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Proceedings of the XXVI Biocontrol Workers' Group Meeting and Technical Programme for 2017-18 & 2018-19

16th-17th May, 2017
Yashwant Singh Parmar University of Horticulture and Forestry
Nauni, Solan, Himachal Pradesh

Compiled and Edited by
Richa Varshney, S K Jalali, B. Ramanujam and Chandish R Ballal

AICRP on Biological Control of Crop Pests
NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES
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Karnataka

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I am thankful to **Dr. P. K. Chakrabarty**, ADG (PP&B), ICAR, New Delhi; **Dr. H. C. Sharma**, VC, YSPUHF, Solan; **Dr. B. V. Patil**, former VC, UAS, Raichur, **Dr. S. N. Puri**, Chariman, RAC, NBAIR; **Dr. R. J. Rabindra,** former Director, NBAII (PDBC), Bangalore; **Dr. L. K. Hazarika**, HOD, Entomology Deparment, AAU, Jorhat; **Dr. D. B. Ahuja**, Director, NCIPM, New Delhi; **Dr. O. P. Sharma**, Principal Scientist, NCIPM, New Delhi; **Dr. P. R. Gupta**, former HOD, Entomology Deparment, YSPUHF, Solan; **Dr. S. Sithnanatham**, Sun Agro, Chennai; **Dr. R. K. Walia**, Project Coordinator (Nematodes), IARI, New Delhi; **Dr. B. Ramanujam**, Principal Scientist, NBAIR; **Dr. S. K. Jalali**, HOD, Molecular Entomology, NBAIR, Bangalore, for chairing / co-chairing different sessions.

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Bangalore
14 June 2017

Chandish R. Ballal
Director & Project Coordinator (AICRP-BC)
ICAR-National Bureau of Agricultural Insect Resources
Bangalore

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

Venue: Dr. Y. S. Parmar University of Horticulture & Forestry, Nauni, Solan
Date: 16th and 17th May 2017

PROGRAMME: May 16th, 2017

0930-1030	**REGISTRATION**
1030-1130	**INAUGURATION**
Invocation	Lighting of lamp, invocation & ICAR Song
Welcome Address	**Dr. K S Verma** Director of Research, YSPUHF, Solan
Project Co-ordinator's Report	**Dr. Chandish R Ballal** Project Co-ordinator, AICRP-BC & Director, NBAIR, Bangalore
Release of Folders, Bulletins, Technology folders, CDs / DVDs, etc	**NBAIR, Bangalore** – AICRP-BC document on newspaper reports, NBAIR calendar 2017-18; Technology Folders **MPKV, Pune** – A folder on Success story of Biological management of papaya mealybug. **TNAU, Coimbatore** - A DVD on the Mass production of Insect Biocontrol Agents. **SKUAST, Srinagar** - Important coccinellid predators on fruit pests in Kashmir. **AAU, Anand** – Know the natural enemies of cotton insect pests **ANGRAU, Anakapalle** - Booklet on ICAR-Tribal Sub Plan Programme – A Boost to the Organic Farming in the Tribal areas of Visakhapatnam district. **GBPUAT, Pantnagar** - Booklets in English and in Hindi on "Success Stories of Farmer's on Biological Control". **UAS, Raichur** – Role of entomopathogens in pest management .
Remarks: ADG (PP), ICAR	**Dr. P K Chakrabarty** ADG (PP& B), ICAR, New Delhi
Remarks: VC, GBPUAT	**Dr. R J Rabindra** Former Director, NBAIR, Bangalore
Remarks: RAC Chairman, NBAIR	**Dr. S N Puri** Former VC, CAU & Chairman, RAC, NBAIR, Bangalore
Chief Guest Address	**Prof. H C Sharma** Vice Chancellor, YSPUHF, Solan
Vote of thanks	**Dr. (Ms) Anju S Khanna** HOD (Ento), YSPUHF, Solan
1130-1145	**TEA**

PRESENTATION OF PROGRESS REPORTS	
May 16th, 2017 (Tuesday); 1145-1245	**SESSION I: BASIC RESEARCH ON BIODIVERSITY AND NATURAL ENEMIES OF INESECT PESTS AT NBAIR AND BIOLOGICAL CONTROL OF PLANT DISEASES**
Chairman Co-Chairman	Dr. P. K. Chakrabarty, ADG (PP&B), ICAR, New Delhi Dr. B. Ramanujam, ICAR-NBAIR, Bangalore
Rapporteurs	Dr. S. Sharma, PAU, Ludhiana Dr. B. L. Raghunandan, AAU, Anand
Speakers	
Biodiversity, Biosystematics, Molecular Characterization and Biocontrol potential of newer natural enemies	Dr. Sunil Joshi, NBAIR, Bangalore
Pest Outbreak reports	Dr. Sampath Kumar, NBAIR, Bangalore
Biological Control of Plant diseases using antagonists	Dr. A.K. Tewari, GBPUAT, Pantnagar
May 16th, 2017 (Tuesday); 1245-1400	**SESSION II: BIOLOGICAL SUPPRESSION OF PESTS OF COTTON and SUGARCANE**
Chairman Co-Chairman	Dr. B. V. Patil, Former VC, UAS, Raichur Dr. D. B. Ahuja, Director, NCIPM, New Delhi
Rapporteurs	Dr. S. M. Galande, MPKV, Pune Dr. Sajad Mohi-ud-din, SKUAST, Srinagar
Speakers	
Biological control of cotton pests	Dr. K. S. Sangha, PAU, Ludhiana
Biological control of sugarcane pests	Dr. S. J. Rahman, PJTSAU, Hyderabad
1400-1430	**Lunch**
May 16th, 2017 (Tuesday); 1430-1600	**SESSION III: BIOLOGICAL SUPPRESSION OF PESTS OF RICE, MAIZE AND SORGHUM**
Chairman Co-Chairman	Dr. S. N. Puri, Former VC, CAU & RAC Chairman, ICAR-NBAIR, Bangalore. Dr. R. K. Walia, Project Coordinator (Nematodes), IARI, New Delhi
Rapporteurs	Dr. R. N. Borkakati, AAU, Jorhat Dr. Chitra Shanker, IIRR, Hyderabad
Speakers	
Biological control of rice pests	Dr. Madhu Subramanian, KAU, Thrissur
Biological control of maize & sorghum pests	Dr. M. Visalakshi, ANGRAU, Anakapalle
May 16th, 2017; 1600-1730	**SESSION IV: BIOLOGICAL SUPPRESSION OF PESTS OF PULSES, OILSEEDS, TOBACCO AND COCONUT**
Chairman Co-Chairman	Dr. L. K. Hazarika, HOD (Entomology), AAU, Jorhat Dr. S. Sithanantham, Sun Agro, Chennai
Rapporteurs	Dr. R. Patidar, CAU, Pasighat Dr. Arunkumar Hosamani, UAS, Raichur

