Proceedings of the XXVII Biocontrol Workers' Group Meeting

17th-18th May, 2018

Kerala Agricultural University

Thrissur, Kerala

Compiled and Edited by

S. K. Jalali, Richa Varshney, J. Patil and Chandish R Ballal

AICRP on Biological Control of Crop Pests

NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES

P. B. No. 2491, H. A. Farm Post, Bengaluru 560024

Karnataka

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I am grateful to **Dr. A. K. Singh,** Deputy Director General (Horticulture & Crop Sciences), ICAR for being the chief guest for the inaugural session for his unstinted encouragement and support. I am thankful to **Dr. R. Chandra Babu,** honourable Vice Chancellor, KAU, Thrissur, for chairing the inaugural session of the workshop and to **Dr. P. K. Chakrabarty** ADG (PP&B), ICAR, New Delhi, for his suggestions for strengthening the biocontrol research under AICRP-BC. I am grateful to **Dr. P. Indira Devi,** Director of Research, KAU, Thrissur, for her welcome address and to **Dr. Madhu Subramanian,** Incharge AICRP-Biological Control, KAU, Thrissur, for delivering the vote of thanks.

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I place on record my gratitude to **Dr. A. K. Singh**, DDG (Horticulture & Crop Sciences), ICAR, New Delhi; **Dr. P. K. Chakrabarty**, ADG (PP&B), ICAR, New Delhi; **Dr. A. N. Mukhopadhyay,** former VC, AAU, Jorhat; **Dr. R. J. Rabindra,** former Director, NBAIR, Bengaluru; **Dr. S. Sithanantham,** Sun Agro, Chennai; **Dr. S. Pathummal Beevi,** former Professor, KAU, Thrissur; **Dr. N. Bakthavatsalam**, NBAIR; **Dr. B. Ramanujam**, NBAIR; **Dr. A. N. Shylesha,** NBAIR; **Dr. S. K. Jalali**, NBAIR; for chairing & co-chairing different sessions.

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Bengaluru
1 June 2018

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ANNUAL GROUP MEET OF ALL INDIA CO-ORDINATED RESEARCH PROJECT ON BIOLOGICAL CONTROL OF CROP PESTS

Venue: **Kerala Agricultural Unviersity, Thrissur, Kerala**
Date: **17th and 18th May 2018**

PROGRAMME: May 17th, 2018 (9.30 am to 11.45 am)

09.30-10.30am	**REGISTRATION**
10.30 am-01.00 pm	**INAUGURATION**
Invocation	ICAR Song KAU Song
Welcome Address	**Dr. Indira Devi** Director of Research, KAU, Thrissur, Kerala
Project Coordinator's Report	**Dr. Chandish R. Ballal** Project Coordinator, AICRP-BC & Director, NBAIR, Bengaluru
Address	**Dr. R. Chandra Babu** Vice Chancellor, KAU, Kerala
Address	**Dr. A. K. Singh** Deputy Director General (HS & CS), ICAR, New Delhi
Remarks	**Dr. P. K. Chakrabarty,** ADG (PP& B), ICAR, New Delhi
Release of Folders, Bulletins, Technology folders, etc.	1. NBAIR, Bengaluru - Crop pest report & Media coverage 2017-18 by **Dr. M. Sampath Kumar** 2. KAU, Thrissur-"Towars a Greener globe four decades of bio control research" by Dr. Madhu Subramanian and Dr. Smitha M.S. 3. ANGRAU, Anakapalle - "Biological Control for the Management of Insect Pests in Major Crops" in Telugu as "Mukkyamaina pantalalo Jeevaniyantrana paddathula dwara hanikaraka purugula nivarana" by **Dr. M. Visalakshi** 4. AAU, Anand – "Integrated pest management of white grub in groundnut" in Gujarati by **Dr. D. M. Mehta and Dr. B. L. Raghunanadan** 5. UAS, Raichur – "Role of Predators in Pest Management" by **Dr. Arunkumar Hosamani**, Humma Ambuja, Mallikarjun Warad, Vijaykumar Ghante and S. G. Hanchinal 6. UAS, Raichur – "Management of Sugarcane Root Grub through Biocontrol - A success Story" by **Dr. Arunkumar Hosamani**, Humma Ambuja, Geeta Bestar, C.M. Kalibavi, Hanamanthappa Srihari, and Mallikarjun Warad. 7. AAU, Jorhat **- Leaflets** five numbers on Biological Control of crop pests" in Assamese "Lao Jatiya Pachalir Anistokari

	Borolia Pokar Niyantran Byabasthapona and 4 others" by **Dr. D. K. Saikia and R. N. Borkakati** 8. AAU, Jorhat – **Bulletin** "Jawik Podhhatire Xashyar Keet Potango Niyantron" in Assamese language by **Dr. D. K. Saikia and R. N. Borkakati**
Vote of thanks	**Dr. Madhu Subramanian** Incharge AICRP-BC, KAU, Thrissur
01.00-01.20 pm	**TEA**
PRESENTATION OF PROGRESS REPORTS	
May 17th, 2018 (Thursday); 01.20 pm-02.30 pm	**SESSION I: BIOLOGICAL SUPPRESSION OF PESTS OF FRUIT, VEGETABLE CROPS AND POLYHOUSE CROP PESTS**
Chairman Co-Chairman	Dr. A. K. Singh, DDG (HS & CS), ICAR, New Delhi Dr. P. K. Chakrabarty, ADG (PP&B), ICAR, New Delhi
Rapporteurs	Dr. T. M. Shivalingaswamy, NBAIR, Bengaluru Dr. Sible G. Verghese, KAU, Kumarakom
Speakers	
Tropical and Temperate Fruits	Dr. S. Jeyarajan Nelson, TNAU, Coimbatore
Vegetables	Dr. J. Halder, IIVR, Varanasi
Polyhouse Crop Pests & Flowers	Dr. Richa Varshney, NBAIR, Bengaluru
02.30-03.15 pm	**LUNCH**
May 17th, 2018 (Thursday); 03.15-04.30 pm	**SESSION II: BASIC RESEARCH ON BIODIVERSITY AND NATURAL ENEMIES OF INESECT PESTS AT NBAIR AND BIOLOGICAL CONTROL OF PLANT DISEASES**
Chairman Co-Chairman	Dr. A.N. Mukhopadhyay, former VC, AAU, Jorhat Dr. B. Ramanujam, NBAIR, Bengaluru
Rapporteurs	Dr. Omprakash Navik, NBAIR, Bengaluru Dr. P. L. Sharma, YSPUHF, Solan
Speakers	
Biodiversity, Biosystematics, Molecular Characterization and Biocontrol potential of newer natural enemies (NBAIR)	Dr. M. Mohan, NBAIR, Bengaluru
Biodiversity and Pest Outbreak reports	Dr. M. Sampath Kumar, NBAIR, Bengaluru
Biological Control of Plant diseases using antagonists	Dr. A. K. Tewari, GBPUA&T, Pantnagar
May 17th, 2018 (Thursday); 04.30-05.30 pm	**SESSION III: BIOLOGICAL SUPPRESSION OF PESTS OF SUGARCANE and COTTON**
Chairman Co-Chairman	Dr. Sithanantham, Sunagro Biotech, Chennai Dr. S. K. Jalali, HOD, NBAIR, Bengaluru
Rapporteurs	Dr. M. Visalakshi, ANGRAU, Anakapalle Dr. Anoop, NCIPM, New Delhi
Speakers	

Sugarcane	Dr. D. K. Saikia, AAU, Jorhat
	Dr. M. Prabakaran, Sun Agro, Chennai
Cotton	Dr. R.V. Nakat, MPKV, Pune
05.50-05.45 pm	tea
May 17th, 2018 (Thursday); 05.45-07.00 pm	**SESSION IV: BIOLOGICAL SUPPRESSION OF PESTS OF RICE AND MAIZE**
Chairman Co-Chairman	Dr. R.J. Rabindra, Former Director, NBAIR, Bengaluru Dr. A. N. Shylesha, NBAIR, Bengaluru
Rapporteurs	Dr. Chitra Shanker, IIRR, Hyderabad Dr. K. Selvaraj, NBAIR, Bengaluru
Speakers	
Rice	Dr. Madhu Subramanian, KAU, Kerala
Maize	Dr. Neelam Joshi, PAU, Ludhiana
May 18th, 2018 (Friday); 09.00 am-10.00 am	**SESSION V: BIOLOGICAL SUPPRESSION OF PESTS OF PULSES, OILSEEDS AND COCONUT**
Chairman Co-Chairman	Dr. N. Bakthavatsalam, HOD, NBAIR, Bengaluru Dr. R.V. Nakat, MPKV, Pune
Rapporteurs	Dr. R. N. Borkakati, AAU, Jorhat Dr. G. Siva Kumar, NBAIR, Bengaluru
Speakers	
Pulses & Oilseeds	Dr. Arun Kumar Hosamani, UAS Raichur
Coconut	Dr. Chandrika Mohan, CPCRI, Kasaragod, Kerala
May 18th, 2018 (Friday); 10.00-11.00 am	**SESSION VI: TRIBAL SUB PLAN PROGRAMME**
Chairperson Co-Chairman	Dr. Devaki Girija, Professor and Head, Dept of Microbiology and Assoc. Director (M&E), KAU, Kerala Dr. S. Jeyarajan Nelson, TNAU, Coimbatore
Rapporteurs	Dr. Jayalaxmi Ganguli, IGKV, Raipur Dr. Jagadeesh patil, NBAIR, Bengaluru
Speaker	
Tribal subplan	Dr. B.L. Raghunandan, AAU, Anand
May 18th, 2018 (Friday); 11.00-12.01 pm	**Session VII: INSTITUTE–INDUSTRY-DEAPRTMENT PARTNERSHIPS**
Chairman Co-Chairman	Dr. S. Pathummal Beevi former head, AICRP-BC, KAU, Kerala Dr. M. Nagesh, NBAIR, Bengaluru Dr. S. J. Rahman, PJTSAU, Hyderabad
Rapporteurs	Dr Reji Rani, O. P., KAU, Vellayani Dr. T. Venkatesan, NBAIR, Bengaluru
	Speakers from Private Industry Dr. Sithantham, Sun Agro Biotech, Chennai, on Scope to strengthen AICRP-Biocontrol R&D linkages with stakeholders" Dr. Prashanth K., PI Industries Ltd., Trichy, Tamil Nadu Kerala State Biocontrol Lab, Mannuthy, Thrissur

	Dr. Balbir Singh, DCM Shriram, Delhi Dr. Laxminarayana Praharaju, Hyderabad Dr. Resmi Deepak, Kerala Dr. U. K. Kulkarni, PDKV, Akola
12.00-12.15 pm	**Tea Break**
May 18th, 2018 (Friday); 12.15-01.30 pm	**Technical Program for 2018-19 & 2019-20**
Chaired by	Dr. R. J. Rabindra, former Director, NBAIR, Bengaluru Dr. C. R. Ballal, Director, NBAIR, Bengaluru
Rapporteurs	Dr. B. Ramanujam, NBAIR, Bengaluru Dr. S. Joshi, NBAIR, Bengaluru Dr. Richa Varshney, NBAIR, Bengaluru Dr. T. Venkatesan, NBAIR, Bengaluru Dr. M. Nagesh, NBAIR, Bengaluru
Presentation of Technical Program by new centres	**Technical Program presented by Dr. J. Patil, NBAIR, Bengaluru** **Technical Program of the New Contingency Centres for the years 2018-19 & 2019-20** ICAR-CPCRI, Kayamgulam ICAR-IIHR, Bengaluru ICAR-CISH, Lucknow ICAR-CTRI, Rajahmundry ICAR-IIRR, Hyderabad ICAR-IIMR, Hyderabad ICAR-IIVR, Varanasi ICAR-NCIPM, New Delhi IGKV, Raipur KAU, Kumarakom KAU, Vellayani DRYSRUH, Ambajipeta UBKV, Pundibari
01.30-02.30 pm	**LUNCH**
May 18th, 2018 (Friday); 02.30-04.30 pm	**Technical Program continued**
Chairman Co-Chairperson	Dr. R. J. Rabindra, former Director, NBAIR, Bengaluru Dr. C. R. Ballal, Director, NBAIR, Bengaluru
Rapporteurs	Dr. B. Ramanujam, NBAIR, Bengaluru Dr. S. Joshi, NBAIR, Bengaluru Dr. Richa Varshney, NBAIR, Bengaluru Dr. T. Venkatesan, NBAIR, Bengaluru Dr. M. Nagesh, NBAIR, Bengaluru
Vote of Thanks	Dr. Chandish R Ballal, Project Coordinator & Director, NBAIR, Bengaluru

