sprayed condition. The predator population (spiders, coccinellids, *Chrysoperla*, *Geocoris* sp. and *Zanchius* sp.) was more in unsprayed conditions as against sprayed conditions on both Bt and non-Bt cotton. During 2015, epidemics of whitefly, *Bemisia tabaci* was recorded in cotton belt of Punjab.

UAS-R: The activity of mirid bug was noticed during second fortnight of October with a peak population during first week of December (1.33 mirid bugs/plant) which was also coincided with the peak activity of associated predators.

5.2.5. Rice

5.2.5.1 Seasonal abundance of predatory spiders in rice ecosystem:

PAU: Regular surveys to study the diversity of spiders from rice growing areas. A total of 10 species were recorded from the rice fields. *Neoscona* sp. was the predominant species (78.11%) at all the locations followed by *Tetragnatha* sp (14.98%). Species diversity (0.867) was calculated as per Shannon-Weiner index of diversity. Species evenness (0.377) and dominance index (0.623) was worked out as per formulae given by Krebs and Southwood, respectively.

5.2.6 Maize

PJTSAU: Filed release of *Trichogramma chilonis* (75,000 & 100,000 parasitoids/ha) at 15 days after seedling emergence, three times at weekly intervals was found effective in reducing maize stem borer damage.

5.2.7 Sorghum

IIMR: Three entomofungal formulations each of *B. bassiana* and *M. anisopliae* were evaluated for their efficacy against *C. partellus* during Kharif 2015 at the Indian Institute of Millets Research (IIMR), Hyderabad in comparison with whorl application of Carbofuran 3G @ 8 kg/ha. It was found that entomofungal formulations of *Metarhizium,* Ma 35, 36 and 52 were effective against the spotted stem borer, causing 48.6 %, 51.4 % reduction in dead hearts and stem tunneling over the untreated control, and they were on par with application of carbofuran. The grains harvested from the experimental plot (19.2 m^2) indicated that the strains Ma 35 and Ma 36 caused significant increase in grain yield (4.16 and 4.25 kg/ plot), respectively as compared to control which recorded 2.85 kg/plot. Carbofuran whorl application @ 8 kg/ha was significantly superior (4.32 kg/plot) and was on par with the strain Ma 36 and Ma 35 and Ma 52.

UAS-Raichur: After 10 days of spray, *B. bassiana* -45 @ 1.5 ml/l was recorded minimum dead hearts (7.58/ plot) which was at par with *M. anisopliae* - 35 @ 1.5 ml/l which recorded 7.88 dead hearts per plot. Untreated control recorded 12.16/ plot dead hearts. Similar trend was noticed on 20 days after spray. On second spray also *B. bassiana* -45 recorded minimum dead hearts and there was no significant increase in number of dead hearts compared to untreated control which recorded 18.36 dead hearts per plot on ten days after second spray. Minimum tunnelling of 12.78 cm was noticed in *B. bassiana* -45 @ 1.5 ml/l and it was at par with *M. anisopliae* - 35 which recorded 15.83 cm tunnelling while untreated control recorded the highest tunnelling of 64.17 cm. The highest grain yield of 10.05 q/ha was recorded in *B. bassiana* -45 and it was at par with *M. anisopliae* - 35 which recorded 9.88 q/ha grain yield. Untreated control recorded 7.46 grain yield.

5.2.8 Pulses

5.2.8.1 Evaluation of *Bt* formulations against pulse borer (*Helicoverpa armigera*) and legume pod borer (*Maruca testulalis*)

PAU: PDBC-BT1 (2%) and Delfin (1 or 2 kg /ha) treatments gave the lowest pod damage in moong bean and at par with each other, followed by chlorpyriphos 20 EC @ 1.5 l/acre.

5.2.8.2 Large Scale demonstration of NBAII liquid formulation (PDBC BT1 and NBAII *BT* -4) against pigeon pea pod borer (*Helicoverpa armigera*)

AAU-A: Lower incidence of *H. armigera* larvae (0.5 to 0.6 /plant), damage on pod (6.8 to 7.6%) and grain (8.0 to 10.0%) were noticed in NBAII liquid formulation as against farmers' practices.

5.2.9 Tropical Fruits

5.2.9.1 Field evaluation of *Metarhizium anisopliae* formulations against mango hoppers, *Idioscopus niveosparsus*

TNAU: Maximum fruit set of 3.2 fruits/inflorescence was recorded in liquid formulation of *M. anisopliae* treatment whereas the least fruit set of 2.3/inflorescence was noted in untreated check. Though superior performance of imidacloprid in checking the hopper population was noted, the fruit set was comparable with *M. anisopliae* liquid formulation. The order of efficacy among the different formulations of *M. anisopliae* in checking the hopper population was liquid formulations > talc formulation > oil formulation.