Speakers	
Biological control of Pulses & Oilseeds pests	Dr. N. Sridharan, TNAU, Coimbatore
Biological control of tobacco pests	Dr. M. Suresh , ANGRAU, Anakapalle
Biological control of coconut pests	Dr. Madhu Subramanaian, KAU, Thrissur and Dr. N. B. V. Chalapathi Rao, YSRUH,
May 16th, 2017; 1730-1745	**Tea Break**
May 16th, 2017; 1745-1845	**SESSION V: BIOLOGICAL SUPPRESSION OF PESTS OF FRUIT CROPS**
Chairman Co-Chairman	Dr. R. J. Rabindra, Former Director, NBAIR, Bangalore Dr. P. R. Gupta, Former HOD (Entomology), YSPUHF, Solan
Rapporteurs	Dr. A. Saravanan, TNAU, Coimbatore Dr. Rabinder Kaur, PAU, Ludhiana
Speakers	
Biological control of temperate fruits pests	Dr. Jamal Ahmad, SKUAST, Srinagar
Biological control of tropical fruit and tea pests	Dr. D. Saikia, AAU, Jorhat
May 16th 2017; 1845-1945	**SESSION VI: BIOLOGICAL SUPPRESSION OF PESTS OF VEGETABLE CROPS, POLYHOUSE CROPS**
Chairman Co-Chairperson	Dr. H. C. Sharma, VC, YSPUHF, Solan Dr. Chandish R. Ballal, Director, ICAR-NBAIR, Bangalore
Rapporteurs	Dr. Roopali Sharma, GBPUAT, Pantnagar Dr. Neelam Joshi, PAU, Ludhiana
Speakers	
Biological control of vegetable pests	Dr. Jaydeep Halder, IIVR, Varanasi
Biological control of polyhouse pests	Dr. Richa Varshney, NBAIR, Bangalore
May 17th, 2017 (Wednesday) 1000-1100	**SESSION VII: TRIBAL SUB PLAN PROGRAMME**
Chairman Co-Chairman	Dr. S. J. Rahman, Principal Scientist & University Head (Entomology), PJTSAU, Hyderabad Dr. D. S. Pokharkar, MPKV, Pune
Rapporteurs	Dr. P.S. Shera, PAU, Ludhiana Dr. M. Visalakshi, ANGRAU, Anakapalle
Repoprt on Tribal Sub Plan programme	Dr. P.L. Sharma, YSPUHF, Solan
May 17th, 2017; 1100-1200	**Session VIII: INSTITUTE–INDUSTRY PARTNERSHIP**
Chairman Co-Chairman	Dr. O. P. Sharma, NCIPM, New Delhi Dr. S. K. Jalali, NBAIR, Bangalore
Rapporteurs	Dr. Jayalaxmi Ganguli, IGKV, Raipur Dr. N.B.V. Chalapathi Rao, DRYSRHU, Ambajipeta
Speakers from Private Industry	Dr. Sithantham, Sun Agro Biotech, Chennai Dr. Karan Sikri, SIKRI FARMS, Kurushetra Mr. Laxminarayana Praharaju, AG Bio Systems Pvt. Ltd.,

	Hyderabad
1200-1215	**Tea Break**
May 17th, 2017; **1215-1330**	**Technical Program Presentation**
Chairperson Co-Chairman	Dr. C. R. Ballal, Director, ICAR-NBAIR, Bangalore Dr. B. Ramanujam, Principal Scientist, ICAR-NBAIR, Bangalore
Rapporteurs	Dr. Sunil Joshi, ICAR-NBAIR, Bangalore Dr. Richa Varshney, ICAR-NBAIR, Bangalore Dr. M. Sampath Kumar, ICAR-NBAIR, Bangalore
AICRP-BC Technical Program for the years 2017=18 & 2018-19 presentation	Dr. S. K. Jalali. Principal Scientist, ICAR-NBAIR, Bangalore
1330-1430	**LUNCH**
May 17th, 2017; **1430-1630**	**Technical Program continued**
Chairperson Co-Chairman	Dr. C. R. Ballal, Director, ICAR-NBAIR, Bangalore Dr. B. Ramanujam, Principal Scientist, ICAR-NBAIR, Bangalore
Rapporteurs	Dr. Sunil Joshi, ICAR-NBAIR, Bangalore Dr. Richa Varshney, ICAR-NBAIR, Bangalore Dr. M. Sampath Kumar, ICAR-NBAIR, Bangalore
AICRP-BC Technical Program	Dr. S. K. Jalali. Principal Scientist, ICAR-NBAIR, Bangalore
1630-1700	**SESSION IX (Plenary): Presentation of Recommendations and Finalization of Technical Programme**
Panel of Experts	Dr. H. C. Sharma, VC, YSPUHF, Solan Dr. S. N. Puri, Former VC, CAU Dr. C. R. Ballal, Director, NBAIR, Bangalore Dr. R. J. Rabindra, Former Director, NBAIR, Bangalore Dr. B.V. Patil, former VC, UAS Raichur Dr. (Ms) Anju S. Khanna, HOD (Ento), YSPHUF, Solan Dr. S. K. Jalali. Principal Scientist, ICAR-NBAIR, Bangalore
Rapporteurs	Dr. Jagadeesh Patil, NBAIR, Bangalore Dr. D. K. Saikia, AAU, Jorhat
Speakers	Presentations of Recommendations & Plan of Work by Chairmen of different technical sessions. Remarks by Panel of Experts
Vote of Thanks	Dr. Chandish R Ballal, Director & Project Coordinator, ICAR-NBAIR, Bangalore
05.00-05.30	**TEA**

INAUGURAL SESSION

The **XXVI AICRP-Biocontrol Workers' Group Meeting** was conducted under the aegis of the Indian Council of Agricultural Research, New Delhi at Y. S. Parmar University of Horticulture & Forestry, Nauni, Nauni, Solan, on 16th and 17th May, 2017. Delegates and invitees from ICAR Institutes, Agricultural Universities, representatives of private commercial production units and staff of Department of Entomology of YSPUHF, Solan, attended the Inaugural Session. The programme was as follows:

Welcome Address	:	**Dr. K S Verma** Director of Research, YSPUHF, Solan
Project Co-ordinator's Report	:	**Dr. Chandish R. Ballal** Project Co-ordinator AICRP on Biological Control
Remarks about Project	:	**Dr. P K Chakrabarty** ADG (PP&B), ICAR, New Delhi
Remarks by Experts	:	**Dr. R J Rabindra** Former Director, NBAIR, Bangalore
	:	**Dr. S. N. Puri** Former VC, CAU, Imphal & Chariman RAC, NBAIR
Chief Guest Address	:	**Dr. H C Sharma** Vice Chancellor, YSPUHF, Solan
Vote of Thanks	:	**Dr. Anju S Khanna,** HOD (Entomology), YSPUHF, Solan

The workshop was inaugurated by **Dr. H C Sharma,** Vice Chancellor, YSPUHF, Solan and by **P.K. Chakrabarty**, ADG (PP) ICAR. **Dr. K. S. Verma,** Director of Research, YSPUHF welcomed the delegates and gave brief account the work carried out at on biological control at YSPUHF, Solan. **Dr. Chandish R. Ballal**, Director, NBAIR Bangalore and Project Coordinator, presented the salient achievements of the AICRP-BC for the year 2016-17. **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 and MPKV, TNAU, SKUAST, AAU-A, ANGRAU, UAS-R and GBPUAT were released by the chief guest and other dignatories. **Dr. Rabindra** and **Dr. Puri** emphasized the role of biocontrol in present day pest management scenario particularly in organic farm situation. They also informed role in polyhouse cultivation, pesticide residue issues and need for registration and mass production of quality biocontrol agents.

Dr. H. C. Sharma, Vice Chancellor, YSPUHF, Solan, 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, faculty and students of YSPUHF, etc. The recommendations and the technical Programme for 2017-18 & 2018-19 were finalized during the meet.