INAUGURAL SESSION

The **XXVII AICRP-Biocontrol Workers' Group Meeting** was conducted under the aegis of the Indian Council of Agricultural Research, New Delhi at Kerala Agricultural University, Thrissur, on 17th and 18th May, 2018. The delegates and invitees from ICAR Institutes, Agricultural Universities, Department of Agriculture, Kerala, representatives of private commercial production units and staff of Department of Entomology of KAU, Thrissur, attended the Inaugural Session. The programme was as follows:

Welcome Address	:	**Dr. K Indira Devi** Director of Research, KAU, Thrissur
Project Co-ordinator's Report	:	**Dr. Chandish R. Ballal** Project Co-ordinator AICRP on Biological Control
Address	:	**Dr. R. Chandra Babu** Vice Chancellor, KAU, Thrissur
Address	:	Dr. A.K. Singh DDG (HS & CS), ICAR, New Delhi
Remarks about Project	:	**Dr. P K Chakrabarty** ADG (PP&B), ICAR, New Delhi
Vote of Thanks	:	**Dr. Madhu Subramanian,** Incharge AICRP-BC, KAU. Thrissur

The workshop was inaugurated by **Dr. R. Chandra Babu,** Vice Chancellor, KAU, Thrissur and by **Dr. A. K. Singh, D**DG (Horticultural and Crop Sciences), ICAR. New Delhi, **Dr. P. Indira Devi,** Director of Research, KAU, Thrissur, welcomed the delegates and gave brief account the work carried out at on biological control at KAU, Thrissur. **Dr. Chandish R. Ballal**, Director, NBAIR Bengaluru and Project Coordinator, presented the salient achievements of the AICRP-BC for the year 2017-18. **Dr. P. K. Chakrabarty**, ADG (PP), ICAR in his address emphasized to cover more cropping area under biocontrol by demonstrating biocontrol technologies to large scale and by coordination between SAUs and ICAR. He also emphasized the role of quality biocontrol agents in pest suppression and importance of registration of quality biopesticides. Publications of NBAIR, ANGRAU, AAU-A, UAS-R, AAU-J, KAU and IGKV were released by the chief guest and other dignitaries.

Dr. R. Chandra Babu, Vice Chancellor, KAU, Thrissur, delivered key note address. He was of opinion that large scale trials should be laid out besides some basic work to unearth the mechanism of functional role. He wishes deliberations all success.

There were delegates from all AICRP-BC centres, private industries, Department of Agriculture, Kerala, faculty and students of KAU, etc. The recommendations and the technical Programme for 2018-19 were finalized during the meet.

SALIENT FINDINGS DURING 2017-18

Chnadish R. Ballal
Project Coordinator, 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, ii) Surveillance for possible entry of potential alien invasives like *Brontispa, Phenacoccus manihoti* the giant whitefly 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, and 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 centres

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. Govind 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, Kayamkulam
3. Central Tobacco Research Institute, Rajahmundry
4. Indian Institute of Rice Research, Hyderabad
5. Indian Institute of Millet Research, Hyderabad
6. Indian Institute of Horticultural Research, Bengaluru
7. Indian Institute of Vegetable Research, Varanasi
8. National Centre for Integrated Pest Management, New Delhi

Voluntary Centres

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

The results from the various experiments conducted at centres across the country during the year 2017-18 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 Taxonomic study of parasitic wasps

Nearly 3000 specimens were collected, bred, curated, identified and preserved. Collection includes- >100 species and >100 collection/survey trips were undertaken. Two species of parasitic wasps were identified for the new invasive rugose spiraling whitefly (RSW) *Aleurodicus rugioperculatus* Martin *viz*., *Encarsia guadeloupae* Viggiani and *Encarsia dispersa* Polaszek, which was found infesting coconut, banana and several ornamental plants in Tamil, Nadu, Andhra Pradesh and Kerala in India. During the survey, several natural enemies were also recorded and maximum parasitism was recorded by *Encarsia guadeloupae* Viggiani. A new species of *Acanthormius* Gupta & Quicke (Hymenoptera: Braconidae) is described and illustrated as a gregarious larval parasitoid of undetermined bagworm moth caterpillar (Lepidoptera: Psychidae) from southern India.

4.1.1.2 Diversity of Trichogrammatids

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

4.1.1.3 Biodiversity of Platygastroidea

Two new genera and 67 new species have been described and imaged in the superfamily Platygastroidea.Two new genera *Indiscelio* Veenakumari et al g. n. with *Indiscelio aulon* sp. n. Veenakumari et al as type species and *Anokha* Rajmohana and Veenakumari g. n. with *Anokha anoojii* sp. n. Rajmohana and Veenakumari as type species are erected. *Cremastobaeus* belonging to the monotypic tribe Cremastobaeini is represented by 24 species worldwide. Only two species, *C. indicus* Mukerjee and *C. unicolor* Rajmohana are known from India. Surveys conducted from different parts of India including the remote Andaman and Nicobar Islands resulted in 22 species of *Cremastobaeus* of which 20 are new to science. Two new species of *Apteroscelio, A. aureus* sp. n. and *A. shyamala* sp. n. are

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

4.1.1.4 Biosystematics and diversity of entomogenous nematodes in India

A total of 15 soil samples were collected randomly from potato growing regions and forest areas of Udagamandalam, Tamil Nadu. A soil sample drawn was anticipated of obtaining EPN and a species *Steinernema* sp. was recorded.. Based on morphological and morphometrical studies, The EPN, *Steinernema* sp. was identified and designated as *S. cholashanense* strain CPRSUS01, which showed the resemblance of the species to *S. cholashanense.* Further identity was confirmed with molecular characterization using the ITS-rDNA region. The sequence of this EPN revealed 99% similarity with *S. cholashanense* isolate from Nepal (GQ377419) and Pakistan (MF039642) and 96% with China population (EF431959). To our knowledge, this is the first report of *S. cholashanense* from India.

4.1.1.5 Taxonomy of Pseudococcidae, Coccidae and Diaspididae (Hemiptera: Coccoidea)

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

4.1.2 Monitoring of invasive pests

4.1.2.1 Surveillance of rugose whitefly in coconut and assessing the population of natural biocontrol agents

Five trips were made to Udupi in Dakshina Kannada and Uttar Kannada districts and two trips in Ramanagara, Mandya, Mysuru districts in Karnataka for survey on incidence and infestation of rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin on coconut and other host plants during 2017-18. Incidence and infestation of rugose on coconut, banana, mango, Indian almond, cashew and many other ornamental plants was recorded to the extent of 20-80% on different host plants. Maximum incidence on coconut, banana, sapota, Indian almond and low to moderate on mango, cashew and few ornamental plants. The pest is spreading at greater extent along the coastal belts and highways towards Goa. As per the natural parasitism as concern, the predominant natural enemies were *Encarsia guadeloupae.* Parasitism was recorded to extent of 30-70 percent and maximum recorded on sapota, *Canna indica* and banana plants. Very severe infestation of RSW was noticed on coconut in Lakshmipura village, Mysuru taluk, with heavy sooty mould development. RSW covered

almost entire leaflets in frond with white waxy mat like appearance. The natural parasitism to the tune of 65-75% was observed.

4.1.2.2 Papaya mealybug on mulberry

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

4.1.2.3 Biological control of mealybug complex in papaya and mulberry

In papaya orchards the incidence of papaya mealybug was very sporadic and only few fruits and leaves were found with papaya mealybug infestation. No other mealybug other than *Paracoccus marginatus* was recorded on papaya plants. 7 per cent infestation of mealybug was observed in Byadamodlu village and 4 percent in Vartur and Ramnagar. Presence of *Acerophagus papayae* was observed in all the infested plants. The parasitism to the tune of 35-40 per cent was recorded in Vartur, 50-60 per cent in Byadamodlu and 20 per cent in Ramnagar.

On mulberry, the incidence of papaya mealybug was less than 5 per cent. In Waderahalli, papaya mealybug was found associated with *Meconellicoccus hirsutus* and the incidence was also less than 5%. Association with cotton mealybug, Phenacoccus *solenopsis* and with long tailed mealybug *Pseudococcus longispinus* was less than 1.0 per cent. In mealybug complex, *A. papayae* and *Aenasius arizonensi*s (Girault) were observed on papaya mealybug and cotton mealybug, respectively. *Scymnus* sp and *Cryptolaemus* larvae were also recorded where ever cotton mealybug and *M. hirsutus* were present. The incidence of natural enemies was less than 5 percent in the mulberry ecosystem.

Post release observations after 45 days revealed that the released parasitoids enhanced the reduction of pest population and the parasitization percentage increased to 72-85 percent in the Byadamodlu. In case of mulberry ecosystem the mealybug complex was efficiently managed by the combination of *Cryptolaemus* and *Acerophagus papayae* as *Cryptolaemus* could survived very well on the cotton mealybug, long tailed mealybug and pink mealybug (*M. hirsutus*) and the adult activity was also seen in mulberry ecosystem after 45 days of release. The release of *A. papayae* in combination with *Cryptolaemus* was beneficial in mulberry compared to papaya ecosystem.

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

Laboratory bioassay studies were conducted with 20 isolates each of *Beauveria bassiana* and *Metarhizium anisopliae.* Among the 20 isolates of *B. bassiana* tested, Bb-5a showed significantly higher mortality (77.36%) followed by Bb-45 isolate (51.14%). Among the 20isolates of *M. anisopliae* tested, Ma-4 and Ma-35 showed significantly higher mortality (81.44 & 88.85% respectively). A glasshouse experiment was conducted to examine the endophytic ability of above isolates of *B. bassiana* (Bb-5a & Bb-45) and *M. anisopliae.* In foliar application method, all four isolates showed varied colonization and persistence in

older and young leaf tissues of the cabbage during 15-60 DAT. Ma-4 isolate showed colonization upto 60DAT, Bb-5a & Bb-45 isolates up to 45DAT and Ma-35 isolate upto 30DAT. These leaf samples were collected at 15 and 30 days after treatment from the potted cabbage plants for leaf bioassay studies against *P. xylostella*. The treated leaf samples collected after 15DAT showed 70.0-76.7% mortality and all the isolates were statistically on par with each other. The treated leaf samples collected after 30DAT showed 13.7-54.8% mortality with significantly higher mortality with Bb-45 isolate (54.80%), followed by Bb-5a (44.43%) and Ma-35 (37.40%).

4.1.4 Molecular Characterization and DNA bar-coding of agriculturally important parasitoids, predators and other insects

Different parasitoids, predators and other insects were collected from various crops and were used for DNA barcoding studies. Molecular characterization and DNA barcodes were generated for 90 agriculturally important parasitoids, predators and other insects based on COI gene & ITS-2. Twenty one *Parapanteles* collected from different places in the country were characterized using CO1 gene and GenBank accession numbers obtained for the same. Nine populations of chrysopids collected from different states were identified as *Chrysoperla zastrowi sillemi* using CO1 gene. *Trichogramma* collected from the tomato field at Coimbatore is identified as *Trichogramma chilonis* (TC-1-KY872646). Molecular characterization of braconid from Coimbatore identified as *Habrobracon hebetor* using CO1 gene. Syrphid occurring in Mandya has been identified as *Paragus serratus* using CO1gene (Genbank acc. no. MG194422). Molecular characterization of parasitoid belong to Scelionidae from Maruteru, West Godavari, using Cytochrome C oxidase I (COI) gene done (HKM 2017-Genbank Acc. No. MF616390). Molecular characterization of *Megachile anthracina* collected from Attur, Bengaluru, was identified using cytochrome c oxidase I (COI) gene (MF351742). Thirty one populations of *Bemisia tabaci* collected on different crops and from different states have been characterized and genbank accession numbers obtained. Different populations of brown plant hopper *Nilaparvatha lugens* collected on paddy from different areas and were characterized using CO1 gene The invasive pest rugose spiraling whitefly *Aleurodicus rugioperculatus* Martin collected from banana, Karnataka was identified using cytochrome oxidase subunit I (COI) gene (GenBank Acc. no. MF445090). Different populations of whitefly collected from coconut, guava and other crops in and around Bengaluru and subjected to molecular studies using CO1 gene. The results clearly proved that the whitefly is Spiraling whitefly *Aleurodicus dispersus* and not *A. rugioperculatus* and the same has been submitted in NCBI (Genbank acc. no. MF149998; MF186939). Spiraling whitefly *Aleurotrachelus trachoides* was identified using CO1 gene (Genbank Acc. no. MF 149999; MF371113).