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

AAU-A: Regular surveys to monitor *Paracoccus marginatus* in papaya growing areas of middle Gujarat revealed that nine fields in seven villages were infested with the mealybug.

MPKV: The incidence of papaya mealy bug was noticed in all districts of western Maharashtra (1.0 to 13.3%). The highest incidence of PMB (13.3%) was recorded in Sahada and Taloda tahsils of Nandurbar district. However, *Acerophagus papaya, Pseudleptomastix* *mexicana* and *Spalgis epius* was found associated with PMB. The average pest population density was relatively low during this year as compared to previous year.

TNAU: Among the eight districts surveyed, maximum incidence and prevalence was noted in Erode district followed by Tirupur and Coimbatore. The incidence was noticed from April 2015 which escalated to a maximum of 8.6% in August 2015 (Erode) followed 7.4% in September 2015 (Erode). The occurrence of mealybug was absent in November and December, 2015.

5.2.10 Temperate Fruits

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

YSPUHF: Among different biopesticides tested, *Metarhizium anisopliae* (10^6 conidia/ cm^2) was the most effective with 70.4% mortality of grubs and was on par with chlorpyriphos, 0.06% which resulted in 85.8% mortality of the grubs.

5.2.10.2 Survey for identification of suitable natural enemies of codling moth, *Cydia pomonella*

SKUAST: Average parasitism by larval and pupal parasitoids of codling moth was 0.63%. Survey did not reveal the presence of indigenous *Trichogramma* sp.

5.2.10.3 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 52.9% reduction in damage over control.

5.2.10.4 Evaluation of predatory bug, *Blaptostethus pallescens* against European red mite (ERM), *Panonychus ulmi* on apple

SKUAST: Average consumption of ERM eggs / nymph/day was 4.7, 6.2, 8.9 and 9.2 in relation to predator: prey ratio of 1: 5, 1: 10, 1: 15 and 1: 20, respectively. Consumption rate of adult female of *B. pallescens* was worked out as 5.0, 8.7, 11.6 and 11.9 eggs of ERM/ day in relation to identical predator prey ratio. Difference in fecundity potential between nymphs and adults was found statistically significant.

5.2.10.5 Field evaluation of anthocorid bug, *Blaptostethus pallescens* against two spotted red spider mite (TRS), *Tetranychus urticae* on apple

SKUAST: Average consumption of TRS eggs / nymph/day was 7.7, 9.1, 10.8 and 10.9 eggs/day in relation to predator: prey ratio of 1: 10, 1: 15: 1: 20 and 1: 25, respectively. Consumption rate of adult female of *B. pallescens* was worked out as 9.7, 11.8, 13.1 and 13.6 eggs/ day in relation to identical predator prey ratio. Positive correlation between feeding and predator density was observed both in nymphs (r= 0.91**) as well as adult females (r= 0.89**). Difference between rate of consumption between nymphs and adults was worked out to be statistically significant.

5.2.11 Vegetables

5.2.11.1 Field demonstration of BIPM package for the management of key pests of tomato

AAU-J: BIPM package and chemical control treatments were equally effective in reducing the sucking pests, *Helicoverpa armigera*. Both the treatments were significantly superior to untreated check. The highest yield was recorded in BIPM package (291.9 q/ ha), followed by chemical control plot (287.0 q/ha).

YSPUHF: Among different biocontrol agents/biopesticides evaluated against the greenhouse whitefly, Azadirachtin (1500 ppm; 3 ml/L) was the most effective with 60.2% reduction over control, which was on par with *Lecanicillium lecanii* (5 g/L of 10^8 conidia/g) and *Chrysoperla* (1 larva/plant,) which resulted in the reduction of 57 and 50% respectively. However, none of these treatments could match the efficacy of imidacloprid (0.0075%), which reduced the whitefly population to the tune of 94.1% over control. As far as the control of *T. urticae* is concerned, all the tested bioagents were only moderately effective resulting in 47.9 to 54.5% reduction of the mite population as against 89.9% reduction by fenazaquin (0.0025%).

TNAU: The cost benefit ratio in BIPM plot was 1: 3.2, whereas farmers practice with four insecticide sprays showed 1: 2.7.

5.2.11.2 Validation of *Ha N*PV in tomato against *H. armigera* at farmers' field

MPUAT: IPM module comprised of five weekly releases of *T. chilonis* @ 1 lakh/ha followed with 2 sprays of *Ha* NPV, first at the occurrence of pest and second spray after 15 days of first spray**.** Farmer practices included three applications of insecticides. Result indicated that the fruit damage was significantly low in IPM modules (13.8%) as against 20.6% fruit damage observed in farmer' practice fields. The yield observed in IPM module was higher (232.34 q/ha).