SALIENT FINDINGS DURING 2016-17

Chandish R Ballal
Director, NBAIR, Bangalore & Project Coordinator (AICRP on Biological Control)

1. Introduction

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

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

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

2. Mandate of AICRP on Biological control of crop pests

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

3. Setup

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

State Agricultural University–based centers

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

ICAR Institute–based centres

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

Voluntary Centre

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

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

4. Brief summary of research achievements

4.1 Basic research work at National Bureau of Agricultural Insect Resources

4.1.1 Biosystematic studies on agricultural insects

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

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

4.1.1.2 Biosystematics of trichogrammatidae (Hymenoptera)

A total of 7711 parasitoids belonging to 18 families were collected from Assam, Rajasthan, Karnataka, Kerala and Tamil Nadu. *Hispidophila* and *Megaphragma* were collected from Assam and are being reported from there for the first time. Periodic surveys for hymenopteran parasitoids were conducted in a ragi field in Karnataka at fortnightly intervals for a whole year. Scelionidae were numerically the most abundant followed by Mymaridae, Encyrtidae, Ceraphronidae and Trichogrammatidae. Trichogrammatidae were fairly evenly distributed throughout the year with one peak in April. Identification services, especially for *Trichogramma* and Trichogrammatoidea were provided especially for a large consignment of over 600 specimens from Kerala.

4.1.1.3 Biodiversity of aphids, coccids and their natural enemies

A total of seven surveys were conducted for collection of aphids, coccids and their natural enemies at Udaipur, Yellagiri, Yercaud, Thandikudi and Thaditankudisai, Shimoga and Pune and 17, 21, 18, 12, 13 1nd 16 species of aphids/coccids were collected, respectively from these places. A total of 527 species were identified by making 911 slides by processing 4484 specimens. A total of 75 identification services provided to different SAUs, ICAR institutes and Private Organisations and through which 105 species were identified. Three species of mealybugs (*Heliococcus singularis* Avasthi and Shafee, *Dysmicoccus debregeasiae* (Green) and *Planococcus nilgiricus* Williams), one soft scale (*Macoccus watti* (Green)), one aphid (*Greenidea maculata* Noordam) and one eriococcid (*Gossypariella crematogastri* Kozár & Konczné Benedicty) were added as new to existing collection of aphids and coccids at ICAR – NBAIR museum. One aphid, *Schoutedenia emblica* Patel & Kulkarni and three species of mealybugs, *viz*., *Phenacoccus parvus* Morrison, *Phenacoccus madeirensis* Green, *Pseudococcus saccharicola* Takahashi were recorded for the first time from Udaipur, Rajasthan. Similarly, one armoured scale, *Semelaspidus artocarpi* (Green), one aphid *Imaptientinum impatiens* (Shinji) and one melaybug, *Heliococcus summervillei* Brookes were recorded for the first time from South India and two mealybugs and one aphid (*Antonina thaiensis* Takahashi *Exallomochlus hispidus* (Morrison) *Uroleucon pseudoambrosiae* (Olive) were collected for the first time from India. One species of soft scale, *viz*., *Pulvinaria urbicola* was re-described. 22 species of parasitoids on 39 species of different coccids were collected and got identified. No new host association or new records could me made this year. An identification guide to field and mounted characters of

mealybug was developed. This guide includes 35 species of economically important mealybugs.

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

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

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

Recently, *Cotesia dictyoplocae* (Watanabe) (Hymenoptera: Braconidae) was fortuitously reared from *A. assamensis* in Assam, India, on the host plant *Persea bombycina* (King ex Hook. f.) Kosterm. (Lauraceae). This is the first report of *C. dictyoplocae* parasitizing larvae of *A. assamensis* in India. Previously, *C. dictyoplocae* was known from China, Japan, and Korea. *Cotesia dictyoplocae* is a gregarious larval parasitoid, and females lay on an average 30 eggs per host larva.

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

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

The banana skipper *Erionota torus* Evans has recently emerged as a serious pest of banana. In the present study for the first time egg parasitism of *E. torus by* Ooencyrtus *pallidipes* (Ashmead), a gregarious parasitoid, is reported from India. The natural percent parasitism observed was 80−82% in the banana field located at Komanal, Shivamogga district, Karnataka.

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

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

4.1.1.5 Biosystematics and diversity of entomogenous nematodes in India

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

Heterorhabditis pakistanense (Nematoda: Heterorhabditidae) was recorded for the first time from Kargil, India. A total of 11 soil samples were collected from the walnut and apple cultivated lands in Kargil district of Jammu and Kashmir. A soil sample drawn from walnut rhizosphere of Adul Gund of Kargil district and positive sample was anticipated with *Heterorahbditis* nematode, this nematode was identified as *H. pakistanense* through morphological and molecular characterization and named as *Heterorhabditis pakistanense* strain NBAIIH05. The genomic DNA of NBAIIH05 was extracted from single first generation hermaphrodite and successfully amplified using Internal Transcribed Spacer (ITS) region of rDNA gene by PCR amplification and then subjected to sequencing. The ITS region of rDNA of isolate *H. pakistanense* NBAIIH05 was successfully amplified and was found to have 816 base pairs. Sequence alignment of ITS region of *H. pakistanense* NBAIIH05

showed maximum identity with *H. pakistanense* Shahina et al. 2016 (99.0%) and formed a highly supported clade. The base sequence (1-795 bp) of this isolate has been deposited in GenBank, NCBI and accession number was obtained GenBank: KX954218.

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

The efficacy of two species of entomopathogenic nematodes (EPN), *Steinernema abbasi* and *Heterorhabditis indica*, against *H. consanguinea* was tested under laboratory and field conditions. In a laboratory assay, *H. indica* caused significantly greater mortality (25-100%) than *S. abbasi* (20-80%) against second instars and *H. indica* caused 17.5-82.5% mortality in third-instar grub larvae, while *S. abbasi* caused (10-60%) mortality. These results revealed that second-instar grubs were more susceptible than third-instar grubs and efficacy of EPN against *H. consanguinea* varies with nematode species. The penetration and multiplication rate for *H. indica* was significantly higher than those of *S. abbasi*. Infective juveniles (IJ) of both nematode species and a commonly used insecticide (phorate) were tested against this insect in a field experiment. Field trail data showed that the percentage reduction in *H. consanguinea* grub population was significantly higher using *H. indica* at a dose of 2.5×10^9 IJ ha^{-1} than *S. abbasi* and phorate application. Phorate application was more efficient in reducing the grub population than both nematode species at the lower application rate (1.25×10^9 IJ ha^{-1}). Overall, these experiments suggest that *H. indica* may be a promising biocontrol agent against *H. consanguinea*.

4.1.2 Monitoring of invasive pests

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

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

4.1.2.2 Studies on Papaya mealybug

In Karnataka, infestation papaya mealybug on mulberry was surveyed in the districts of Maddur, Hassan, Tumkur, Mandya, Chamarajnagar, Ramanagar, Kollegal, Kolar and Chikballapur area. The occurrence of papaya mealybug was nil in the surveyed areas. In the homesteds >85% parasitization by *Acerophagus papayae* and also 15-25 per cent by *Pseudleptomastix mexicana* was found in all the places where ever papaya mealybug was observed. On request 18 shipments of *Acerophagus papayae* was received this year by papaya growers out of fear only and no orchard recorded severe incidence of papaya mealybug.

Hibiscus was found to harbor papaya mealybug in low populations in most of the localities and was found invariably associated with *Maconellicoccus hirsutus*, *Phenacoccus solenopsis, Ferrisia virgata*, on tapioca it was found associated with *P. madeirrensis*. Parasitism by *A. papayae* was very high (>82%). Several weeds which were previously found to harbor Papaya mealybug, *viz*., *Parthenium, Sida acuta, Acalypha, Abutilon* and crotons were free from papaya mealybug.

4.1.2.3 Erythrina Gall wasp managment

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

4.1.2.4 Establishment of *C. connexa* gall fly

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

4.1.2.5 Invasive whitefly *Aleurocanthes bangalorensis*

Aleurocanthes bangalorensis was observed to be severe on jamun trees in and around Bangalore. Two encyrtids and one eulophid parasitoid collected are under identification. *Acletoxenus indicus* Malloch, a dipteran maggot was found feeding on the whitefly.