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, castor, cotton, maize and 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 41 spider specimens were collected from rice ecosystem. The samples were belonging to four families namely Araneidae, Oxyopidae, Tetragnathidae and Salticidae. Out of 41samples 17 turned to be *Neoscona theisi*.
- Twelve soil samples were found positive for *Beauveria* spp. The isolates were tentatively identified as *Beauveria* spp. Four new native insect pathogenic isolates have been identified from the insect pathogenic/Bt isolates obtained from previous year (2016-17).
- None of the soil samples were found positive for the presence of EPNs.

AAU-J: Extensive surveys were conducted in brinjal, tomato, okra, cole crops cucurbits, papaya, bhut jolokia for the presence of natural enemy. Highest number of spider population (0.70 to 1.84 spider/ m^2) was recorded in rice fields. Altogether 68 numbers of spiders from 4 different families (lycosidae, Oxyopidae, araneidae and Tetragnathidae) were collected from different rice fields. The predominant spider was *Lycosa pseudoannulata* (25) and *Oxopes javanus* (22). In vegetative growth stage of rice crop, more number of odonates(10 dragonfly and 17 damselfly) followed by reproductive stage (15) damselfly and (dragonfly) was recorded. The most dominant damselfly and dragonfly species were *Ceiagrion coromandelianum* and *Diplacodes trivialis*. Seventy eight numbers of cocccinellids predators was recorded from rice fields. *Micraspis discolor* was the the most dominant predator amongst the predators collected from rice fields. Egg masses of stem borer were collected and 8.6 per cent parasitasation by *Trichogramma* sp., *Telenomous* sp. and *Tetrastichus* sp. was observed the per cent parasitasm by *Cotesia* sp. (leaf folder larvae) was 11.2. From vegetable ecosystem, maximum number of spiders was collected from tomato (12) and brinjal (14) crop.

KAU: Study on seasonal abundance of spiders in rice ecosystem was carried out in farmer's field at Thanikkudam in Thrissur. Two species of spiders were collected consistently from the rice field and were identified as *Pardosa pseudoannulata* (Boesenbeg and Strand) and *P. irriensis* (Barrion and Litsinger). The former accounted for nearly 99 per cent of the catch.

PAU: In cotton among predators, *Chrysoperla* sp. was the predominant species. 11 species of spiders were recorded from the rice fields. *Neoscona theisi* was the predominant species (72.05%) at all the locations followed by *Tetragnatha javana* (14.29%). Mean percent parasitisation of white fly due to *Encarsia* sp. was 5.20.

SKAUST: A total of twenty five natural enemies including parasitoids and predators were collected from fruit orchards in different districts of Kashmir and Laddakh during 2017-18. Majority of natural enemies were collected on apple. Among these, *Coccinella undecimpunctata*, *Priscibrumus uropygialis*, *Chilocorus infernalis*, *C. septempunctata*, *Scymnus* sp., *Chrysoperla zastrowi sillemi* dominated on apple associated with different pests. Among aphelinid parasitoids *Encarsia perniciosi* and Aphytis *proclia* together

exhibited 16.0 to 20.0 per cent parasitism in unmanaged orchards against San Jose scale. *Azotus kashmiriensis* and *Marietta* sp. acted as hyper parasitoids of *Encarsia pernicious* and Aphytis *proclia*. *Aphelinus mali* was found a promising parasitoid of woolly apple aphid, *Eriosoma lanigerum* displaying a maximum of over 75.0% parasitism. *C. undecimpunctata* was first time recorded from Kargil on apricot. *Chilocorus infernalis*as usual displayed active association of with *Parthenolecanium corni* on plum. An unidentified hemipteran bug was also discovered from the scale on plum. Three predators, *viz*., *C. septempunctata*, *C. undecimpunctata* and *C. zastrowi sillemi* were recorded first time on in University campus, Shalimar.

YSPUHF: Many coccinellid beetles have been recorded from different agro-ecological zones of Himachal Pradesh. Among these, *Oenopia billieti,* and *Halyzia sanscrita* are the new additions to the previously reported list taking the total number to 49. Syrphid flies were also collected from different flowering plants in the state. *Chrysoperla zastrowi sillemi* was recorded preying on aphids and whiteflies on apple, peach, okra and cucumber at different locations of the state. *Dinocalpus coccinellae* and *Pediobius foveolatus* were collected as parasitoids of *Coccinella septempunctata* and *Megalocaria dilatata* at Nauni. *Diadegma semiclausum* and *Diadromus collaris* were recorded as larval and pupal parasitoids of *Plutella xylostella,* infesting cauliflower and cabbage. *Orius* sp. and *Anthocoris* sp. were collected from peaches infested with leaf curl aphid and thrips. *Nesidiocoris tenuis, Neochrysocharis formosa, Diglyphus* sp., *Quadrastichus plaquoi* were collected from tomato, cucumber and beans infested with *Tuta absoluta,* greenhouse whitefly, serpentine leafminer and phytophagous mites.

MPKV: The natural enemies fauna recorded included coccinellids, *Dipha aphidivora* Meyrick , syrphids and parasitoid *Encarsia flavoscuttellum* on sugarcane woolly aphid on sugarcane. *Coccinella transversalis* F., *M. sexmaculata, Brumoides suturalis* (F.), *Scymnus coccivora* Ayyar, *Triomata coccidivora* and *B. suturalis* were observed in mealybug colonies on custard apple. *Acerophagus papayae* N & S, *Mallada boninensis* Okam. and *Spalgis epius* on papaya mealy bugs. *Chrysoperla zastrowi sillemi* Esben was observed in cotton, maize, bean, jowar, okra and brinjal, while *Mallada boninensis* Okam. on cotton, beans, mango, papaya. *Cryptolaemus* adults were recovered from the pomogranate, custard apple, guava, papaya and grape orchards. The entomopathogens particularly the cadavers of *S. litura* and *H. armigera* infected with *Nomuraea rileyi, Metarhizium anisopliae, Sl*NPV, *Ha*NPV were collected from soybean, cabbage, capsicum, pigeon pea and tomato crops in farmers' fields.

TNAU: The natural enemies, *viz*., *Trichogramma* sp., *Cryptolaemus montrouzieri*, *Chrysoperla zastrowi sillemi* and parasitoids of papaya mealybug, scales were collected and documented. *Encarsia Guadeloupe* was observed in coconut. The activity of egg parasitoid, *Trichogramma* sp was observed in vegetables and flowers. The predators, *viz., C. montrouzieri, Chrysoperla zastrowi sillemi and Mallada sp* were seen on mealybug, scales, whiteflies, psyllids infesting the crops namely tapioca, papaya, brinjal, bhendi, curry leaf and coconut while *Dipha aphidivora* and *Micromus igorotus* were observed on sugarcane woolly aphid.

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 2017-2018. However, *Tuta absoluta* and *Paracoccus marginatus* were observed in Gujarat, while in Himachal Pradesh *T. absoluta* was observed. In Maharashtra, the mealybug species *Pseudococcus jackbeardsleyi* and *Paracoccus marginatus* were recorded on custard apple and papaya respectively, in Pune region. *Tuta absoluta* was recorded in Junnar tahasils of Pune district during April to May 2017 on tomato crop. The leaf damage percentage due to pin worm was 3.13 per cent and fruit damage is ranged between 12 – 20 with an average of 4.0 fruits/ plant. In Tamil Nadu incidence of papaya mealybug varies from modereate to high during June to October. However, *Acerophagus papayae*, has widely spread and established in most of the districts of Tamil Nadu. Natural predators like *Cryptolaemus montrouzieri*, *Spalgius epius* and *Mallada igorotus* were also noted.

4.2.1.2 Surveillance of rugose whitefly *Aleurodicus rugioperculatus* in coconut and assessing the population of natural bio control agents

DYSRHU: The incidence of rugose white fly was observed on coconut and oil palm in the east, west and srikakulam districts of Andhra Pradesh in 2017-18. Coconut, oil palm and seethaphal were most preferred host plants. Among the natural enemies coccinellids predator *Jauravia pallidula* was observed in Kalavalapali village, West Godavari district and natural incidence of predator *Dichochrysa* sp. nr. *astur* (Banks) was observed in Kadiyapulanka nurseries in East Godavari district. The parasitisation by *Encarsia guadeloupae* was not observed in the white fly infested gardens and nurseries up to December 2017.The *E. guadeloupae* parasitoid leaf clips were obtained from Coconut Research station , Aliyarnagar , TNAU and released in farmers field in white fly infested gardens revealed the establishment of parasitoid and rate of parasitization varied from nil to 70 per cent.

TNAU: The rugose whitefly population escalated from July to November and declined during Dec. 2017 and Jan. 2018 and again increased during Feb 2018. From, Feb, 2018, the pest was reported from new areas like Dindigul, Tanjore, Pudukottai and Thiruvarur Dt. The incidence was less than 25 per cent in new areas. Natural enemies like the parasitoid *Encarisa* sp and predators, *viz., Chrysoperla zastrowi sillemi*, *Mallada* sp. and *Cryptolaemus montrouzieri*, were observed in the infected leaflets. Among the naturally occurring predators, *Mallada* sp. was found actively predating on rugose whitefly.

KAU Thrissur: The severity of infestation ranged from high to severe during September but decreased to medium levels by December and low levels by March, 2018. Parasitism by *Encarsia guadeloupe* ranged from 10-54 per cent in September, 2017, which increased substantially to over 90 per cent by October, 2017. Mean parasitism was 87.98 during December. Higher mean parasitism of 93.31 and 92.02 were recorded during December and January, respectively. The parasitism remained high on four out of five palms during March but was very low at 7.83 per cent on one palm where the leaves had fresh infestation.

CPCRI: Rugose Spiralling Whitefly was noticed to spread in all districts of Kerala (Palakkad, Malappuram, Thrissur, Idukki, Kozhikode, Kannur, Ernakulam, Kasaragod, Pathanamthitta, Alappuzha, Kollam and Thiruvananthapuram districts), Tamil Nadu (Pollachi, Pattukottai, Tiruppur, Thanjavur, Theni, Marthandam), Andhra Pradesh (Kadiyam, East Godavari- Damalacheruvu, Pottilanka; West Godavari-Kalavalapalli, Chikkala and Kakinada), Karnataka (Udupi, Mulki, Sulia Mangaluru, Dharwad), and Goa (Colva Beach). In several infested coconut gardens of these places, the pest incidence exceeded 20 adult whiteflies per palm leaflet. In the surveillance survey, various alternate plants (*Psidium guajava*, *Musa* sp., *Myristica fragrans, Colocasia* sp., *Garcinia* sp., *Annona muricata, Murraya koenigii, Spondias mombin, Annona squamosa, Mangifera indica, Heliconia stricta, Strelitzia reginae* and *Artocarpus heterophyllus Annona reticulata*, *Saccharum officinarum*, *Elaeis guineensis* and the ornamental yellow palm (*Dypsis lutescens*) have been registered as egg laying/ feeding hosts in coconut homesteads; however, the pest, was found to be relatively more confined to coconut, indicating its host preference. A novel discovery of sooty mould scavenging beetle, *Leiochrinus nilgirianus* Kaszab (Coleoptera: Tenebrionidae) was reported from coconut palms infested by RSW in Kerala, India.
OUAT: Survey on the exotic rugose whitefly, *Aleurodicus rugioperculatus* and its natural enemies in the coconut plantations of Odisha indicated that, this species of whitefly has not yet entered into Odisha.

4.2.3 Pest outbreak

AAU, Anand: Cotton sucking pest incidence at Puniyad village in Karjan taluk was severe during October 2017. Severe pink boll worm damage was recorded at several places in Anand district (22.031N, 73.096E) during November 2107. During December 2017, red cotton bug and dusky cotton bug severity was recorded on cotton crop grown at Karjan taluk of Vadodara district.
AAU, Jorhat: Severe incidence and damage of swarming caterpillar was observed in rice crop during August to September 2017 in the regions of Nalbari, Bongaigaon, Alengmora and Dergaontaluks of Jorhat district of Assam. Severe diamond back moth incidence in cabbage was reported in Allengmora, TeokBoloma villages of Jorhat district during March 2018.

ANGRAU, Anakapalle: Severe early shoot borer infestation (>50 %) was observed in the sugarcane ratoon crop during July 2017 at several villages at Ravikamatam, Narsipatnam, Kotavuratla, Devarapalli and Chodavarammandals in Visakhapatnam district. Severe ring spot disease was reported at Chodavarammandal.

GBPUAT, Pantnagar: Severe infestation of leaf folder and yellow stem borer (35-40%) was observed in rice during August 2017 and February 2018 at Ramnagar district. Severe incidence of white rust disease was reported in mustard crop grown in Udham Singh Nagar district during January 2018. Severe incidence (60-70%) of mango thrips was found in major mango growing belts of UP and Uttarakhand during March 2018.