5.2.11.3 Survey and surveillance of tomato pinworm, *Tuta absoluta*

AAU-A: Surveys revealed the incidence of *T. absoluta* to the tune of 8.0 to 90.0%.

MPKV: The incidence of *T. absoluta* on tomato was observed in Yedagan, Umbraj, Pipmpalwandi, Manjarwadi and Avasari villages of Pune district. The leaf and fruit damage by pinworm was 28.6 and 12.5%, respectively, with the peak incidence being recorded in March, 2016.

SKUAST: Incidence of *T. absoluta* was not observed on tomato and eggplant during surveys in and around Kashmir.

UAS-R: The incidence of pin worm was noticed from second fortnight of September onwards and continued till the harvest of the crop. The peak activity of pin worm was observed during second fortnight of January with the highest moth traps (2221.1 moths/ trap).

YAPUHF: *T. absoluta* was recorded on tomato leaves, flowers, terminal shoots and fruits at Nauni, Solan, in a survey conducted during May to December 2015 in different tomato growing areas of Himachal Pradesh. Mirid bug, *Nesidiocoris tenuis* (Reuter) (Hemiptera: Miridae) was found associated with the pest.

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

UAS-R: Among the different biological control agents evaluated, *Metarhizium anisopliae* @ 1.5 ml/l was the most effective one with the minimum number of larvae (2.9 larvae/ top five leaves) and fruit damage (5.3%). The highest fruit yield (25.8 t/ha) was also recorded on *Metarhizium anisopliae* @ 1.5 ml/l.

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

AAU J: The damage of shoots (9.5%) and fruits (17.7%) was minimum in BIPM package as compared to chemical control plots (13.0 and 20.0%, respectively). The yield of BIPM package was 203.5 q/ha as against 208.7 q/ha in chemical control plot and both were found to be on par with each other.

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

PAU: Three sprays of profenophos 0.05% at fortnightly interval was effective with the least shoot damage (5.2%) and fruit damage (7.1%) and gave maximum yield (313.9 q/ha). However, the BIPM module consisting release of *T. chilonis* @ 50,000 parasitoids/ha followed by spraying of NSKE 5% and *B. thuringiensis* @ 1 lit/ha twice at weekly interval was the next best treatment showing with 278.4 q/ha yield.

5.2.11.7 Biological control of brinjal mealybug, *Coccidohystrix insolitus*

TNAU: The insecticide treated plot showed minimum number of mealybug per plant (1.4) after 15 days of first spray and 1.8 mealybugs/ plant after 15 days of second spray with an yield of 70 t/ha. The next best treatment was release of *Cryptolaemus* @ 1500/ha with a population of mealybugs of 32.4/plant after 15 days of 1st release and 5.3/plant after 15 days of second release with yield of 67.8 t/ha. Highest number of predators were found in the treatment with *Cryptolaemus* @ 1500/ha (5.3 and 8.6/10 plants after 1st and 2nd release, respectively).

5.2.11.8 Bioefficacy evaluation of EPN formulations of NBAIR against ash weevil in brinjal

TNAU: Chlorpyriphos drenching recorded the maximum reduction of weevil population (84.1%), followed by soil application of EPN along with *Metarhizium anisopliae* NBAIR formulation (76.4%).

5.2.11.9 Role of habitat manipulation on natural enemies of cabbage pests

AAU-J: Minimum larval population of *Plutella xyllostella* (1.90/plant) and maximum number of coccinelids (1.77/plant) were observed in cabbage intercropped with mustard and cowpea, with highest yield of 174.9 q/ha. The next best treatment was cabbage intercropped with mustard and sorghum as border crop in respect of yield (174.5 q/ha), which was followed by cabbage with sorghum as border crop (166.1 q/ha).

5.2.11.10 Efficacy of *Bt* strains against diamond back moth in cauliflower

TNAU: NBAII BTG4 and PDBC BT1 *Bt* strains @ 2% sprays were effective in reducing the larval population up to 59.0% over control after 1st round of spray. But, these *Bt* strains were found less effective as compared to insecticides, which reduced larval population by 79.0% over control. After three rounds of spraying, the *Bt* strains were able to reduce the larval population of DBM up to 84.0% (NBAII BTG 4 @ 2%) as compared to 90.0% reduction of larval population in insecticide treated plot. Both *Bt* strains were on par in their efficacy in checking the larval population of DBM. The curd yield was maximum in insecticide treated plot (12.4 t/ha) as compared to 11.3 to 11.9 t/ha in *Bt* strains treated plots. The order of efficacy among the *Bt* strains in containing the larval population of DBM was NBAII BTG4 2% > PDBC BT1 2% > NBAII BTG4 1% > PDBC BT1 1%.