4.1.2.6 *Anagyrus amnestos* a parasitoid of Madeira mealybug

Anagyrus amnestos was collected from parasitized nymph and adult Madeira mealybugs of both male (Nymphs) and female which collected from *Abutilon* plants during the survey. *A. amnestos* is a koinobiont, gregarious, super parasitoid, in which, adults laid eggs inside the body of the mealybug.

4.1.2.7 Surveillance for alien invasive pests

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

At Himachal Pradesh, different vegetable and fruit ecosystems at Solan, Kandaghat, Nainatikkar, Deothi, Subathu, Sarahan, Una, Bilaspur, Ghumarwinn Rekongpeo, Ribba, Akpa, Moorang, Tabo, were surveyed for the collection of pests like, *Aleyrodicus digessi, Phenacoccus manihoti, Paracoccus marginatus, Phenacoccus madeirensis* and *Tuta absoluta* but only *Tuta absoluta* was recorded at Nauni, Dharja, Solan, Kandaghat, Nainatikkar, Deothi, Subathu, and Sarahan locations of the state. Under open conditions the leaf miner was recorded infesting tomato and potato, whereas, in a polyhouse the pest was found to infest tomato, brinjal and potato.

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

In maize field experiment, Bb-5a isolate showed significantly lower dead hearts (2.7 and 2.53 in kharif and rabi, respectively) as compared to untreated control, which showed higher number of dead hearts (5.83 and 7.13). Significantly higher cob yield was obtained in the plots treated with Bb-5a (11.8 and 13.0 kg/10 plants in *kharif* and *rabi*) compared to the lower yield of control plot (10.0 and 9.0 kg/10plants in *kharif* and *rabi*).

In sorghum field trial, Bb-23 and Bb-5a isolates showed significantly lesser dead hearts of 6.78 and 9.33 % respectively, respectively as compared to untreated control where 19.8% dead hearts were recorded. The grain yield obtained in Bb-5a treated plot (151 gm/10 plants) and Bb-23 treated plot (147 gm/10 plants) were significantly higher compare to untreated control (105 gm/10 plants).

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

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

NBAIR-BtAN4 a new indigenous organism for control of both lepidopteran and coleopteran pests was identified. It expresses cry1, cry2, cry8 and vip3a toxins. Transcriptome analysis was done to understand the range of toxins expressed by this organism. The isolate was found toxic to the several coleopteran pests like *Oryctes rhinoceros, Papillio* sp., *Callosobrochus chinensis* and *Sitophilus oryzae*.

NBAIR-BtAN4 was also tested against the important lepidopteran pests like *Helicoverpa armigera* and *Plutella xylostella*. It was found to be toxic to both and the LC_{50} was determined as 414.59 ng/ml for *H. armigera* and 545.15 ng/ml for *P.xylostella*.

4.1.5 Studies on insect viruses

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

4.1.6 DNA barcoding and genomics studies on natural enemies

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

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

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

A protocol to rear *Geocoris ochropterus* was standardized utilizing beans and *Sitotroga cerealella* eggs. They can be multiplied in same container till 3rd instar. After that they can be separated to other containers as more space is required with growing size. Approximately 83% nymphs develop into adults. It was found out that with 6 pairs 593 adults can be harvested in 32-35 days. The total number of eggs fed was about 586 during the nymphal period. Total feeding by one female was 3372 eggs and feeding per day was 51.25 eggs. Adult male fed upon 2306.5 eggs and mean feeding per day was 50 eggs.

The net reproductive rate was 28.60, The approximate duration of a generation, Net generation time of the predator when reared on *S. cerealella* were 51.9 and 56.77, respectively, finite rate of increase, hypothetical females in F2 and weekly multiplication rate was 1.06, 817.96 and 1.50, respectively.

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

4.2.1 Biodiversity of biocontrol agents from various agro ecological zones

AAU-A: The activity of biocontrol agents were monitored during *kharif* and *rabi* season in different crops. With a view to know the activity of egg-parasitoid, *i.e., Trichogramma* species, sentinel cards with eggs of *Corcyra cephalonica* were placed in various crops *i.e.*,

tomato, groundnut, maize, cotton, castor, okra and observed for egg parasitism. The diversity of *Chrysoperla*, coccinellids, spiders, antagonistic bacteria-*Bt*, entomopathogenic nematodes (EPN) was studied.

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

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

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

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

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

and *Raphitelus* in xylophagus grubs infesting almond was observed from September to December 2016.

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

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

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

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

The natural parasitism of *Trichogramma* was not noticed in the crops like cotton, maize, soybean, sugarcane, tomato and brinjal in Pune region. The chrysopid, *Chrysoperla*

zastrowi sillemi Esben. was observed in cotton, maize, bean, jowar, okra and brinjal, and *Mallada boninensis* Okam. on cotton, beans, mango, papaya and hibiscus. The *Cryptolaemus* adults were recovered from the custard apple and papaya orchards and on hibiscus. The cadavers of *S. litura a*nd *H. armigera* infected with *Nomuraea rileyi, Metarhizium anisopliae, Sl*NPV, *Ha*NPV were collected from soybean, jawar, maize, cabbage, pigeon pea, tomato crops in farmers' fields. The mealybug, *Paracoccus marginatus* was observed in papaya orchards along with encyrtid parasitoid, *A. papayae* and *S. epius* in Dhule and Pune region.

4.2.1.1 Surveillance for alien invasive pests

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

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

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

4.2.2 Pest outbreak

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

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

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

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

4.2.3 Biological suppression of plant diseases

4.2.3.1 Biological control of diseases of rice, lentil and chickpea

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

4.2.3.2 Biological control of chilli anthracnose diseases

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

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

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

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

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

4.2.4 Biological suppression of sugarcane pests

4.2.4.1 Monitoring of sugarcane woolly aphid and its natural enemies

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

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

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

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

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

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

4.2.4.4 Management of white grub, *Holotrichia consanguinea* in sugarcane using bioagents

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

4.2.5 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) and Haryana (Sirsa, Fatehabad) to monitor whitefly population and its natural enemies on cotton crop revealed that whitefly remained below ETH level (6 adults/ leaf) in almost all the cotton growing districts of Punjab except in some villages of Khuhian Sarvar block of Fazilka district. The PAU recommended strategy was successfully implemented in cotton growing areas through the joint efforts of farm experts from PAU and Department of Agriculture (Punjab). The population of coccinellids, *Chrysoperla*, spiders and *Zanchius* sp. varied from 0.0 to 1.0, 0.0 to 13.0, 0.0 to 7.5 and 0.0 to 1.0 per 10 plants, respectively. The population of predators were maximum till end July, but declined thereafter.

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

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

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

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

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

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

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

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

4.2.5.5 Monitoring biodiversity and outbreaks for invasive mealy bugs on cotton

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

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

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

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

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

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

4.2.5.8 Biological suppression of pink bollworm, *Pectinophora gossypiella*

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

4.2.6 Biological suppression of rice pests

4.2.6.1 Seasonal abundance of predatory spiders in rice ecosystem

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

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

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

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

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

4.2.7 Biological suppression of maize pests

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

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

4.2.7.2 Evaluation of NBAII entomopathogenic strains against maize stem borer

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

4.2.8 Sorghum

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

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

4.2.9 Biological suppression of pulse pests

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

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

4.2.9.2 Evaluation of biocontrol agents against pod borers of cowpea

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

4.2.10 Biological suppression of tropical fruit pests

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.2.11 Biological suppression of temperate fruit pests

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

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

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

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

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

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

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

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

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

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

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

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

4.2.12 Biological suppression of oilseed pests

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

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

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

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

4.2.13 Biological suppression of vegetable pests

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

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

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

YSPUHF: *Tuta absoluta* was recorded from tomato at Nauni, Dharja, Solan, Kandaghat, Nainatikkar, Deothi, Subathu, and Sarahan locations of the state. Under open conditions the leafminer was recorded infesting only tomato and potato, but, in a polyhouse the pest was

found to infest tomato, brinjal and potato. At these locations 42 to 89 per cent of the tomato plants were infested with *T. absoluta* with the number of mines/leaf/infested plant varying from 1-11 and fruit damage varying from 0-6 per cent at different locations. The severity of the pest was more on tomato than on brinjal and potato.