DRYSRHU, Ambajipeta: Severe rhinoceros beetle damage was observed during July and September 2017 in Ratnagiri, Tadikalapudi village of Pedavegimandal of West Godavari and Vizianagaram districts. During December 2017-January 2018, coconut plantations at several

villages at Kadiyam and Chagallumandals were severely infested with RSW. The RSW infestation was also noticed in the border trees grown nearby namely, Annona, Jackfruit@10 egg spirals/leaf and papaya.

MPKV, Pune: Moderate to severe infestation of sugarcane whitefly was observed in Sangamner, Rahata, Shevagaon and Kopargaon tehsils of Ahmednagar, Jalgaon, Rahuri and Nandurbar district during June to October 2017.

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

PAU, Ludhiana: First record of South American tomato pinworm, *Tuta absoluta* in Punjab was reported from Patiala and Ludhiana districts in a survey undertaken at July 2017.

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

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

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

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

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

4.2.4 Biological suppression of plant diseases

4.2.4.1 Field evaluation of promising *Trichoderma/ Pseudomonas* isolates for crop health management

GBPUA&T: In Rice (var.HBC 19 &Type 3)**,** amongst all the bioagents, PBAT-3, Psf-2 and Th-14 were comparatively better than other bioagents in reducing diseases (sheath blight, brown spot) and increasing yield. Minimum brown spot disease severity was recorded with NBAIR-2 (47.46%) which was at par with Psf-2 (50.94%) and NBAIR-1 (50.94%) but significantly better than other treatments and control (60.46%). In Chickpea (variety PG-186), maximum per cent seed germination was observed in NBAIR-1-Th and carbendazim (69.8%). Minimum mature plant wilt was observed with BARC and PBAT-3 (4.7%).

4.2.5 Biological suppression of sugarcane pests

4.2.4.1 Monitoring of sugarcane woolly aphid and its natural enemies

MPKV: *Micromus igorotus*, *Dipha aphidivora* and *Encarsia flavoscutellum* were predominant and well established in the sugarcane growing areas of western Maharashtra. The incidence of SWA was relatively Low in Sangli, Satara and Kolhapur districts during this year. The average SWA incidence and pest intensity rating were 1.65 per cent and 2.00, respectively. The natural enemies recorded in the SWA infested fields were mainly the predators like *D. aphidivora* (0.10-2.40 larvae/leaf), *M. igorotus* (1.33-4.66 grubs/leaf), syrphid *Eupoderes confractor* (0.40-1.20 larvae/leaf) and spider (0.10-0.60 /leaf) during August to November, 2017.

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

4.2.4.2 Efficacy of entomopathogenic nematodes and entomofungus for the management of white grub in sugarcane ecosystem

ANGRAU: Percent reduction in plant damage due to white grub recorded high in *Heterorhabditis indica* (79.86 %) , *Metarhizium anisopliae* (67.74%) and Chlorantraniliprole 18.5SC (72.91%) over untreated control . Higher yield increase was recorded in *Heterorhabditis indica* (39.1 %) compared to untreated control.

4.2.5 Biological suppression of cotton pests

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) to monitor whitefly population and its natural enemies on cotton crop revealed that whitefly remained low to moderate except in some late sown crops. No major outbreak was recorded. Ten species of natural enemies of *B. tabaci* were observed, including

8 predators and two species of parasitoid. Among predators, *Coccinella septempunctata*, *Cheilomenes sexmaculata* and *Brumoides suturalis*, *Serangium* sp., *Chrysoperla zastrowi sillemi Zanchius breviceps*, *Geocoris* sp. and spiders were most commonly recorded predators. Out of these, *Chrysoperla* was the predominant species. The population of coccinellids, *Chrysoperla*, spiders and *Zanchius* sp. varied from 0.0 to 2.0, 0.0 to 44.0.0, 0.0 to 18.0 and 0.0 to 2.0 per 10 plants, respectively. *Encarsia lutea* and *Encarsia sophia* were the two parasitoids that emerged from whitefly pupae. The mean parasitization of whitefly by *Encarsia* spp. in different cotton growing areas of Punjab was 5.20 per cent (range = 1.5 to 9.1%).

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

MPKV: The incidence of aphids (15.87-53.40), jassids (4.42-9.47), thrips (6.53-10.47) and white flies (4.27-5.87) per three leaves per plant found relatively high from 1st week of August till end of November 2017. The infestation of mealy bug *P. solanopsis* incidence was meagre throughout the season in the experimental field as well as low infestation of mealy bugs was observed in Jalgaon,Dhule and Nandurbar. The highest population of coccinellids (1.27 grubs and/or beetles/plant) was observed in 4th week of October, 2017 (43rd MW) and the peak population of chrysopid (1.6 grubs/plant) was recorded in 4th week of October 2017. The spiders were noticed through the crop growth period.

4.2.5.3 Monitoring the pink bollworm infestation in western Maharashtra

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

4.2.5.4 Monitoring of whitefly, its natural enemies and pink bollworm in cotton

PAU: Regular surveys conducted in cotton growing areas of Punjab (Fazilka, Bathinda, Mansa and Muktsar) to monitor whitefly population and its natural enemies on cotton crop revealed that whitefly remained low to moderate except in some late sown crops. No major outbreak was recorded. Ten species of natural enemies of *B. tabaci* were observed, including 8 predators and two species of parasitoid. Among predators, *Chrysoperla* was the predominant species. *Encarsia lutea* and *Encarsia sophia* were the two parasitoids that emerged from whitefly pupae.T he mean parasitization of whitefly by *Encarsia* spp. in different cotton growing areas of Punjab was 5.20 per cent (range = 1.5 to 9.1%) .

4.2.5.5 Evaluation of entomofungal agents and botanicals for the management of sucking pests in cotton

MPKV: Three sprays of *Lecanicillum lecanii* (1 x 10^8 conidia/g) @ 5 g/litre given at fortnightly interval recorded lowest population of aphids (6.68), jassids (2.48), thrips (2.82)

and white flies (1.81) compared to the untreated control. The *L. lecanii* recorded seed cotton yield 17.85 q/ha which is at par with dimethoate 0.05 per cent (18.50 q/ha).

4.2.5.6 Management of Pink bollworm (PBW) by using *Trichogrammatoidea bactrae* in Bt cotton

UAS-R: Number of PBW larvae in parasitoid released field and chemical treated field was 23.25 and 11.60 larvae per 10 bolls, respectively, which is lower than control (32.85 larvae per 10 bolls). However lowest rosette flower (3.26%) and locule damage (20.48%) was observed in chemical treated field.

4.2.5.7 Biointensive Pest Management in Bt cotton ecosystem during 2017-18

UAS-R: Biointensive practice recorded 15.24, 26.32 and 22.86 PBW larvae, Good open balls (GOB) and bad open balls (BOB), respectively. While in farmers practice it was 12.28, 31.46, and 18.64 PBW larvae, GOB and BOB, respectively. Lowest locule damage and highest yield was observed in farmer practice.

4.2.5.8 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 chrysopid and two applications each of neem (azadirachtin 10000 ppm) and *Lecanicillium lecanii* resulted in 38.3 per cent reduction in whitefly incidence as compared to 78.2 per cent in chemical control. The predator population was more in BIPM (1.02/ plant) as compared to chemical control (0.50/ plant) and untreated control (0.84/ plant). The yield increase in BIPM and chemical control was 6.36 and 11.82 per cent over untreated control, respectively.

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

PAU: Field evaluation of biopesticides for the management of whitefly on Bt cotton revealed significantly lower population in chemical treatments (spiromesifen 240 SC @ 500 ml/ha & diafenthiuron 50 WP @ 500g/ha) followed by application of botanical (Econeem plus 1%; azadirachtin 10000 ppm @ 1250 and 1500 ml/ha) and biopesticide (*Lecanicillium lecanii* @ 2500 and 3000 ml/ha).

4.2.6 Biological suppression of rice pests

4.2.6.1 Seasonal abundance of predatory spiders in rice

PAU: A total of 11 species were recorded from the rice fields. *Neoscona theisi* was the predominant species (72.05%) at all the locations followed by *Tetragnatha javana* (14.29%). Species diversity (1.025) was calculated as per Shannon-Weiner index of diversity. Species

evenness (0.445) and dominance index (0.555) was worked out as per formulae given by Krebs and Southwood, respectively**.**

4.2.6.2 Management of rice stem borer and leaf folder using entomopathogenic nematodes and entomopathogenic fungi

ANGRAU: Paddy leaf folder damage, yellow stem borer damage and white ear recorded significantly low in entomopathogenic nematodes, entomopathogenic fungi and chemical treatments compared to control. Percent reduction in leaf folder damage was high in *Beauveria bassiana* (78.48%) and percent reduction in stem borer damage recorded high in *Metarhizium anisopliae* (39%) over untreated control. Grain yield recorded high in *Beauveria bassiana* (NBAIR strain) (5.7 t/ha).

KAU: The results did not indicate any significant difference between the different treatments in terms of infestation or yield. The stem borer attack was negligible while leaf roller damage was low. The blue beetle was the most predominant insect pest recorded.

4.2.6.3 Management of plant hoppers through BIPM approach in rice

Hopper population was (0.44 hoppers/hill) significantly low in farmers practice plot (2.06 hoppers/hill) compared to 4.33 hoppers /hill in control plot. Reduction in hopper population was high in BIPM plot (89.84%) and farmers practice plot (52.42 %) over control plot. Grain yield recorded significantly high in BIPM practice.

4.2.7 Biological suppression of maize pests

4.2.7.1 Biological control of maize stem borer, *Chilo partellus* using *Trichogramma chilonis*

ANGRAU: Maize stem borer, *Chilo partellus* damage recorded low in *Trichogramma chilonis* release (1.87%DH) and chloraniliprole spraying (1.67%DH) at Singavaram village, Denkada mandal, Vizianagaram district. Maize stem borer damage recorded nil in Trichogramma *chilonis* release plot compared to monocrotophos spray (2.1% DH) and untreated control (13.97% DH) at Chollangipeta village, Denkada mandal, Vizianagaram district. Similarly maize stem borer, *Chilo partellus* damage recorded low in *Trichogramma chilonis* release (1.67% DH) and chloraniliprole spraying (2.67% DH) at padmanabham village, Padmanabham mandal, Visakhapatnam district.

MPUAT: IPM module comprising use of *T. chilonis* recorded minimum leaf injury rating (LIR) and dead heart per cent that is 1.83 and 2.00 respectively compared to farmers practice Comparatively higher yield was recorded in IPM modules (21.50 q/ha) as compared to farmers practice (18.50 q/ha).

4.2.7.2 Field evaluation of NBAIR entomopathogenic strains against stem borer *Chilo partellus* (Swinhoe) in fodder maize

PAU: Chemical control was significantly better than other treatments (NBAIR entomopathogenic isolates *viz*.Bb-5a, Bb-23, Bb-45 and Ma-35) in reducing the leaf injury (2.26%) and dead hearts (0.62 %) by maize borer. Leaf injury incidence (4.14 to 5.39 %) and dead hearts (2.40 to 3.45 %) in all the fungal isolates was at par with each other but significantly better than untreated control. Fodder yield in all the fungal isolates (142 to 150 q/ha) was significantly better than untreated control (121 q/ha) but less than chemical control field.

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

PAU: Field evaluation of Bt formulations was carried out against stem borer *C. partellus* in *kharif* maize along with *Trichogramma* releases, chemical control, chlorantraniliprole 18.5 SC (Coragen) @ 75 ml/ha)and untreated control. Chemical control was significantly better than other treatments in reducing dead heart incidence. The dead hearts in both Bt formulations (Delfin WG and Dipel 8 L) were at par with each other followed by *Trichogramma* releases. However, all the treatments were significantly better than untreated control in reducing the dead heart incidence.

4.2.8 Biological suppression of pests of pulses

4.2.8.1 Evaluation of NBAIR Bt formulation against pod borer complex in pigeon pea

PAU: Evaluation of NBAIR Bt formulation against pod borer complex in pigeonpea was conducted at farmer's field in Jalandhar district along with chemical control and untreated control. The number of webbed pods per plant and the per cent pod damage was lowest in chemical control (1.10, 6.97, respectively), followed by NBAIR Bt (1.59 and 10.76%, respectively) and both these treatments were significantly better than untreated control. The NBAIR Bt recorded 10.32q/ha grain yield which was significantly better than untreated control (8.94 q/ha).