5.2.11.11 Evaluation of fungal pathogens against sucking pest of hot chilli (*Capsicum sinensis*)

AAU-J: The mean population of *Aphis gossypi* and *Scirtothrips dorsalis* was 6.3 and 2.7% /10 leaves in imidacloprid treated plot followed by NBAIR Bb 5a strain with 8.0 and 3.6/ 10 leaves after third spray. Highest yield of hot chilli (50.7 q/ha) was recorded in imidacloprid @ 20 g a.i/ha treated plot. This was followed by NBAIR-Bb5a with yield of 42.0 q/ha.

5.2.11.12 Evaluation of predatory bug, *Blaptostethus pallescens* against red spider mite of okra

PAU: The release of *B. pallescens* @ 30 nymphs/ m row was superior in suppressing the mite population (7.7 mites/plant) and it was statistically at par with chemical control (4.2 mites/plant).

5.2.11.13 Evaluation of biointensive IPM module against *Aleurodicus dispersus* on cassava

TNAU: The implementation of BIPM module effectively reduced the spiralling whitefly population (86.3 whiteflies/ plant) as compared to 380.5 whiteflies/ plant in insecticide sprays. The untreated check harboured 520.4 whiteflies/ plant. The population reduction of spiralling whitefly achieved by BIPM was 83.4% as compared to 26.9% in farmers' practice with two rounds of insecticide sprays.

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

YSPUHF: Evaluated C*hrysoperla zastrowi sillemi* (1 larva/plant), *Lecanicillium lecanii* (5 g/L of 10^8 conidia/g), Azadirachtin (1500 ppm; 3 ml/L) and methyl demeton (0.025%) against the green peach aphid, *Myzus persicae* on capsicum (cv. Solan Bharpur). All the treatments were only moderately effective and statistically at par against the aphid resulting in 46.2 to 62.7% reduction in the aphid population over control.

5.2.12 Biological suppression of polyhouse crop pests

5.2.12.1 Monitoring of pests and natural enemies in *Chrysanthemum* under polyhouse conditions

TNAU: Survey on the pests of *Chrysanthemum* grown in poly house was carried out in different places, *viz*., Kothagiri, Yercaud and Kodaikanal. The survey revealed occurrence of whitefly (*Bemisia tabaci*), serpentine leaf miner (*Liriomyza trifolii*) and tetranychid mite (*Tetranychus urticae*).

5.2.12.2 Evaluation of efficacy of predators against cabbage aphids in polyhouse

SKUAST: *Coccinella septempunctata* was found superior to *C. z. sillemi* in terms of pest suppression, as evident from statistically significant differences in aphid densities after second release of predators. Per cent reduction in aphid density was 76.5 and 63.1 for *C. septempunctata* and *C. z. sillemi*, respectively, over control indicating coccinellid to be more effective. Differences in per cent reduction in aphid density when compared for the two predators were found statistically significant after first to fifth release.

5.2.12.3 Evaluation of predatory mite, *Neoseiulus longispinosus* against phytophagus mite in carnation under poly house conditions

YSPUHF: Among different treatments of bio-pesticides and bioagents, *N. longispinosus* at 1: 10 predator: prey ratio was the most effective resulting in 74.2% reduction of mite population over control, which was on par with fenazaquin (0.0025%) treatment resulting 85.2% reduction of mites.

5.2.12.4 Evaluation of biocontrol agents against sap sucking insect pests of rose in polyhouses

YSPUHF: Biocontrol agents like *Beauveria bassiana, Metarhizium anisopliae, Lecanicillium lecanii* (5 g/L each of 10^8 conidia/g), *coccinella septempunctata* (10 beetles/plant) and Azadirachtin (1500 ppm; 3 ml/L) were evaluated against the rose aphid, *Microsiphum rosaeiformis* on rose under polyhouse conditions at Nauni, Solan during October-2015. Methyl demeton (0.025%) and water spray were included in the experiment as standard recommended insecticide and control, respectively. Results revealed botanical, Azadirachtin (1500 ppm; 3 ml/L) resulted in the highest reduction (79.9%) in aphid population over control and equally good performance (68.8% reduction) was given by *Coccinella septempunctata* when released @ 10 beetels/plant. Entomopathogenic fungi *viz.*, *L. lecanii*, *M. anisopliae* and *B. bassiana* (each @ 5 g/L of 10^8 conidia/g), however, were only moderately effective resulting in 51.2, 36.3 and 31.3% reduction of aphid population over control, respectively. In contrast, methyl demeton (0.025%) was the most effective causing 92.5% reduction in aphid population.