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

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

PJTSAU: The marginal incidence of the pest was observed.

4.2.13.2 Biological control of brinjal mealy bug *Coccidohystrix insolitus*

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

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

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

4.2.13.4 Evaluation of BIPM against major pests of curry leaf

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.2.13.10 Biointensive management of insect pests of tomato under field conditions

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

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

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

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

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

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

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

4.2.13.14 Biological control of *Myllocerous subfasciatus* on brinjal

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

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

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

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

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

4.2.13.17 Role of habitat manipulation on natural enemies of cabbage pests

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

4.2.14 Biological suppression of polyhouse crop pests

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

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

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

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

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

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

4.2.15 Large scale adoption of proven biocontrol technologies

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

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

4.2.15.2 Rice

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

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

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

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

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

4.2.15.3 Pigeon pea

UAS-R: Large scale demonstration of NBAII BTG 4 *Bt* was done in a Askihal village of Raichur taluka over an area of 10 ha. Totally ten farmers were selected to demonstrate the effectiveness of NBAII BTG 4 *Bt* in comparison with farmers practice. The results indicated that NBAII BTG 4 *Bt* recorded 9.04 per cent damage compared to farmers practice which recorded 8.26 per cent pod damage. Similarly the grain damage was 1.64 was noticed in NBAII BTG 4 *Bt* compared to farmers practice (1.23%). NBAII BTG 4 *Bt* recorded 10.36 q/ha grain yield and in farmers practice it was 11.42 q/ha grain yield

4.2.15.4 Brinjal

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

4.2.15.5 Sugarcane

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

PAU: Large-scale demonstrations of effectiveness of *T. chilonis* against stalk borer, *C. auricilius* were carried out on an area of 456 acres at eight villages. The incidence of stalk borer in release fields (3.1 %) was significantly lower than untreated control (7.7 %). The reduction in incidence over control was 59.7 per cent. It can be concluded that twelve releases of *T. chilonis* at 10 days interval during July to October @ 50,000 per ha were better than untreated control against stalk borer.

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

of the state reduced the incidence of stalk borer, *Chilo auricilius* by 56.6 per cent.
Large scale demonstrations on the effectiveness of *T. chilonis* @ 50,000 per ha at 10 days interval (eight releases) over an area of 1550 acres conducted at farmers' fields in collaboration with three sugar mills, for the management of early shoot borer, *Chilo infuscatellus* indicated 54.3 per cent reduction of shoot borer incidence.

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

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

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

4.2.15.6 Maize

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

4.2.16 Tribal Sub plan programme (TSP)

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

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

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

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

ANGRAU: Organic farming in paddy, rajmah, ginger

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

Organic farming in Paddy

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

Organic farming in Rajmah

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

Organic farming in Ginger

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

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

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

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

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

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

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

TSP was implemented was implemented in four villages (Moorang, Akpa, Nichar & Sungra) in Himachal Pradesh. 200 tribal farmers cultivating apple, almond, peas, beans, cauliflower and cabbage in area of 200 ha were benefited. Inputs like, *Metarhizium anisopliae, Beauveria bassiana,* Yellow sticky traps, Blue sticky traps, Neem Baan, *Trichoderma viridae* and *Pseudomonas* were provided. These farmers were exposed to the

use of bio-pesticides for pest management for the first time. In peas, beans, cauliflower and cabbage there was a reduction of 2-3 sprays of chemical pesticides. In case of apple, farmers saved about Rs 15000/- per hectare by avoiding chemical treatment for the control of apple root borer.

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

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

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

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

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

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

PROCEEDINGS OF THE TECHNCIAL SESSIONS

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

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

Chairman: Dr. P. K. Chakrabarty
Co- Chairman: Dr. B. Ramanujam
Rapporteurs: Dr. Sudhendu Sharma and Dr. Raghunandan, B.L.
Speakers: Dr. Sunil Joshi, Dr. M. Sampath Kumar and Dr. A. K. Tewari

Achievements

- Biodiversity of insect pests and several natural enemies revealed that several species of scelionidae and a new genus was reported, a total of 7711 parasitoids belonging to 18 families of trichogrammatids were collected from 5 states in the country, an identification guide to field and mounted characters of mealybug was developed, the guide includes 35 species of economically important mealybugs and 75 identification services were provided to different organizations, the world fauna of Microgastrinae (in total 269 species) was described and a new species of entomopathogenic nematode, *Heterorhabditis pakistanense* (Nematoda: Heterorhabditidae) was recorded for the first time from Kargil, India.
- A new invasive insect, rugose spiraling whitefly *Aleurodicus rugioperculatus* Martin was recorded on coconut, banana, custard apple, sapota and several ornamental plants in Tamil Nadu, Andhra Pradesh and Kerala.
- An endophytic *Beauveria bassiana* (Bb-5a isolate) could reduce infestation of *Chilo partellus* by 53.7% and increase in cob yield 1.8 kg / 10 maize plant.
- *Bacillus thuringiensis* isolate (NBAIR-BtAN4) was found to be toxic to *Helicoverpa armigera* and *Plutella xylostella* giving LC_{50} value of 414.59 ng/ml and 545.15 ng/ml, respectively.
- Nucleopolyhedrosis viruses (NPVs) have been isolated from Bihar hairy caterpillar *Spilosoma obliqua*, semi looper *Achaea janata,* armyworms *Spodoptera mauritia, Spodoptera litura* and borer *Helicoverpa armigera*.
- A protocol to rear *Geocoris ochropterus* was standardized utilizing beans and *Sitotroga cerealella* eggs. Approximately 83% nymphs develop into adults. The feeding potential of nymphs was 586, while adult female fed 3372 and male 2306.5 eggs during life span.
- Several natural enemies were recorded by different centres during the period.
- Serious pest outbreak of armyworm and *Spodoptera mauritia* was recorded from Assam and Kerala on rice, whitefly from Tamil Nadu on coconut and pink bollworm from Raichur (Karnataka) on cotton.
- Biological control of plant diseases on rice, lentil, chickpea, chilli, tomato was achieved with increased yield and reduced disease incidence and intensity by GBPUAT, PAU and AAU-A.

Recommendations / Suggestions

For Basic Research

1. A proposal from ICAR – NBAIR should be sent to the ADG (PP&B) ICAR for facilitating generation of toxicological data for promising strains of microbials having bio-efficacy data identified through AICRP-BC.
2. District wise map of coccinellid distribution may be prepared by NBAIR.
3. Feed back on status of control of rugose whitefly infesting coconut in the fields treated with bio-control agents should be collected and documented.
4. The data on the pest incidence and outbreaks collected from AICRP-BC centers may be shared with NCIPM, New Delhi.

For Plant Disease Management

1. A status paper on role of zero tillage vis-à-vis pests out breaks may be prepared based on available information.
2. Bio-efficacy data for microbial consortia (GBPUAT, Pantnagar) may be developed.
3. Multi-location testing of promising strains of antagonists of GBPUAT, Pantnagar may be done at different centers for rice and chickpea.