TNAU: NBAII-BTG4 @ 2% spray was effective in reducing the larval population of Maruca *vitrata* and *Exelastis atomosa* in all stages *viz.*, pre flowering, post flowering and pod emergence with lesser pod and seed damage. It was also effective in controlling *H.armigera* after three sprays. NBAII-BTG4 formulation was found to be on par with the chemical Flubendiamide. Both the Bt formulation and the chemical sprays gave higher grain yield of 517.5 and 486.25 Kg/ha respectively than control (375 Kg/ha).

UASR: Significantly less larval population was recorded in NBAIR BtG 4 treated field compared to farmer practice. NBAIR BtG4 recorded 10.18 per cent pod damage with grain yield of 8.75q/ha while in farmers practice the per cent pod damage was 8.38 with a grain yield of 9.50 q/ha.

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

PAU: Integration of botanical/microbials and insecticide spray schedule for the management of pod borer complex in mungbean revealed minimum percent pod damage (11.25%) in treatment with two sprays of spinosad 45 SC. It was at par with treatments with Bt (1^{st} spray) and spinosad 45 SC (2^{nd} spray); Neem 1% (1^{st} spray) and spinosad 45 SC (2^{nd} spray) and two sprays of Bt. The yield in the respective treatments was 10.91, 10.68, 10.42 and 10.37 q/ha. Significantly higher pod damage (31.3%) and lowest yield (7.65 q/ha) was recorded in untreated control.

MPKV: Three sprays of chlorpyriphos 0.05% at fortnightly interval was significantly superior over other treatments in suppressing the larval population of *H. armigera* (av. 1.14 larvae/plant) and *Maruca testulalis* (av. 4.28 larvae/plant) in pigeon pea and recorded minimum pod (7.84 %) and seed (5.57%) damage with maximum 16.93 q/ha yield. It was however, at par with the NBAII-BT G4 @ 2% in respect of pod damage (8.87%), grain damage (6.32%) and yield (15.92 q/ha).

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

UAS-R: Hear NPV NBAIR @ 2 ml/l recorded 1.84 larvae per plant and it was at par with Hear NPV UASR @ 2 ml/l which recorded 1.92 larvae per plant at seven days after spray. While the farmer practice recorded lowest larval population of 1.06 larvae per plant which was statistically superior over the Hear NPV treatments and similar trend was noticed at 10 days after spray.

4.2.9 Biological suppression of tropical fruit crops pests

4.2.9.1 Effect of bio pesticides for management of mango hoppers, pests *Idioscopus* spp in field condition

DRYSRHU: The chemical insecticide treatment (malathion) and bio-pesticide treatment *Beauveria bassiana* recorded a mean surviving population of 19.50, 17.50 and 10.75and 20.38, 16.13 and 15.75 numbers of hoppers per tree , respectively after 1^{st}, 2^{nd} and 3^{rd} spray . In untreated control block a high population of mango hoppers ranging from 37 .00 to 44.38 was recorded consistently.

KAU Vellayani: Significant reduction in the damage by the hoppers and Webber (*Orthaga* sp.) was observed at 3^{rd}, 5^{th}, 10^{th} and 15^{th} day of intervals, when *Metarhizium anisopliae* 0.5 % @ 5 g/l, *Beauveria bassiana* ITCC 6063 @ *20* g /l were applied.

4.2.9.2 Biological control of Papaya/mulberry mealybug/ complex with *Acerophagus papayae* and *Cryptolaemus montrouzieri*

TNAU: With the release of *Acerophagus papayae*, the pest incidence became nil within three months whereas in the unreleased field, the PMB incidence increased by March, 2018, the per cent incidence was 9.3. The association of *A. papayae* and *Cryptolaemus* with papaya mealybug was more significant and the spatial and temporal distribution of parasitoids *A. papayae* and predators like *Cryptolaemus* and *Spalgis* coincided with the population of mealybug. This might be reason for effective containment of the mealybug without severe outbreaks even in control plots.

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

KAU Thrissur: Chloryriphos applied at the rate of 2.5 ml/l applied either as spray or leaf axil filling were the most effective treatments in controlling pseudostem weevil infestation in banana compared to *Metarhizium anisopliae* and *Beauveria bassiana*. It was significantly superior to the remaining treatments, which were on par with each other.

4.2.10 Biological suppression of temperate fruit crops pests

4.2.10.1 Monitoring of apple codling moth from various agro-ecological zones of Kashmir to see its spread.

SKAUST: Surveys during May- September' 2017 in apple orchards of Drass of district Kargil, Anantnag, Budgam, Baramullah, Pulwama, Kupwara, Bandipora, Ganderbal and Srinagar did not indicate the presence of codling moth, *Cydia pomonella* in these areas. During surveys although lepidopteran pests like *Archips pomivora*, Fireworm, *Rophobota naevana* (Hubner), Hairy caterpillar etc. were found at many places. Fireworm, *Rophobota naevana* (Hubner) was reported from almost all the districts of Kashmir, attacking apple from flowering to fruit 3rd stage. Codling moth, *Cydia pomonella* was found confined to Ladakh region only.

4.2.10.2 Integrated Pest Management of apple Codling moth, *Cydia pomonella*

SKAUST: Release of *T. cacoeciae* @2.5 lakh/ha. (4 releases/ season) + Trunk banding + Pheromone trapping + disposal of infested fruits + spray of **Heterorhabditis pakistanensis** (NBAIR) resulted in 48.21 % reduction in damage over control which was much better than use of Mating Disruption pheromone alone and chemical control.

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

SKAUST: Chemical treatment proved to be effective in reducing European red mite population. Per cent reduction in mites population per leaf over control for treatments T1

(100 bugs/plant), T2 (200 bugs/plant) and T3 (Fenazaquin 40 EC) was 26.65, 41.88 and 73.47 respectively. Same trend was observed in red spider mite.

4.2.10.4 Feeding potential of *Chilocorus infernalis* against *Parthenolecanium corni* scale plum in laboratory

SKAUST: Developmental duration of 1st to 4th instar grubs of *C. infernalis* was recorded as 2.5, 3.5, 5.5 and 7.5 days respectively. Larval duration varies from 17-21 days and average pupal period is 11.5 days whereas an adult female survived an average of 30.5 days. Total fecundity by grubs of *C. infernalis* against scales by 1st to 4th instar was 5.33, 15.0, 29.0 and 56.33. Total consumption of scales during larval period of the predator was 105.66. An adult female consumed a total of 283.2 scales during a period of 30.5 days. A single female of *Chilocorus infernalis* was worked out to consume a total of 388.86 scales during its life time

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

SKAUST: In field conditions, no mortality of larvae of *P. brassicae* was found on first day after foliar application of nematodes. However, on second day maximum (27.77%) mortality of *P. brassicae* larvae was noticed at 12 lakh IJs/plot. Increase in rate of larval mortality was dependent on both increase in dosage from 6.0 to 12.0 lakh IJS/ plot and also with the advancement in days in fields.

4.2.10.6 Evaluation of *Trichogramma* spp against apple fruit moth, *Argyresthia conjugella* under laboratory conditions

YSPHUF: *Trichogramma* spp namely *Trichogramma achaeae, Trichogramma pretiosum* (thelytokous strain), *Trchogramma chilonis, Trichogramma pieridis* and *Trichogramma embryophagum* exhibited low efficacy against the pest. Maximum parasitisation (16.6 per cent) was observed due to *T. embryophagum. T. pieridis* failed to parasitize the eggs of apple fruit moth.

4.2.10.7 Management of apple root borer using *Metarhizium anisopliae*

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

4.2.11. Biological suppression of pests in plantation crops

4.2.11.1 Surveillance of rugose whitefly *Aleurodicus rugioperculatus* in coconut and assessing the population of natural bio control agents

DRYSRHU: The incidence of rugose whitefly was observed on coconut and oil palm in the various districts of Andhra Pradesh. The host preference of rugose white fly *A.*

rugioperculatus was also recorded by scoring the presence of live egg spirals on leaf and categorized as Low «10 egg spirals/ leaflet) Medium (10-20 egg spirals/leaflet) and High intensity (>20 egg spirals/ leaflet). Among the natural enemies, the natural incidence of coconellid predator *Jauravia pallidula* and *Dichochrysa* sp. nr. *astur* (Banks) was observed. The *E. guadeloupae* parasitoid leaf clips were obtained from Coconut Research station, Aliyarnagar, TNAU and released in farmer's field in whitefly infested gardens revealed the establishment of parasitoid and rate of parasitization varied from nil to 70 per cent.

4.2.11.2 Screening of coleopteran specific Bt formulation (NBAIR strains) against red palm weevil (*Rhynchophorus ferrugineus*)

CPCRI: Three liquid formulations of coleopteran specific *Bacillus thuringiensis* (Bt) supplied by ICAR-NBAIR, Bengaluru, *viz.*, 4Aa1, 4AT2 and BTAN4 showed no grub mortality up to 24h. BTAN4 induced 8% mortality of grubs at 48h after treatment and attained maximum of 36% at 10 days after treatment. The formulation 4AT2 affected a maximum of 34% grub mortality at 10 days after treatment. Preliminary field evaluation of the formulation (BTAN4) on red palm weevil infested palms was carried out at Neendakara, Kollam district in farmer's field and could recover one palm out of 5 treated palms infested by red palm weevil.

4.2.11.3 Screening of coleopteran specific Bt formulation (NBAIR strains) against rhinoceros beetle (*Oryctes rhinoceros*)

CPCRI: Three liquid formulations of *Bacillus thuringiensis* (Bt), *viz.*, 4Aa1, 4AT2 and BTAN4 caused no mortality in first instar grubs (average weight of 2.0g) at 24h after treatment. The formulation 4AT2 caused 12% mortality of grubs at 48h. The formulations 4Aa1 and BTAN4 induced maximum of 30% and 14% grub mortality at 10 days of treatment. The formulations tested on 2nd instar grubs indicated maximum of 22% grub mortality with 4AT2 at 10 DAT followed by 20% mortality with 4Aa1 and BTAN4.

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

DRYSRHU: The spraying treatments of *Beauveria bassiana*, *Metarhizium anisopliaea* and Azadirachtin 1500 ppm were on par with chemical check treatment (Lamada cyhalorthrin) throughout the observational period. In untreated control the bag worm population increased throughout the observational period.

4.2.12 Biological suppression of pests in vegetables

4.2.12.1 Bio-intensive pest management of *Helicoverpa armigera, Tuta absoluta* and sucking pests of tomato

TNAU: At 105 DAT, the per cent fruit damage caused by *H. armigera* (5.16 %) and *T. absoluta* (5.30 %) was significantly lesser in BIPM plots when compared to chemical treatment plot (10.92 and 9.10 %, respectively) and control plots (14.80 and 18.50%, respectively).

IIVR: BIPM had lowest whitefly (0.27), aphid (0.20), jassid (0.23) and leaf miner (0.97) populations per leaf followed by chemical module. However, lowest fruit damage was recorded in chemical control module (1.44%) followed by BIPM module (5.05%).

MPKV: BIPM treatment was found significantly superior over other treatments by recording minimum number of larval population of *H. armigera* (2.20 larvae/1o plants) with fruit damage on number basis (16.60%) and on weight basis (14.80 %). In case of sucking pests population the treatment with BIPM recorded minimum number of 2.97 thrips/ plants and 2.93 whiteflies/plants. The highest marketable fruit yield (218.25 q/ha) was recorded in BIPM treated plots whereas untreated control plot recorded lowest yield (156.40 q/ha).

YSPUHF: Bio-intensive Integrated Pest Management (BIPM) module comprising of pheromone trap (PCI), marigold as trap crop, six releases of *Trichogramma achaeae @* 50000/ha, two sprays of azadirachtin 1500ppm @ 2ml/L, one spray of *Lecanicillium lecanii* (5g/L of 10^8 conidia/g) was as effective as chemical control against *Tuta absoluta* in tomato.

4.2.12.2 Role of habitat manipulation for insect pests, nematodes and natural enemies in brinjal

TNAU: The pest population assessed in brinjal crop with all combination of inter and border crops showed no significant variation on the incidence of shoot damage of *Leucinodes orbonalis* and hopper population. But the incidence of *Epilachna* beetle was minimum in brinjal with coriander as inter crop and cowpea as border crop (T1) was minimum as against the sole crop but coccinellids was high in same treatment. The nematode population (Root knot and reniform nematodes) was significantly lower in Brinjal crop intercropped with radish (192.6 no.s./ 250 gm soil) and coriander (201.6 nos./250 gm soil).

4.2.12.3 Bio-intensive insect management in brinjal

TNAU: The per cent shoot damage and number of damaged fruits noted were significantly low (3.64 % and 0.46no./plant) in BIPM plots as compared to spraying of pesticides in farmers practice (7.29% and 1.46no./plant) and untreated check (19.79% and 3.25 no./plant). The cost benefit ratio realized in BIPM is 1:7.64.