MPKV: Three sprays of abamectin 0.5 ml/lit @ 15 days interval was found to be the most effective in reducing the mite population on rose (8.22 mites/ 10 compound leaves/plant) as compared to other treatments. However, four releases of predatory mites @ 10/ plant at weekly interval and three sprays of *Hirsutella thomsonii* (1 x 10^8 conidia/g) @ 5 g/litre were the next best treatments with an average 18.22 and 20.89 mites/10 compound leaves/plant, respectively.

PAU: The release of *B. pallescens* @ 30 nymphs/ m row was found to be the most effective in suppressing the mite population (7.7 mites /plant) and it was statistically at par with chemical control (4.2 mites/ plant).

5.2.13 Biological suppression of storage pests

5.2.13.1 Evaluation of *Uscana* sp. (Trichogrammatidae) against *Callosobruchus* sp. on storability of pigeon pea seed

Directorate of Seed Research: The results of the experiments showed that increase in number of *Uscana* sp. is directly proportional to the level parasitism. The highest parasitism of 42% and lowest seed infestation was observed in the treatment (*Uscana* sp. 40 were released). The germination of pigeon pea seeds was highest in the treatment of *Uscana* sp. 40 released (82.33%) compared to 75% seed germination in control.

5.2.14 Large-scale adoption of proven biocontrol technologies

5.2.14.1 Rice

AAU-J: Large scale demonstration of bio control based IPM package in rice was carried out in the farmers' field at village Borholla in Jorhat district. There was no significant difference in population of *Nephotettix* sp./hill and dead heart (%) in BIPM and farmers' practice. The incidence of dead hearts (3.4%) and damaged leaves (2.5%) due to *Cnaphalocrocis* sp. was significantly high in farmers' practice plots compared to BIPM. In case of white ear heads, the per cent incidence was 1.99 in BIPM plots, which was significantly superior to farmers' practice plots (2.8) @ 125 DAT. Maximum yields of 4126.0 kg/ha was registered in BIPM package, which was at par with farmers' practice (3984.4 kg/ha). The population of natural enemies like spiders and coccinellids were significantly high in BIPM compared to farmers' practice. It can be concluded that BIPM package proved as effective as farmers' practice on large scale for the management of important key pests of rice.

KAU: Large scale validation of IPM practices in rice was carried out in an area of 10 ha at Anakkappara in Vadekkenchery Panchayat of Palghat District. The adoption of IPM practices led to substantial reduction in infestation by major pests. The mean stem borer population in IPM plots was 37% lower as compared to non IPM plots. Similarly, the dead heart as well as white ear head symptoms recorded 83 and 92% reduction respectively. The population of natural enemies was higher in IPM plots. The yield obtained from IPM plots was 37% more than that obtained from non IPM plots. The cost of cultivation also was 16% lower in the former. The increased yield as well as reduced cost resulted in an increase in profit by Rs 52,960/ha. The cost benefit ratio, of 1:2.97 which is almost double for IPM fields as compared to 1:1.45 for non IPM fields.

PAU: Large scale demonstration of biocontrol based IPM (six releases of *T. chilonis* and *T. japonicum* each @ 100,000/ha in ten locations in the village Nabha (Patiala) in organic *basmati* rice (var. Pusa 1121) over an area of 50 acres resulted in lower incidence of insect pests. The net return in biocontrol package was Rs. 14652 as compared to Rs. 8379 in farmers' practice, with cost benefit ratio of 1: 3.88 and 1: 2.76, respectively.

GBUAT: During kharif season 2015, large scale field demonstrations of biocontrol technologies were conducted in 42 farmers' fields covering an area of 70 acres in different villages of Nainital district. The Pant Bioagent-3 was applied as soil application with FYM/ vermicompost (5-10 t/ha colonized with PBAT-3), as seed treatment (10 g/kg seed), seedling dip treatment (10 g/lit. water) and need-based foliar sprays of PBAT-3 (10 g/lit. water) were given. By adopting bio-control technologies, an average yield of 45.0 q/ha was obtained as compared to conventional farmers' practice (37.0 q/h).

5.2.14.2 Sugarcane

PAU: Large scale demonstration of effectiveness of temperature tolerant strain of *Trichogramma chilonis* (TTS) @ 50,000/ ha @ 10 days interval (twelve releases) against *Chilo infuscatellus* over an area of 1500 acres at farmers' fields was conducted in collaboration with three sugar mills. Bioagent treated plots showed 53.1% of reduction of pest damage.