SESSION - II: BIOLOGICAL SUPPRESSION OF PESTS OF COTTON AND SUGARCANE

Chairman: Dr. B. V. Patil
Co- Chairman: Dr. D. B. Ahuja
Rapporteurs: Dr. S. M. Galande and Dr. Sajad Mohi-ud-din
Speakers: Dr. K. S. Sangha and Dr. S. J. Rahman

Achievements

- Regular surveys conducted in cotton growing areas of Punjab (Fazilka, Bathinda, Mansa and Muktsar) and Haryana (Sirsa, Fatehabad) through PAU recommended strategy, which successfully managed the whitefly menace in cotton growing areas.
- Significantly lower number of jassids (2.13), whiteflies (2.96), aphids (6.55) and thrips (4.37) were recorded in the application of entomopathogenic fungi, *Lecanicillium lecanii* (40g/10 l of water) in Anand.
- In Raichur, the incidence of mealybug was noticed during second week of October till harvest of the crop. The primary parasitoid, *Anesius arizonesis* could successfully suppressed the mealybug population.
- In a study revealed significantly lower population of whitefly was recorded in chemical treatments (spiromesifen & diafenthiuron), followed by application of botanical (Neem baan) and biopesticides (*Lecanicillium lecanii* and *Metarhizium anisopliae*). However, the effect of different treatments on seed cotton yield was insignificant in Punjab.
- Minimum larvae of pink bollworm, minimum locule damage were noticed in continuous release of *Trichogrammatoidea bactrae.* Maximum seed cotton yield of 22.40 q/ha was noticed in continuous release of *Tr. bactrae.*
- The woolly aphid infestation was scanty on sugarcane in Telangana and Pune (Maharashtra) and natural enemies like *D. aphidivora*, *M. igorotus*, *Eupeodes confrater* and spiders, besides parasitoid *Encarsia flavoscutellum* found well established in all sugarcane fields.

- Use of entomopathogenic fungi and nematodes indicated that cane yield recorded was significantly high in *Heterorhabditis indica* (67.21 t/ha) compared to other agents and chemical insecticide chlorpyriphos where yield recorded was 49.72 t/ha in Anakapalle.
- Study on use of trash mulching + *T. chilonis* release were found to be effective in managing shoot borer in sugarcane with high incremental benefit cost ratio in Anakapalle.

Recommendations / Suggestions

For Cotton Pests

1. Remove weeds from cotton growing areas of Punjab state to prevent the incidence of white fly.
2. Prepare the pictorial graphs of pest population, natural enemies of sucking pest of cotton and yield data for at least 3-5 years to indicate any consistency in the occurrence or any variation with suitable reasons.
3. Conduct the large scale demonstrations of *Lecanicillium lecanii* against sucking pest of cotton.

For Sugarcane Pests

1. Record the per cent infestation of internode borer on node basis instead of cane basis.
2. Use heat tolerance strain of *Tricogramma chilonis* TTS against early shoot borer in sugarcane.

SESSION - III: BIOLOGICAL SUPPRESSION OF PESTS OF RICE, MAIZE AND SORGHUM

Chairman: Dr. S.N. Puri
Co- Chairman: Dr. R. K. Walia
Rapporteurs: Dr. R.N. borkakati and Dr. Chitra Shanker
Speakers: Dr. Madhu Subramanian and Dr. M.Visalakshi

Achievements

- Regular survey to quantify the diversity of spiders was carried in rice growing areas in Punjab. *Neoscona* sp. was the predominant species (74.48%) at all the locations. Species diversity (0.929) was calculated as per Shannon-Weiner index of diversity. Species evenness (0.404) and dominance index (0.596.
- The overall incidence of rice stem borer (4.06% dead heart, 2.82% white ears) and leaf folder (0.94%) was less in conventionally managed fields as compared to organic fields (4.60% dead heart, 5.11% white ears, 2.29% leaf folder). Natural parasitism in the eggs, larvae and pupae of stem borer and leaf folder ranged from 1.97 to 20.18 and 0.31 to 2.44 per cent in organic and conventional rice, respectively, In Punjab.
- Evaluation of *Beauveria bassiana* and *Metarhizium anisopliae* against the rice bug, *Leptocorisa oratorius* in a farmer's field at Vadakkenchery in Palghat District showed non- significant differences between the different treatments.
- At Anakapalle, field release of *Trichogramma chilonis* at 15 Days after germination, three times at weekly interval was found effective in reducing maize stem borer damage with higher cob yields.

- In sorghum, sprays of *Beauveria bassiana* recorded minimum population of larvae and pupae, minimum tunnelling, low number of entry holes, minimum dead hearts and higher yield compared to other treatments.

Recommendations / Suggestions

For Rice Pests

1. Besides pitfall trap method for quantification of spiders, visual counts also need to be taken in order to cover all the species of spiders.

2. Diseases need to be mentioned for foliar spray of *Pseudomonas flourescens* and correct concentration of *Metarhizium anisopliae* to be mentioned in all trials.

3. What should be minimum egg parasitization levels for effective suppression of insect pests needs to be considered and only those species which give minimum acceptable parasitization should be promoted, besides larval count or damage should also be considered for more appropriated for assessment of parasitism.

For Maize and Sorghum pests and Nematodes work

1. The data of all borers on maize and sorghum like pink stem borer may also be recorded in trial against *Chilo partellus*.
2. The alternate method of release of Tricho card may be explored as pinning of tricho cards in the field is very tedious process.
3. Dr. R.K.Walia had following suggestions for the group, particularly working on EPNs and PPNs:
   a) AICRP (Nematodes) has a programme of biocontrol of PPNs; the salient finding can be presented during Annual Group Meeting of AICRP-BC.
   b) AICRP (Nematodes) is also mandated to take up work on isolation, identification of indigenous strains of EPNs. AICRP-BC can help in identification of EPN strains and training of AICRP (Nematodes) scientists on EPN work.
   c) AICRP (Nematodes) scientists may also participate in experiments pertaining to EPNs in AICRP-BC.

SESSION – IV: BIOLOGICAL SUPPESSION OF PESTS OF PULSES, OILSEEDS, TOBACCO AND COCCONUT

Chairman:	Dr. L.K. Hazarika
Co- Chairman:	Dr. S. Sithanatham
Rapporteurs:	Dr. R. Patidar and Dr. Arunkumar Hosamani
Speakers:	Dr. N. Sridharan, Dr. M. Suresh, Dr. Madhu Subramaniam and Dr. N. B. V. Chalapathi Rao

Achievements

- Formulations of *Bacillus thuringiensis* PDBC Bt1 (1%), Bt 1(2%), NBAII BT G4 (1%), NBAII Bt G4 (2%), Delfin @1 Kg/ha, Delfin @ 2.0 Kg/ha, *Beauveria bassiana* (Mycojaal) 1.5 Kg/ha, *Beauveria bassiana* (Mycojaal) 2.0 Kg/ha, chlorpyriphos 20EC @ 3.75 litre/ha and untreated control were evaluated against lepidopteran pests in moong bean. Among all these bioagents, higher dose of PDBC Bt1 (2%) and both

doses of Delfin were at par with each other and recorded the lowest pod damage in Punjab.

- *B. thuringiensis* sprayed at 15 days interval recorded the lowest mean infestation of 12.25 per cent, followed by *Beauveria bassiana* sprayed at 15 days interval with 16.59 per cent mean infestation of pod borers of cowpea at Thrissur.
- Against mustard aphid, *Lipaphis erysimi* sprays of entomopathogenic fungi resulted in higher seed yield in the treatment *B. bassiana* + *L. lecanii* @ 5g/ liter (9.66 q/ha) followed by *L. lecanii* + *M. anisopliae* @ 5g/ liter (9.28 q/ha) at Anand.
- In Ludhiana, chemical control with Dimethoate @ 4 ml/litre of water significantly reduced the aphid population from 53.06 to 0.67 aphid per plant and was superior to biopesticide formulations against mustard aphid
- At Bhubaneswar, all the Biopesticides, three sprays of *Metarrhizium anisopliae* (2×10^8 spores/g)+ *Lecanicillium lecanii* (2×10^8 spores/g) @ 5 ml/l at 15 days interval proved to be the best treatment in reducing the aphids and producing the highest yield (8.23 q/ha) with highest B: C ratio (1.55).