MPKV: Treatment with chlorpyriphos 0.04 per cent and BIPM were found on par with each other by recording shoot infestation (7.72% and 9.16%), fruit damage on number (6.33% and 7.82 %) and on weight basis (3.92% and 4.61 %), respectively. The highest marketable fruit yield (230.56 q/ha) was recorded in chlorpyriphos 0.04 per cent treated plots, which was at par with BIPM treated plot (217.46 q/ha).

OUAT: Lower fruit damage (44.87%), higher yield (13.80 t/ha) and higher B:C ratio (1:2.34) were noted in BIPM package. The fruit damage, yield and B:C ratio in farmers practice were 52.72%, 12.63 t/ha and 1:0.80, respectively.

SKAUST: Mean per cent fruit and shoot borer infestation was less in chemical treatment followed by biocontrol based management treatment. Mean fruit infestation in treatments T1 (5 releases of *T. chilonis*), T2 (3 sprays of chlorpyriphos 20 EC@ 1.0 ml/lit. of water) and T3 (untreated check) was worked out as 10.64, 5.96 and 23.97, respectively.

4.2.12.4 Efficacy of biocontrol agents for management of fruit borer *Earias vittella* on bhindi

TNAU: Three releases of *Trichogramma* @ 50000 /ha was able to control the damage 100% and was on par with flubendiamide treatment (2.72 % damage) while realising the fruit yield of 9.7t/ha.

MPKV: The treatment with chlorpyriphos 0.04 per cent was found to be significantly superior over all other treatments in reducing shoot infestation (5.43%), fruit damage on number (9.86%) and on weight basis (11.43%). It was however, at par with *B. thuringiensis* @ 1 kg/ha in respect of shoot infestation (6.25%) and fruit damage on number basis (11.62%) as well as weight basis (12.94%). The highest marketable fruit yield (201.77 q/ha) was recorded in chlorpyriphos treated plots which was at par with *B. thuringiensis* @ 1 kg/ha (196.88 q/ha).

4.2.12.5 Effect of biopesticides for the management of shoot and fruit borers *Earias vittella* in bhendi

KAU Vellayani: Damage caused by the insect pest *Earias vitella* to the crop bhindi was reduced significantly in the plots treated with biopesticides *Beauveria bassiana* (ITCC 6063) talc based formulation @ 20g /l and *Metarhizium anisopliae* @ 5g/l. Significant reduction in the damage by the leaf webbers was observed at 3rd, 5th, 10th and 15th day of intervals, when *Metarhizium anisopliae* 0.5 % @ 5 g/l, *Beauveria bassiana* ITCC 6063 @ *20* g /l were applied.

4.2.12.6 Biological control of lepidopteran pest complex and aphid on cabbage treatments

TNAU: The results revealed that the efficacy of BIPM practices was significantly superior in reducing the population of DBM by recording 0.84 larvae/plant after three rounds of spray while it was 2.26 and 8.88 larvae /plant in chemical treatment and control plot. The CB ratio was 9.75 in BIPM plot and it was only 4.09 in chemical treatment.

NBAIR: The mean number of holes on cabbage leaves (2.21 holes/plant) were significantly (P<0.05) lower in biocontrol based management practices. The percent head damage (7%) was recorded significantly lower in the biocontrol agent applied field in comparison to farmer practices (32.2%).

CAU: The number of holes per plant and number of Diamond back moth larvae were significantly less in field treated with biocontrol component than farmers practice. The percent reduction of aphids per plant was significantly more in field treated with biocontrol based component than farmers practice (F= 15.34, df = 1, 14, P = 0.0015).

4.2.13 Biological suppression of oilseed crops pests

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

AAU-A: The results obtained in the year 2017-18 are not in line with the results of previous year (2016-17). However the treatment *Beauveria bassiana* + *Lecanicillium lecanii* recorded low aphid index (1.51) among the biocontrol treatments and with regard to seed yield consistent results were not recorded as compared to previous year. Low seed yield was recorded in the current year. Among the biocontrol treatments *Beauveria bassiana* + *Lecanicillium lecanii* recorded the highest seed yield (4.77q/ha).

OUAT: Among the tested fungal bio-pesticides *Lecanicillium lecanii* @ $1x10^8$ spores/g applied at a dose of 2.5kg/ha was found significantly superior in reducing the aphid population and comparable to the commercial neem formulation, i.e. azadirachtin 1500ppm @ 1l/ha.

4.2.14. Biological suppression of polyhouse crop pests

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

KAU RARS, Kumarakom: Incidence of serpentine leaf miner, *Liriyomyza trifolii* was recorded in 40% of polyhouses surveyed with 5 to 20 percentages of infested leaves. Incidence of Tetranychid mite *Tetranychus truncatus* Ehara (population ranging from 2-5/cm^2) were observed in 40 percent of polyhouses surveyed. At one polyhouse infestation of Spodoptera litura could be seen. Incidence of powdery midew, leaf blight, leaf spot and rust diseases were also observed.

b) Evaluation of microbial agents for the management of major pests of yard long bean

KAU-RARS, Kumarakom: Data on population of aphids was insignificant to be analyzed after first spraying and second spraying. Observations recorded on 3, 5 and 7 days after third spraying showed that *Beauveria bassiana* 1% (10^8 spores/ml and 10^9 spores/ml) and *Lecanicillium lecani*i 1% (10^8 spores/ml and 10^9 spores/ml) were effective in reducuing aphid population.

4.2.14.2 Evaluation of biocontrol agents for the control of sucking pests in capsicum under polyhouse

YSPUHF: Chemical treatment imidacloprid (0.5ml/L) was the best treatment resulting in 92.6 to 95.1 per cent reduction in the aphid population over control. Ten days after the second spray/ release, among biocontrol agents, *Chrysoperla zastrowi sillemi* (4 larvae / plant) resulted in the highest (73.8%) reduction in the aphid population followed by on par reduction by azadirachtin (2ml/L of 1500ppm) (68.6%) and *Lecanicillium lecanii* (5g/l of 10^8conidia/ g) (66.2%). Other biocontrol agents resulted in 44 to 58.3 per cent reduction in the aphid population over control 10 days after the second spray/ release.

4.2.15 Large-scale adoption of proven biocontrol technologies

4.2.15.1 Rice

AAU-A: Large scale demonstration was conducted in rice during *kharif* 2017-18. Among different insect pests, infestation of paddy leaf folder was very low (1%-2%). No incidence of dead hearts, silver shoots, BPH was recorded. High incidence of false smut disease (45-50%) was recorded in both the modules.

AAU-J: The per cent incidence of dead heart in BIPM plots was 5.10 and 3.15 at 45 DAT and 60DAT, respectively. The corresponding figures in farmers practice (chemical control) was 5.05 and 3.78 per cent. Both the treatments were comparatively superior to untreated control plots both at 45 DAT (5.14 %) and 60 DAT (4.82%). In case of leaf folder damage, no significant differences in damaged leaves were observed at 45 DAT, where as in BIPM plots at 60 DAT, the per cent damaged leaves due to *Cnaphalocrosis sp*. was 4.10 as compared to 4.72 in farmers practice plots and both treatments were significantly different from each other. Maximum damaged leaves (6.14%) were recorded at untreated control plots. Grain yield in BIPM package (4680.94 kg/ha) was significantly better as compared to 4313.80 and 3270.38 kg/ha in farmers practice and untreated control plots, respectively. The net returns over control in BIPM package were Rs. 18,011.2 as compared to Rs. 11,668.40 in farmers practice plot with cost: benefit ratio of 1:1.76 and 1:126, respectively.

GBPUA&T & NBAIR: Large scale field demonstrations of bio-control technologies were conducted at the end of certified organic growers (**515 no**.) covering an area of **189.0 ha** in association with Nature Bio-Foods Ltd. Seed bio-priming, seedling dip treatment, Five foliar sprays with PBAT-3and release of trichocards interventions were carried out. An average yield of 29.0 q/ha was recorded bio-control treatment along with need-based organic practices as compared to a yield of 24.66 q/ha obtained by the farmers adopting recommended organic practices. Maximum yield of 36 q/ha was obtained by the farmers who used PBAT-3 along with Trichocard and need based organic practices.

KAU: Large scale validation of BIPM in rice was carried out over an area of 100 ha in Vadekkenchery Panchayat of Palghat District from Sept 2017 to January 2018, using the variety Uma. The mean stem borer population in BIPM plots was 43 per cent lower as compared to non BIPM plots. Similarly, the dead heart as well as white ear head symptoms recorded 86 and 78 per cent reduction in IPM plots as compared to non BIPM plots. The yield obtained from BIPM plots, at 8000 kg/ha was approximately 20 per cent more than that obtained from non BIPM plots (6800 kg/ha). The increased yield as well as reduced cost resulted in an increase in profit by Rs 35,800/ha. The cost benefit ratio, at 2.96 was almost double for BIPM fields as compared to 1.90 for non BIPM fields.

OUAT: Large scale bio-intensive pest management module was demonstrated in 2ha of farmers' field in paddy crop (Swarna sub1) during *Kharif* 2017. B:C ratio for BIPM was 1.84 which was higher than farmer's practice and control.

PAU: Large scale demonstrations of biocontrol based IPM (six releases of *T. chilonis* and *T. japonicum* each @ 1, 00, 000/ha) conducted in organic *basmati* rice (var. Pusa 1121) over an area of 101.98 hectare rendered lower incidence of dead hearts in biocontrol field (2.09 %) as against untreated control (4.63 %) resulting in a reduction of 54.5 per cent. Similarly, leaf folder damage in release field was significantly lower in biocontrol fields (2.43%) as compared to untreated control (5.57%) with a mean reduction of 56.2 per cent (Table 12). The mean incidence of white ears was significantly lower in biocontrol field (2.91%) as against untreated control (5.82%) resulting in a reduction of 50.0 per cent.

4.2.15.2 Bt cotton

AAU-A: More number of PBW damaged bolls were recorded in the month of November 2017 *ie*., 28.88 % infested bolls in BIPM package and 26.23% infested bolls in farmers practice block. In case of sucking pests, there was an incidence of thrips and aphid only. No whitefly and jassid infestation noticed. There was a significant difference in bioefficacy of different modules on aphid population. Farmers practice package recorded less number of aphid (4.88/leaf) compared to BIPM package (5.86 /leaf). BIPM package recorded 22.03 q/ha cotton seed which was on par with the yield recorded in farmers practice (23.12 q/ha)

4.2.15.3 Tomato

AAU-A: No significant difference was observed between BIPM package and chemical control with regard to the parameters *viz*., number of *H. armigera* larvae/plant and fruit damage as compared to untreated control. BIPM package found equally effective as chemical control against *H. armigera*. Similarly with regard to fruit yield recorded in chemical control module (16.43 t/ha) was at par with the yield recorded in BIPM package (16.25 t/ha). However, low yield was recorded in untreated control (10.89 t/ha)

4.2.15.4 Sugarcane

ANGRAU: Large scale demonstration using temperature tolerant strain *T. chilonis* was conducted in 4.04 hecatre area. Incidence of early shoot borer incidence was low (4.51 to 12.65 % DH) in biocontrol field compared to farmer's practice (21.66 % DH). Early shoot borer incidence upto 120 days (3.42 % DH) and internode borer incidence (3.02%) and internode borer intensity (20.73 %) recorded low in biocontrol field.

OUAT: The egg parasitoid, *Trichogramma chilonis* @50,000/ ha was released at 10 days interval starting from 45 DAS (days after sowing) in the farmers field in sugarcane (87A - 298) crop of 5 ha grown during *rabi* 2017-18. Per cent dead heart due to early shoot borer was less in BIPM treatment (8.17%) compared to farmer's practice (6.89%)

PAU: Large-scale demonstrations on the effectiveness of *Trichogramma chilonis* (Biocontrol based IPM technology) @ 50,000 per ha at 10 days interval during July to October, 2017 (twelve releases) over an area of 3342.70 hectare conducted at farmers' fields in collaboration with six sugar mills of the state reduced the incidence of stalk borer, *Chilo auricilius* by 57.5 per cent . *T. chilonis* release over an area of 254.14 hectare reduced incidence of stalk borer,

C. auricilius over control by 59.3 per cent. *T. chilonis* also reduced early shoot borer, *Chilo infuscatellus* incidence by 54.7 per cent over an area of 632.12 hecatre. Large-scale demonstrations of effectiveness of *T. japonicum* against top borer, *S. excerptalis* were carried over an area of 89.84 hecatres reduced its incidence over control by 53.9 and 80.4 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: 19.55) as against chemical control (1: 10.96).