Release of *T. chilonis* @ 50,000/ha at 10 days interval during July to October, 2015 (twelve releases) over an area of 7150 acres at farmers' fields in collaboration with five sugar mills reduced the incidence of stalk borer, *Chilo auricilius* by 55.2%. Similarly 59.9% reduction of stalk borer was observed in an area of 140 acres in Jalandhar and Hoshiarpur districts of Punjab.

Large scale demonstration of effectiveness of *T. japonicum* @ 50,000/ha @ 10 days interval during mid-April to June end, 2015 (eight releases) against top borer, *Scirpophaga excerptalis* over an area of 190 acres in collaboration with two sugar mills indicated 53.6% reduction of top borer.

5.2.14.3 Maize

PAU: The demonstrations on the biological control of maize stem borer, C*hilo partellus* were conducted at farmers fields on an area of 325 acres in Hoshiarpur and Ropar districts of Punjab. Dead heart incidence of 6.7% was observed in fields where *T. chilonis* was released, which was on par with chemical control (4.2%) as against 14.8% incidence in untreated control. The net return in biocontrol package was Rs. 9653/- as compared to Rs.13248/- in farmers' practice, with cost benefit ratio of 1: 47.09 and 1: 36.80, respectively.

5.2.14.4 Brinjal

OUAT: Large scale demonstration of BIPM in brinjal covering 100 acres in the village of Karatapeta in Angul district of Odisha was carried out. BIPM adopted included pheromone traps, weekly release of *Trichogramma chilonis* @ 50,000/ha / week (total of 15 releases) and two sprays of *Bt*. Farmers' practice was spraying of Rynaxypyr @ 0.3 ml/L at fortnightly intervals. The shoot borer and fruit borer incidence was significantly low in BIPM plots recording 12.8 and 21.9% respectively, whereas it was 29.1 and 43.7% in farmers' practice plots. Consequently, the yield was also higher in the BIPM plots (20,321 kg/ha) with the cost: benefit ratio of 1: 5.1, whereas the yield in farmers' practice plot was 12,209 kg/ha with C: B ratio of 1: 1.22. The BIPM practice produced a net return of Rs. 162,240/- over the farmers practice.

5.2.14.5 Pea

GBPUAT: During rabi 2015-16, large scale field demonstrations of bio-control technologies was conducted on pea variety Arkil, at 25 farmers fields at Golapar area in Nainital district covering an area of 36 acres. Pant Bioagent-3 (PBAT-3) was applied as soil application with FYM/ vermicompost (5-10 tonnes/ha) colonized with PBAT-3 followed by seed biopriming (10 g/kg seed). Due to the successive application of biocontrol agents, the farmers got desired yield of green pea of 65 q/ha as compared to the yield in conventional farmers practices (42 q/ha).

5.2.15 Tribal Sub Plan Programme (TSP)

ANGRAU-Anakapalle: Organic farming of Paddy

Arakuvalley Tribal Farmers with small land holdings of half an acre to one acre are benefited from ICAR- Tribal sub Plan Programme implemented by AICRP Biological Control centre at ANGRAU RARS, Anakapalle by conducting Front line demonstrations on Paddy Organic farming techniques in 40 acres area at two villages *i.e*., Kothavalasa and Gunjariguda, Dumbriguda mandal, Araku valley, Visakhapatnam district, Andhra pradesh during kharif and rabi, 2015-16. About 50 farmers are successfully cultivated paddy and obtained good yields due to adoption of organic farming practices in paddy.

Supplied the paddy variety 2 kg per each farmer; issued *Pseudomonas flourescens* @ 250 g/ 30 kg seeds/acre Conducted method demonstration on seed treatment with *P. flourescens* for @ 5 g/kg seed during first and second week of July, 2015. Issued liquid Biofertilizers – *Azospirillum* and Phosphobacteria @ 500 ml per farmer. Trichocards (*Trichogramma chilonis*) for 4 releases @ 40,000 egg parasitoids per acre were also supplied.

Tribal farmers realized the use of biofertilizers application with good tillering and more productive tillers (8-10 tillers/hill) without zinc deficiency symptoms without incidence of stem borer as deadhearts and white ears and also leaf folder damage in organic farming block compared to check plot with poor tillering (4 tillers/hill) severe zinc deficiency with severe incidence of stem borer as deadhearts and white ears and leaf folder damage. Organic farming FLD farmers recorded higher yields (4025 kg/ ha) compared to 2100 kg/ha in farmers practice of without using fertilizer application and plant protection.