Recommendations / Suggestions

For Pulses and Oilseed Pests

1. NBAIR Bt 4 formulation, which was found effective in suppression the pigeon pea pod borer with higher grain yield, should be taken up or large scale demonstrations and it was suggested that larval count must be considered.
2. The house suggested maintaining the uniformity among the dosages of biocotrol agents.
3. Biological suppression of storage insect pests of pulses is the need of the hour and house suggested to initiate the cost effective biocontrol programs against storage pests.

For Tobacco Pests

1. In tobacco aphid count should be taken properly and may be expressed as number per unit area.

For Coconut Pests

1. In coconut the EPNs were not effective on red palm weevil and the house suggested to look for other biocontrol agents for its managaement.
2. Biocontrol agents employed for cocnut pests management must be identified upto species level.

SESSION - V: BIOLOGICAL SUPPRESSION OF PESTS OF FRUITS

Chairman: Dr. R.J. Rabindra
Co-Chairman: Dr P.R.Gupta
Rapporteurs: Dr.P.A. Saravavanan and Dr. Rabinder Kaur
Speakers: Dr. Jamal Ahmed and Dr. D. Saikia

Achievements

- Field studies conducted on management of mango hoppers revealed that all the treatments, *viz*., *B. bassiana*, malathion and azadirachtin were significantly superior to the untreated control at Thrissur.
- The incidence of papaya mealybug was very low in Maharashtra, Tamil Nadu, Anand and Thrissur. All natural enemies were found to be well distributed.
- At Ambajipeta, high incidence of thrips and hopper population on mango was recorded in the months of January and February in the mango orchards. Among biopesticides the four sprays of *Lecanicillium lecanii*, *Beauveria bassiana* and *Metarhizium anisopliae* were effective in suppressing mango hoppers, though imidacloprid was most effective treatment.
- Field evaluation of *Beauveria bassiana* (IIHR formulation) against tea mosquito bug showed that it had a maximum reduction of fruit damage (81.1%) at Coimbatore.
- Against citrus trunk borer, *Pseudonemophas versteegi*, EPN (CAU-1) as stem injection gave significantly higher 34.0% reduction of pest population at Pasighat, whereas at at Rengging, CAUH-1 stem injection gave the highest reduction in trunk borer infestation among the EPNs with 32.7%.
- Three different species of earwigs were collected from banana plants infested by pseudostem weevils at Kannara and Vellanikkara. They were identified as *Auchenemus hinksi* Ramamurthi, *Paralabis dohrini* Kisby and *Euborellia shabi* Dohrn.
- For the management of apple root borer, *Dorysthenes hugelii*, although chlorpyriphos (0.06%) was the most effective treatment resulting in 83.2 per cent mortality of the root borer grubs, *Metarhizium anisopliae* was equally effective resulting in 68.3 per cent mortality of the pest at Solan.
- Biointensive integrated management of codling moth of apple involving one spray of chlorpyriphos 20 EC @ 1.5 ml/lit. + sequential releases of *T. cacoeciae* + one spray of NSKE + trunk banding + disposal of infested fruits + pheromone traps resulted in 37.7% reduction in damage over control in Kargil.
- Two releases of anthocorid bugs, *Blaptostethus pallescens* against two spotted spider mite, *Tetranychus urticae* on apple @ 200 per plant resulted in less mite population and higher reduction in mites' population (43.2) over check.

Recommendations / Suggestions

For Temperate Fruit Crop Pests

1. The granulosis virus has been successfully developed as a commercial product for the management of codling moth in Europe. Hence, SKAUST, Srinagar centre, should make intensive efforts to isolate indigenous strains of granulosis virus (GV) for further R & D.

For Tropical / Sub-Tropical Frui Crop Pests

1. It was reported that in Anand district some farmers were applying chemical pesticides for the management of papaya mealy bug. The use of chemical pesticides will destroy the natural enemies and destroy the equilibrium and hence should be discouraged. AAU, Anand should take special efforts to educate the farmers not to apply chemical pesticides against papaya mealy bug as well as for sugarcane woolly aphid.
2. It has been observed that Bt formulation has been tested against mango hoppers in Ambajipeta. Since, Bt is basically meant for lepidopteran peste it needs to be deleted in this particular experiment.

SESSION – VI: BIOLOGICAL SUPPRESSION OF PESTS OF VEGETABLES CROPS, POLYHOUSE CROPS

Chairman: Dr. H.C. Sharma
Co-chairman: Dr. Chandish R. Ballal
Rapporteurs: Dr. Roopali Sharma and Dr. Neelam Joshi.
Speakers: Dr. Jaydeep Halder and Dr. Richa Varsheny

Achievements

- At Coimbatore, *Tuta absoluta* maximum moth collection of pinworm, leaf damage and fruit damage in tomato was observed in October (3-23), November (5-25) and December (3-17 adult moths trap) as compared to rest of the cropping period, while in Raichur it was during second week of January (1060.07 moths /trap), at Solan in different locations 42 to 89 per cent of the tomato plants were infested. In Varanasi, occurrence was recorded during second week of January (2 SMW), 2017 and at Pune maximum incidence of the pinworm was noticed in the month of March, 2016.
- Two releases of *Cryptolaemus montrouzieri* @1500 /ha caused brinjal mealy bug *Coccidohystrix insolitus* reduction 91.5 per cent sustaining the predator population of 10.4 nos./10 plants and realizing the fruit yield of 63.4 t/ha at Coimbatore.
- The application of EPN (NBAIR formulation) 20kg/ha along with *Metarhizium anisopliae* (NBAIR formulation) 5kg/ha mixed with 250 kg FYM/ha resulted 87.7% reduction of ash weevil with minimum leaf damage of 8.4% on brinjal at Coimbatore.
- By adopting BIPM module leaf roller population was reduced by 78.94 per cent and psyllid population upto 59 per cent. The leaf yield was also high in BIPM plot 7.75 t/ha with the cost benefit ratio of 1:3.99 at Coimbatore.
- Effect of biopesticides for the management of shoot and fruit borers *Earias vittella* in orka was studied at Vellayani, Bhubneswar and Pune. Entomopathogenic fungi and *B. thuringiensis* were found to be best treatment and were almost on par with insecticides.
- BIPM package for suppression *Leucinodes orbanalis* on brinjal resulted in yield of 263.8 q/ha as against 260.1 q/ha in chemical control plot at Jorhat, while in Punjab yield was significantly higher in chemical control (328.3 q/ha) followed by BIPM module (262.1 q/ha).
- *Beauveria bassiana* and dimethoate were found superior in controlling the sucking pests on chilli crop with minimum pest population at Vellayani.
- At Varanasi, *Beauveria bassiana* (Bb-83) IIVR strain was found most promising against the yellow mites in chilli with highest per cent mite reduction (56.57 PROC) over the control followed by *Metarhizium anisopliae* (Ma-35) NBAIR strain (53.60 PROC). *B. bassiana* (Bb-83) IIVR strain treated plots registered significantly highest green chilli yield (6175 kg/ha) as compared to other entomopathogens.
- Among bio-agents/biopesticides, *Neoseiulus longispinosus* and azadirachtin were the best treatments for the control of *Tetranychus urticae* in tomato resulting in 60.3 and 51.2% reduction in the mite population over control at Solan. Both these treatments, however, were significantly less effective than fenazaquin, which caused 91.1 per cent over control.