4.2.15.5 Large-scale demonstration on biological suppression of *Spodoptera litura* with *Nomuraea rileyi* in soybean

MPKV: Two sprays of *N. rileyi* (2.0×10^8 cfu/ g) was significantly superior in suppressing the larval population of *S. litura* (2.80 larvae/m row) due to fungal infection with 16.27 q/ha.

4.2.15.6 Large scale demonstration on biological suppression of apple root borer in apple

YSPUHF: A large scale demonstration on the management of apple root borer, *Dorysthenes hugelii* by using *Metarhizium anisopliae* covering an area of 5h and 11 orchards. *Metarhizium anisopliae* (10^8 conidia/g) was applied @ 30g/ tree basin mixed in well rotten farm yard manure (FYM) during July- August i.e. at the time of egg hatching and emergence of new/young grubs. Chemical treatment comprising of chlorpyriphos (0.06%) was also applied. *Metarhizium anisopliae* treatment resulted in 71.1 to 82.2 per cent mortality of the apple root borer grubs in different orchards, which was close to chemical treatment (77.4-86.6%).

4.2.15.7 Large scale demonstration on biological suppression of maize stem borer

PAU: Large scale demonstrations using *T. chilonis* against maize stem borer, C*hilo partellus* was carried out at farmer's fields on an area of 163.49 hectare. Two releases of *T. chilonis* @ 100,000/ ha at 10 and 17 days old crop resulted in 57.4 per cent reduction in dead hearts incidence over control as compared to 74.8 in chemical control. The net returns over control in biocontrol package were Rs. 6240.25/- as compared to Rs.8817.25/- in chemical control.

4.2.16 Tribal Sub plan programme (TSP)

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

Fifty tribal farmers (chick pea growers) were selected from Dahod district and distributed bio-inputs. Training and demonstration programmes were organized. There was a significant reduction (65-70%) in incidence of *Fusarium* wilt and *H. armigera* and 12-15% higher yield was recorded in the treated fields compared to untreated.

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

Fifty tribal farmers (okra growers) were selected from Tapi district and distributed bio-inputs. Training and demonstration programmes were organized on use of bio-inputs in cultivation of okra. Fields were visited to record the use of bio-inputs by the farmers and bio-efficacy of inputs distributed. Significant reduction (55-60%) in pest and disease was observed with 10-15% increase in the fruit yield.

ANGRAU: Organic farming in paddy, rajmah, ginger and production of trichocards

Awareness programmes on organic farming in paddy, rajmah, ginger and production of *Trichogramma chilonis* card using Eri silk worm eggs in tribal areas was conducted at Chittempadu, Koyyuru mandal; Asarada, GK veedhi mandal. Total of 74 tribal farmers of Chintapalli region, Visakhapatnam district were benefitted through this programme. Imparted training to 29 tribal farmers of Chittempadu village, Koyyuru mandal, Chinthapalli division on nutrient management and pest management in organic paddy cultivation with special emphasis on biological control. 30 farmers from Asarada, GK veedhi mandal, Chinthapalli were benefitted through training on nutrient management, pest management and post harvest practices in rajma. 15 tribal farmers from Asarada, GK veedhi mandal, Chinthapalli were benefitted through exposure visit and training on trichocard production using Eri silkworm eggs and *Corcyra* eggs at AICRP on Biological control, RARS, Anakapalle. Prepared Booklet (Telugu) on " Mukkyamaina pantalalo Jeevaniyantrana paddathula dwara hanikaraka purugula nivarana" (Biological control of insect pests in important crops) under TSP programme of AICRP on Biological Control and released by Hon'ble Vice chancellor, ANGRAU during Kisan mela held at RARS, Anakapalle, on 29 .1.2018.

YSPUHF: Demonstrations on the use of eco-friendly methods of pest management for apple and vegetable crop covering 100ha benefitting 100 farmers have been conducted in Telangi and Sangla villages of district Kinnaur. The farmers were exposed to the use of bio-pesticides for the first time. The apple farmers saved about Rs. 14000/ha as cost of insecticides for the management of root borer. In case of cauliflower number of pesticide sprays was reduced by

5. Project Coordinator's and monitoring team visits to AICRP centres during 2017-18

Sl.No.	Dates	Visit of Director/ NBAIR Scientist	Place of visit	Highlights of visit
1	04-10-18 to 08-10-18	Dr. Richa Varshney	GBPUA&T, Pantnagar	Review the progress of the research programme
2	06-11-2017 to 07 –11-2017	Dr. M Mohan, Principal Scientist	AAU, Anand	Review the progress of the research programme
3.	13-02-2018 to 14-02-2018	Dr. Ramya, Scientist,	AAU, Anand	Review the progress of the research programme
4.	28-02-2018	QRT Team & Dr. Chandish Ballal, Director, NBAIR and	PJTSAU, Hyderabad	Review the progress of the research programme

		Project Coordinator, AICRP BC, NBAIR		
5.	29.1.2018 to 30.1.2018	Dr.B.Ramanujam, Scientist, NBAIR, Bengaluru	TNAU, Coimbatore	Review of AICRP biocontrol of crop pests scheme
6.	26-01-2018	Dr. Chandish Ballal, Director,NBAIR, and Project Coordinator, AICRP BC, NBAIR	AAU, Jorhat	Review the progress of the research programme.
7.	15-02-2018	Dr. P. K. Chakravarty, Director,NBAIR, Honb'l Vice Chancellor	AAU, Jorhat	Review the progress of research programme on biocontrol.
8.	02-11-2017	Dr. Chandish R. Ballal, Director, NBAIR and Project Coordinator, AICRP BC, NBAIR	KAU, Vellanikkara, Thrissur.	Review of the activities of the centre.
9.	During October and November 2017	Dr. S. K. Jalali Dr. Omprakash Navik	UAS Raichur	For evaluation trial and review of the activities of the centre.

6. Publications: During the year 2017-18, a total of **164** 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,Bengaluru	37	-	-	37
AAU, Anand	1	2	6	9
AAU, Jorhat	9	-	23	32
GBPUAT,Pantnagar	9	1	9	19
KAU, Thrissur	-	-	-	-
MPKV, Pune	6	1	1	8
PAU, Ludhiana	13	-	4	13
PJTSAU,Hyderabad	-	1	-	1
SKUAST, Srinagar	6	-	1	7
TNAU, Coimbatore	12	-	-	12
YSPUHF, Solan	15	-	-	15
UAS-Raichur	4	-	3	7
Total	**112**	**5**	**47**	**164**

7. Profile of experiments and demonstrations carried out during 2017-18

Crop/Insect	Experiments	Large Scale Demonstrations
Biodiversity of biocontrol agents	2	-
Antagonists of crop disease management	2	-
Sugarcane	2	7
Cotton	9	1
Tobacco	0	0
Rice	3	6
Maize	3	1
Plantation crops	4	0
Pulses	3	0
Oilseeds	1	1
Tropical and temperate fruits	10	0
Vegetables	6	1
Polyhouse crops	3	0
Flowers	1	0
TSP	7	0
Total	**56**	**17**

8. Budget of AICRP on Bio control for 2017-18

Item of Expenditure	Sanctioned and allotted grants (Rs. in lakh)	Grants released during2016-17 from ICAR (Rs. in lakh)	Total expenditure (Rs.)
Pay and allowances	409.00	409.00	409.00
Rec. Contingencies	45.63	45.63	45.63
T.A	8.11	8.11	8.11
TOTAL	**462.74**	**462.74**	**462.74**

PROCEEDINGS OF THE TECHNCIAL SESSIONS

The Significant achievements and recommendations of the various sessions are as follows.

SESSION I: BIOLOGICAL SUPPRESSION OF PESTS OF FRUIT, VEGETABLE CROPS AND POLYHOUSE CROP PESTS

Chairman	:	Dr. A. K. Singh
Co- Chairman	:	Dr. P. K. Chakrabarty
Repporteurs	:	Dr. T. M. Shivalingaswamy
		Dr. Sible G. Verghese
Speakers	:	Dr. S. Jeyarajan Nelson (Fruit crop pests)
		Dr. J. Halder (Vegetable crop pests)
		Dr. Richa Varshney (Polyhouse crop pests)

Achievements

- Release of *T. cacoeciae* @2.5 lakh/ha. (4 releases/ season) + Trunk banding + Pheromone trapping + disposal of infested fruits + spray of *Heterorhabditis pakistanensis* (NBAIR) resulted in 48.21 % reduction in damage over control in J& K.
- *Metarhizium anisopliae* treatment resulted in 71.1 to 82.2 per cent mortality of the apple root borer grubs in different orchards in Solan, which was comparable to chemical treatment (77.4-86.6%).
- Significant reduction in the damage by hoppers and webber (*Orthaga* sp.)was observed at 3rd, 5th, 10th and 15th day intervals, when *Metarhizium anisopliae* 0.5 % @ 5 g/l, *Beauveria bassiana* ITCC 6063 @ *20* g /l were applied in Kerala.
- The per cent shoot damage and number of damaged fruits in brinjal due to BFSB were significantly low (3.64 % and 0.46no./plant) in BIPM plots in Tamil Nadu, Maharahstra and Orissa.
- The efficacy of BIPM practices was significantly superior in reducing the population of DBM in Karnataka, Tamil Nadu and Pasighat.
- *Beauveria bassiana* 1% (10^8 spores/ml and 10^9 spores/ml) and *Lecanicillium* lecanii 1% (10^8 spores/ml and 10^9 spores/ml) were effective in reducuing aphid population in yard long bean under polyhouse condition in Kerala.

Recommendations / Suggestions

Fruit crops

- Label expansion for use of chlorpyrifos and bioagents in banana can be proposed (**Action**: Centres to send proposal to PC, AICRP-BC).

Vegetable crops

- Yield data has to be statistically analyzed (**Action**: All centres).

Polyhouse and jasmine pests

- The quantity of biopesticide required per season per cluster of farms (tomato, onion, and other crops) need to be known for making it available through AICRP centres (**Action**: Concerned centres).
- Outsourcing for bioagent production may be explored (**Action**: All centres).
- All AICRPs (Acarology/Whitegrub/Nematode) should be invited to attend the workshop and technology available with them can be utilized (**Action**: All centres).
- Emphasis should be laid on mass production and utilization of predatory mites (**Action**: Concerned centres).

SESSION II: BASIC RESEARCH ON BIODIVERSITY AND NATURAL ENEMIES OF INSECT PESTS AT NBAIR AND BIOLOGICAL COTROL OF PLANT DISEASES

Chairman	:	Dr. A.N. Mukhopadhyay
Co- Chairman	:	Dr. B. Ramanujam
Rapporteurs	:	Dr. Omprakash Navik
		Dr. P. L. Sharma
Speakers	:	Dr. M. Mohan (Biodiversity)
		Dr. M. Sampath Kumar (Pest outbreak)
		Dr. A. K. Tewari (Plant diseases)

Achievements

- Nearly 3000 specimens were collected, bred, curated, identified and preserved.
- Among the 20 isolates of *B. bassiana* tested, Bb-5a showed significantly higher mortality (77.36%) in diamondback moth followed by Bb-45 isolate (51.14%).
- Molecular characterization and DNA barcodes were generated for 90 agriculturally important parasitoids, predators and other insects based on COI gene & ITS-2.
- PBAT-3, Psf-2 and Th-14 were comparatively better than other bioagents in reducing diseases (sheath blight, brown spot) and increasing yield in paddy.
- In Chickpea (variety PG-186), maximum per cent seed germination was observed in NBAIR-1-Th and carbendazim (69.8%).

Recommendations / Suggestions

- Quantify the data on natural enemies, crop/pest wise (**Action**: All centers).
- The centers should intervene with appropriate control measures when outbreak of pests/diseases occurs (**Action**: All centers).
- Surveillance for *Tuta absoluta* should be taken up by the centers having potato cultivation in their areas (**Action**: Concerned centres).
- In case of consortia, registration for the individual microbial should be taken separately and later they could be recommended as tank mix for disease management (**Action**: GBPUAT).

- GBPUAT center should supply their strains of *Trichoderma/ Pseudomonas* to other AICRP centers for validation on disease management (**Action**: GBPUAT).
- The SAUs where there is post of plant pathologist/microbiologist, active work on disease management programme with *Trichoderma* should be taken up. It would be highly desirable to involve **AAU-A; AAU-J; PAU; ANGRAU** and other centres to work in a coordinated manner for disease management, besides GBPUAT.