AAU-A: Biocontrol technologies for management of *Fusarium* wilt and pod borer (*Helicoverpa armigera*) in chickpea in Gujarat

Under the TSP project 50 tribal farmers were selected from Panchmahal and Mahisagar districts of Gujarat. Primarily the selected farmers were inspired to grow pigeon pea with improved seeds and biocontrol based IPM techniques to get better production. Biocontrol agents like *Trichoderma asperellum*, pheromone traps and neem based Azadirachtin were provided as inputs to control pests and diseases. In the TSP implemented fields more productive tillers (8-10 tillers/hill) were observed without zinc deficiency, lesser incidence of stem borer and leaf folder incidence, compared to the fields of traditional cultivation which showed severe zinc deficiency, poor tillering (4 tillers/hill) and severe incidence of stem borer as dead hearts and white ears and leaf folder damage. The tribal farmers in the TSP implemented fields recorded higher yields (4025 kg/ ha) compared to farmers practicing traditional cultivation (2100 kg / ha).

MPKV: Management of insect pests of horticultural/plantation crops in tribal area in Maharashtra

Tribal dominating areas of Harsul and Daltpatpur in the Taluka Trimbak of Nasik district in Maharashtra were selected for implementation TSP. Fifty Wadis (fruit orchards) of tribal farmers were selected to carry out operation of TSP. Bio fertilizers, bio pesticides and fruit fly and yellow sticky traps have been supplied to the selected tribal farmers. The anticipated impact of TSP Project on economic improvement of the tribal people and wealth creation in tribal areas will be known after harvesting of mango and cashew nuts.

OUAT: Demonstration on biointensive pest management on brinjal at Kandhamal and Keonjhar districts.

Demonstration on biointensive pest management was carried out in 20 acres of farmers' field on brinjal crop at Kandhamal and Keonjhar districts. Twenty beneficiaries were selected covering three blocks and six villages near KVK, G. Udayagiri. Similarly, twenty beneficiaries were selected covering one block and two villages of Keonjhar district near RRTTS, Keonjhar. Demonstration was given on 0.5 acre of existing brinjal crop of each beneficiary. The inputs, such as pheromone traps with lucin-lure @ 10 traps/acre, *Btk* @ 2 g/l and *Trichogramma chilonis* egg parasitoid @ 20,000/acre were provided to the beneficiaries and compared with the existing practice of spraying insecticides like Rynaxypyr @ 0.3 ml/l at 15 days interval

TNAU: Biocontrol methods for vegetable pest management in Tamil Nadu

Under the TSP, three trainings to tribal farmers were organised during the period under report. First training was organised at Kolli hills of Namakkal district. In this training, thirty tribal farmers were trained on the establishment of kitchen garden and its utility on nutritional security with free supply of vegetable seeds and other inputs. They were explained about the bio intensive pest management of vegetable crop to obtain pesticide-free vegetables. Demonstrations were carried out to explain the preparation of neem oil emulsion, neem seed kernel extract, seed treatment, use of sticky traps, pheromone traps and release of tricho cards, *Chrysoperla* and *Cryptolaemus* predators.

YSPUHF-Solan: Use of eco-friendly methods of pest management for apple, apricot and vegetable crop pests.

TSP was implemented in three villages (Poh, Tabo & Lari) in the Lahaul and Spiti district of Himachal Pradesh. 150 tribal farmers cultivating apple, apricot, peas, beans, cauliflower and cabbage in area of 275 ha were benefited. Inputs like, *Metarhizium anisopliae,* Yellow sticky traps, Blue sticky traps, Azadirachtin, *Helicoverpa* pheromone lure, *Spodoptera* pheromone lure, DBM pheromone lure, *Trichoderma viridae* and *Pseudomonas* were provided. Training to these farmers were provided and exposed to the use of biopesticides for pest management for the first time. On peas, beans and cole crops there was a reduction of 2-3 sprays of chemical pesticides.

6. Director and monitoring team visits to AICRP centers during 2015-16

Sl. No	Dates	Visit of Director/ NBAIR Scientist	Place of visit	Highlights of visit
1.	16.4.2015 to 17.4.2015	Dr. C. R. Ballal HOD, NBAIR	PAU, Ludhiana	Reviewed the progress of AICRP–BC work at PAU centre.
2.	2.5.2015	Dr. A. Verghese Director, NBAIR	KAU, Vellinikerra	Reviewed the progress AICRP–BC work at KAU.
3.	16.6.2015	Dr. A. Verghese Director	ANGRAU, Anakapalle	Discussed about the biocontrol research work to be taken up at the new centre of ANGRAU, at Anakapalle (AP)
4.	21.7.2015 to 22.7.2015	Dr. A. Verghese Director	SKUAST	Reviewed the progress of work of AICRP on Biocontrol at SKUAST, Srinagar
5.	14.9. 2015	Dr. A. Verghese Director	SKUAST Srinagar	Visited High Mountain and Agriculture Research Institute, of SKUAST-K at Leh and conducted biocontrol survey and stem borer.
6.	12.10.2015 to 13.10.2015	Dr. B. Ramanujam P.S.& I/C AICRP BC	PJTSAU, Hyderabad	Reviewed the progress of AICRP–BC work at PJTSAU centre and visited the experimental plots.
7	27.01.2016 to 30.01.2016	Dr. B. Ramanujam P.S.& I/C AICRP BC Dr. A.N Shylesha, P.S & Dr. M. Mohan, P.S	UAS-Raichur	Reviewed the progress of AICRP–BC work at UAS-R centre and visited the experimental plots. Participated in the Field day on the management of tomato pinworm
8	27.01.2016 to 03.02.2016	Dr. Sunil Joshi P.S.	OUAT, Bhubaneswar	Reviewed the progress of AICRP–BC work at OUAT, Bhubaneswar
9	29.02.2016 to 02.03.2016	Dr. B. Ramanujam P.S.& I/C AICRP BC	ANGRAU, Anakapallle	Reviewed the progress of AICRP–BC work at ANGRAU centre at Anakapalle and visited the experimental plots. Visited the TSP implemented villages at Araku valley.
10	16.03.2016 to 20.04.2016	Dr. Richa Varshney Scientist	GBPUAT, Pantnagar	Reviewed the progress of AICRP–BC work at GBPUAT, Pantnagar
11	17.03.2016 to 19.03.2016	Dr. B. Ramanujam P.S.& I/C AICRP BC	KAU, Thrissur	Reviewed the progress of AICRP–BC work at KAU Centre and visited the organic rice cultivation plots at Adat Panchayat.
12	18.3.2016	Dr. A. Verghese	PJTSAU,	Reviewed the progress of work of

		Director	Hyderabad	AICRP centre at PJTSAU, Hyderabad
13	19.03.2016 to 20.03.2016	Dr. S. K. Jalali HOD, NBAIR	AAU,Anand	Reviewed the progress AICRP-BC work at AAU, Anand centre
14	21.03.2016 to 22.03.2016	Dr. S. K. Jalali HOD, NBAIR	MPUAT, Udaipur	Reviewed the progress AICRP-BC work at MPUAT, Udaipur
15	22.3. 2016	Dr. A. Verghese Director	KAU, Thrissur	Visited the Biocontrol station at RARS, Kumarakom and discussed about the performance of NBAIR strains of Biocontrol agents
16	22.03.2016 to 24.03.2016	Dr. B. Ramanujam P.S.& I/C AICRP BC	MPKV, Pune	Reviewed the progress of AICRP–BC work at MPKV centre and visited the experimental plots and the TSP implemented villages in Nasik district.

7. Publications: During the year 2015-16, a total of **325** 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	Total
NBAIR, Bangalore	108	34	40	182
AAU, Anand	-	-	5	5
AAU, Jorhat	1	-	9	10
ANGRAU, Anakapalle	8	3	1	12
GBPUAT, Pantnagar	4	6	4	14
KAU, Thrissur	1	-	-	1
MPKV, Pune	1	1	3	5
PAU, Ludhiana	10	7	8	25
PJTSAU, Hyderabad	1	-	7	8
SKUAST, Srinagar	2	3	1	6
TNAU, Coimbatore	10	6	4	20
YSPUHF, Solan	7	5	-	12
MPUAT, Udaipur	3	-	-	3
UAS ,Raichur	-	-	2	2
IGKV , Raipur	10	-	6	16
IIVR	2	2	-	4
Total	**168**	**67**	**90**	**325**

8. Profile of experiments and demonstrations carried out during 2015-16

Crop/Insect	**Experiments**	**Large Scale Demonstrations**
Biodiversity of biocontrol agents	2	0
Antagonists of crop disease management	4	0
Sugarcane	4	4
Cotton	6	0
Tobacco	1	0
Rice	3	5
Maize	2	1
Sorghum	1	0
Pulses	5	2
Oilseeds	2	0
Coconut	1	0
Tropical Fruits	9	0
Temperate Fruits	5	0
Vegetables	20	4
Mealybugs	1	0
Polyhouse crops	8	0
Storage pests	1	0
TSP	6	0
Total	**81**	**16**