SESSION III: BIOLOGICAL SUPPRESSION OF PESTS OF SUGARCANE and COTTON

Chairman : Dr.S. Sithanantham
Co- Chairman : Dr. S.K. Jalali
Rapporteurs : Dr. M. Visalakshi
Dr. Anoop, NCIPM, New Delhi

Speakers : Dr. D. K. Saikia (Sugarcane pests)
Dr. M. Prabakaran, Sun Agro, Chennai (Sugarcane internode borer)
Dr. R. V. Nakat (Cotton pests)

Achievements:

- Percent reduction in plant damage due to white grub incidence high in *Heterorhabditis indica* (79.86 %), *Metarhizium anisopliae* (67.74%) and Chlorantraniliprole18.5SC (72.91%) over untreated control in Anakapalle.
- Three sprays of *Lecanicillum lecanii* (1 x 10^8 conidia/g) @ 5 g/litre given at fortnightly interval recorded lowest population of aphids (6.68) , jassids (2.48), thrips (2.82) and white flies (1.81) in cotton compared to the untreated control.
- In Raichur number of PBW larvae in parasitoid released field and chemical treated cotton field was 23.25 and 11.60 larvae per 10 bolls, respectively, which was lower than control (32.85 larvae per 10 bolls).

Recommendations / Suggestions

- The valuable finding on higher cost-benefit ratios obtained through *Trichogramma* releases along with pheromone trapping and need based chemical sprays compared to chemical control is the highlight of PBW trial and should be part of future programmes for promotion of the technology (**Action**: UAS-R; PJTSAU; AAU-A; ANGRAU).
- A one page write up on success story on management of sugarcane pests by using *Trichogramma* spp. (temperature tolerant strains) may be forwarded to sugarcane research institutes like SBI and IISR (**Action**: PAU – to send write-up to PC, AICRP-BC so that the same can be forwarded to SBI and IISR).

SESSION IV: BIOLOGICAL SUPPRESSION OF PESTS OF RICE and MAIZE

Chairman : Dr. R. J. Rabindra
Co- Chairman : Dr. A. N. Shylesha
Rapporteurs : Dr. Chitra Shanker
Dr. K. Selvaraj

Speakers : Dr. Madhu Subramanian (Rice pests)
Dr. Neelam Joshi (Maize pests)

Achievements:

- In Kerala incidence of stem borer and leaf folder was low while the incidence of blue beetle was moderately high. The leaffolder incidence was significantly the lowest (1.89%) in *Heterorhabditis indica* treated plots at Anakapalle. In organic plots the reduction in hopper population over control was high in BIPM (89.84%) in comparison to farmers' practice (52.42%).
- In large scale demonstrations of BIPM the pest incidence was significantly lower in three locations *viz*., Ludhiana, Jorhat and Bhubaneswar while the benefit cost ratio was also higher as compared to farmers practice in Bhubaneshwar, Jorhat and Pantnagar.
- Results of two trials in maize across three locations showed that the Bb-45 isoltae of *Beauveria bassiana* recorded the lowest leaf injury among the entomopathogenic fungi but was not significantly higher than the insecticidal treatment. Two sprays of Bt commercial formulations gave on par control as that of insecticide treatment for stem borer of maize.
- At Udaipur, IPM module was found to be the most effective against *Chilo partellus* with a yield increase of 40.52% over control.

Recommendations / Suggestions

- Besides pitfall trap method, sweep netting can also be used for collection of spiders in rice (**Action**: Concerned centres).
- In case of evaluation trial on entomopathogenic nematode or any microbial, insect recovery from the field to assess the infection rate will add value to the studies (**Action**: Concerned centres).
- When commercial Bt formulations are used, care should be taken to incorporate the correct dosage based on International units (IU) and as per label claims, so that the treatments are comparable. Trade names should be avoided in the technical programme (**Action**: Concerned centres).
- Successful technologies identified in AICRP Biological Control programme should be incorporated in the state recommendations through SAUs. This raised the question of CIB registration for bio-pesticides and label claims. The SAU–AICRP partners brought to the attention of the house that the universities do not allow the inclusion of bio-agents in recommendations of the SAU if they are not covered by label claims. It was suggested that a brain storming session may be held to decide upon how best to overcome this problem. The issue may be raised in the forthcoming meeting on

registration of Microbial biopesticides to be held at New Delhi (**Action**: AICRP-BC HQ at NBAIR, Bangalore).

SESSION V: BIOLOGICAL SUPPRESSION OF PESTS OF PULSES, OILSEEDS AND COCONUT

Chairman : Dr. N. Bakthavatsalam
Co- Chairman : Dr. R. V. Nakat
Rapporteurs : Dr. R. N. Borkakati, AAU, Jorhat
Dr. G. Siva Kumar, NBAIR, Bengaluru
Speakers : Dr. Arunkumar Hosamani (Pulses & oilseed pests)
Dr. Chandrika Mohan (Coconut pests)

Achievements

- In Tamil Nadu, NBAII-BTG4 @ 2% spray was effective in reducing the larval population of *Maruca vitrata* and *Exelastis atomosa* in all growth stages of pigeon pea.
- Significantly less larval population was recorded in NBAIR BtG 4 treated pigeon pea field compared to farmer practice in Raichur.
- Among three liquid formulations of coleopteran specific *Bacillus thuringiensis* (Bt) (*viz.*, 4Aa1, 4AT2 and BTAN4), BTAN4 induced 8% mortality of grubs of red palm weevil at 48h after treatment and attained maximum of 36% at 10 days after treatment.
- *Beauveria bassiana* + *Lecanicillium lecanii* treatment recorded low aphid index (1.51) and highest seed yield among the biocontrol treatments in mustard

Recommendations / Suggestions

- Basic studies have to be taken up on the effect of host plants on the preferences of *Encarsia guadeloupe* to *Aleurodicus rugioperculatus* {Rugose spiraling Whitefly (RSW)} and *Aleurodicus dispursus* (Spiraling whitefly) (**Action**: NBAIR, CPCRI, DRYSRHU**)**
- CTCRI formulation developed from cassava leaves may be tested for the management of RSW in nurseries (**Action**: CPCRI).
- Technical programme for the Biological Suppression of Storage Pests has to be formulated (**Action**: NBAIR)
- Influence of nutrition on pathogenicity of entomo-fungal pathogen has to be studied (**Action**: NBAIR)

SESSION VI: TRIBAL SUB PLAN

Chairman : Dr. Devaki Girija, Professor and Head, Dept of Microbiology and Assoc. Director (M&E), KAU, Kerala
Co- Chairman : Dr. S. Jeyarajan Nelson, TNAU, Coimbatore

Rapporteurs : Dr. Jayalaxmi Ganguli, IGKV, Raipur

Dr. Jagadeesh Patil, NBAIR, Bengaluru

Speaker : Dr. B. L. Raghunandan

Achievements

- *Fusarium* wilt and pod borer (*Helicoverpa armigera*) in Chickpea and okra pests was managed by providing biological inputs and trainings at Dahod and Tapi districts of Gujarat. 100 farmers were benefitted.
- Total of 74 tribal farmers of Chintapalli region, Visakhapatnam district were benefitted through traiing programme on organic farming in paddy, rajmah, ginger and production of *Trichogramma chilonis* card using Eri silk worm eggs.
- Trichocard production unit was started at Asarda Village.
- 100 farmers were benefitted in Telangi and Sangla villages of district Kinnaur through demonstration and training. The farmers were exposed to the use of bio-pesticides for the first time. The apple farmers saved about Rs. 14000/ha towards cost of insecticides for the management of root borer. In case of cauliflower number of pesticide sprays was considerably reduced.

Recommendations / Suggestions

- Biocontrol labs of State Govt. should take up the work on mass production and supply to farmers.. Centres to identify the biocontrol Labs in their respective states and provide training and nucleus cultures as per need to these labs). (**Action:** All centres)
- In ginger for rhizome rot problem rhizome treatment with *Trichoderma* should be taken up as a routine practice. Action plan should be formulated for control of rhizome rot problem in ginger and efficacy report should be submitted and presented. (**Action**: ANGRAU).

SESSION VII: INSTITUTE-INDUSTRY-DEPARTMENT PARTNERSHIPS

Chairman : Dr. S. Pathummal Beevi former head, AICRP-BC, KAU, Kerala
Co- Chairman : Dr. M. Nagesh, NBAIR, Bengaluru
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Dr. Laxminarayana Praharaju, Hyderabad
Dr. Resmi Deepak, Kerala
Dr. U. K. Kulkarni, PDKV, Akola

Recommendations / Suggestions (Action: All concerned centres)

- The role of National Biodiversity Authority in the export of commercial products of biocontrol agents may be elicited.
- Information on export of biopesticides from different commercial units may be documented by AICRP-BC.
- The commercial production units expressed the need for hand holding and training/HRD on basic taxonomy and molecular characterization.
- Explore the possibility of collaborative R&D programmes on P-P-P mode
- Technologies on shelf life enhancement of trichogrammatids and pheromone trapping systems and trap designs to be put up for commercialization.
- Technical audit of biopesticide production units for Quality control, to be strengthened
- Annual demand of biopesticides from each state may be obtained for addressing production concerns

SESSION VIII: TECHNICAL PROGRAM

Chairperson	:	Dr. R. J. Rabindra
Co- Chairman	:	Dr. Chandish R. Ballal
Rapporteur:		Dr. Sunil Joshi, Dr. Richa Varshney, Dr.B. Ramanujam, Dr. M. Nagesh, Dr. T. Venkatesan
Presenter	:	Dr. J. Patil

Recommendations / Suggestions

- Various suggestions given were incorporated in the technical program which included the programme for 13 new contingency centres.

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Indian Institute of Rice Research (IIRR), Hyderabad Dr. Chitra Shanker, Pl. Scientist (Ento.) Dr. C. Kannan, Pl. Scientist (Pl. Pathology)	**Indian Institute of Millet Research (IIMR), Hyderabad** Dr. G. Shyam Prasad, Pl. Scientist (Ento.)
Indian Institute of Vegetable Research (IIVR) Varanasi Dr. Jaydeep Halder, Scientist (Ento.)	**National Centre for Integrated Pest Management (NCIPM), New Delhi** Dr. Anoop Kumar, Scientist (Ento.) Dr. M. K. Khokhar, Scientist (Pl. Patho.)
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Dr. Jayalaxmi Ganguli, Asso. Prof. (Ento.)	
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Uttar Banga Krishi Viswavidyalaya (UBKV), Pundibari Dr. S. K. Sahoo, Asso. Prof. (Ento)	
Others	
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Indian Agricultural Research Institute (IARI), Division of Entomology, New Delhi Dr. B. Paul, Sr. Scientist (Ento.)	**State Biocontrol Laboratory (SBCL), Mannuthy** Mr. Suresh Kumar, N. S., Agri. Officer Mr. Nimba Franco, Asst. Officer Ms. Meena Nair, Deputy Director
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ACRONYMS

AICRP-BC	All India Coordinated Research Project of Biological Control of Crop Pests, Bengaluru
NBAIR	National Bureau of Agricultural Insect Resources, Bengaluru
AAU-A	Anand Agricultural University, Anand
AAU-J	Assam Agricultural University, Jorhat
ANGRAU	Acharya N.G.Ranga Agricultural University, Anakapalle
GBPUAT	Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar
KAU	Kerala Agricultural University, Thrissur
MPKV	Mahatma Phule Krishi Vidyapeeth, Pune
PAU	Punjab Agricultural University, Ludhiana
PJTSAU	Pandit Jayashankar Telangana State Agricultural University, Hyderabad
SKUAST	Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar
TNAU	Tamil Nadu Agricultural University, Coimbatore
YSPUHF	Y.S. Parmar University of Horticultural and Forestry, Solan
CAU	Central Agricultural University, Pasighat
MPUAT	Maharana Pratap University of Agriculture & Technology, Udaipur
OUAT	Orissa University of Agriculture & Technology, Bhubaneswar
UAS-R	University of Agricultural Sciences, Raichur
IGKV	Indira Gandhi Krishi Viswavidhyalaya, Raipur
KAU RARS	KAU-Regional Agricultural Research Station, Kumarakom
KAU RARS	KAU-Regional Agricultural Research Station, Vellayani
YSRUH	Dr. Y S R Horticultural University, Ambajipeta
UBKV	Uttar Banga Krishi Vishwavidyalaya, Pundibari, West Bengal
CISH	Central Institute of Subtropical Horticulture, Lucknow
CPCRI	Central Plantation Crops Research Institute, Kayamkulam
CTRI	Central Tobacco Research Institute, Rajahmundry
IIHR	Indian Institute of Horticultural Research, Bengaluru
IIRR	Indian Institute of Rice Research, Hyderabad
IIMR	Indian Institute of Millet Research, Hyderabad
IIVR	Indian Institute of Vegetable Research, Varanasi
NCIPM	National Centre for Integrated Pest Management, New Delhi

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