- Per cent fruit damage and the population of sucking pests were less in BIPM compared to chemical treated plot. BIPM package resulted in yield of 242.8q/ha, which was superior to yield of 234.7q/ha in chemical control plot on tomato at Jorhat.
- Development of bio-intensive IPM package for the suppression of insect pests of capsicum under field conditions at Solan indicated that *Chrysoperla zastrowi sillemi*, *Lecanicillium lecanii* and azadirachtin were statistically equally effective against green peach aphid, *Myzus persicae* resulting in 54.8 to 61.2 per cent reduction of the aphid population over control, but, were less effective than imidacloprid was the most effective treatment resulting in 87.2 per cent reduction of the aphid population over control.

Recommendations / Suggestions

For Vegetable Crop Pests

1. Uniform protocol was not followed by many Centres and many have their own protocols, besides data was also incomplete, therefore, uniform protocol should be followed by all centres as per technical program of AICRP-BC.
2. If infestation of pests was low, then experiments results should not be presented.
3. Surveillance should be done, by all centres
4. The states where sericulture is practiced in open like Assam; *Bacillus thuringiensis* (Bt) should not be a component.
5. All Centres should have their own *Corcyra* producing units which can help in mass production of *Trichogramma*, *Goniozus*, *Chrysoperla*, anthocorids and several other natural enemies.
6. In all experiemtns crop varieties should be mentioned.

For Polyhouse Pests

1. Experiments on nematodes managaement in polyhouse should be included with networking with AICRP Nematodes.

SESSION - VII: TRIBAL SUB PLAN PROGRAMME

Chairman: Dr. S.J.Rahman
Co-Chairman: Dr. D. S. Pokharkar
Rapporteurs: Dr. P.S. Shera, and Dr M. Visalakshi
Speaker: Dr. P.L.Sharma

Achievements

- At AAU, Anand, 100 tribal farmers (50 Pigeon pea growers and 50 chick pea growers) were selected from Dahod district and distributed bio-inputs to the tribal famers and gave demonstration and training on use of bio-inputs in farming. There was a significant reduction in the incidence of *Fusarium* wilt and *Helicoverpa armigera* in pigeon pea to the tune of 60-65%. 10-12% increase in yield was observed. In chick pea 62-65% reduction in *Fusarium* wilt disease incidence and 10-15% increase in yield was observed. 200 tribal farmers (okra growers) were selected from Tapi district and distributed bio-inputs and gave demonstration and training on use of bio-inputs in the cultivation of okra. Increased adoption of biocontrol practices in cultivation of okra.

Reduction (65-70%) in pests and disease incidence. 12-15% increase in yield was observed.

- At ANGRAU, Anakapalle, total 143 acres area of Araku valley and Chinthapalli area, Visakhapatnam district was covered. Inputs were distributed to 45 paddy farmers; 50 Rajma farmers and 67 ginger farmers. Conducted front line demonstrations in organic farming paddy in three villages, *i.e*., Naduguda, Ramguda of Araku Valley and Idulabailu of Chinthapalli areas. All biological inputs were distributed among farmers. Organic farming paddy farmers recorded higher yields (4500 kg/ ha) compared to traditional tribal farmers (2300 kg / ha) without any fertilizer application and plant protection measures. Enhancement of yield levels by 95% with improved quality benefitting 45 paddy farmers covering 43 acres.
- Front line demonstrations on organic farming of Rajmah were conducted in two villages i.e, Gunjariguda (Araku valley) and Asarada (Chinthapalli). Around 20-30% of yield increment along with improved quality suitable for export benefiting 50 tribal farmers covering around 50 acres of tribal agricultural acreage. Front line demonstrations on organic farming of ginger were conducted in three villages, *i.e*., Gunjariguda , Kothavalasa (Araku valley) and Asarada (Chinthapalli). Around 15-20% of yield increment with export oriented quality produces benefiting 67 tribal farmers covering around 50 acres of tribal agricultural acreage.
- At SKAUST, Srinagar six tribal areas of Kargil have been selected for benefiting the farmers with IPM technologies of management of codling moth. Six core groups of literate orchardists have been made to implement the programme and help a total of 150 farmers under 10 groups. Each core group will be provided basic training related to IPM of Codling moth, including timing of chemical spray, use of Tricho cards and pheromone traps, trunk banding of apple for trapping and killing of larvae, debarking of old trees and disposal of infested fruits etc. Instructions and guide lines for IPM of Codling moth will be distributed to farmers in their local language.
- At MPKV, Pune the village Dalpatpur and Harsul in Trimbakeshwar Tahasil of Nashik district is a Tribal (ST) dominating areas in Maharashtra. The *wadi* of 0.40 ha consisting 9-10 years old plantation of fruit crops of 40 mango trees, 30 Cashew nut trees, 10 plants of Amla, 5 plants of Drumstick and forest species, *i.e*., *Teak* and *Bamboo* planted on border. One-day training programme on IPM of fruit crops to tribal youth and tribal farmers was organized. In IPM training, pests of mango and cashew nut and their management strategies were presented to 25 tribal youth farmers and 50 tribal farmers. Thereafter, demonstration was organized for enrichment of FYM with biofertilizer and biopesticdes.
- At TNAU, Coimbatore under the TSP, three trainings to tribal farmers were organised during the period under report. First training was organised Jawathu hills, Polur block, Tiruvannamalai district. Under the training programme sixty tribal farmers were enriched with knowledge on organic cultivation using biofertilizers, growth regulators, antagonists, biopesticides, entomofungal agents and entomophages and establishment of homestead vegetable cultivation. In addition, demonstrations on the use of nimbicidine, egg parasitoid *Trichogramma* spp. predators like green lace wing, *Chrysoperla* and *Cryptolaemus* were also conducted. One hundred and twenty tribal farmers of Sembukarai and Thumanoor villages of Periyanaickkan Palayam block, Coimbatore district and Manjavadi village, Pappireddipatti block of Dharmapuri district got exposed for one day training about the production of pesticide residue free crop produce.

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

Recommendations / Suggestions

1. TSP programmes spread should be horizontal benefitting maximum number of tribal farmers.
2. The maximum preference should be given to promote biocontrol agents under this programme.
3. The technologies validate under NARS should be a platform for planning the inputs to be provided under TSP programmes.
4. Critical inputs only need to be supplied for TSP farmers. After implementation of TSP programme, tribal farmers should be in a position to adopt the technology with easily available inputs at farmers' level.
5. The intervention in TSP programme should be as per the package of practices and recommendations, which can be easily adoptable by tribal farmers.
6. There is a need to work out a model to ensure that the beneficiaries of the TSP are continuing the adoption of technologies even after ceasing of TSP.

SESSION - VIII: INSTITUTE INDUSRTY PARTNERSHIP

Chairman: Dr. O. P. Sharma
Co- Chairman: Dr. S. K. Jalali
Rapporteurs: Dr. Jayalakshmi Ganguli and Dr. N.B.V. Chalapathi Rao.
Speakers: Dr. Sithanantham, Sri Karan Sikri and Sri Praharaju Laxinaryana

Recommendations / Suggestions

1. Dr. Sithanatham in his presentation commented that bio-control research has progressed a lot in the past five years and the associated workers. He shared his experience about that *Trichogramma* programme in Africa its characterization and repositories. He emphasized about public private partnership between ICAR and approved R&D institutions of interest, capacity and specialization can add more novel biocotrol projects. He request NBAIR for organizing a separate stakeholders' consultation workshop for prioritizing problems, refocusing on policy and technical support.
2. Dr. Karan Sikri in his presentation said that he is a farmer turned entrepreneur. He stated that bio- control products are less than 3% in the market and suggested that public private partnership will help in commercialization of bioagents. He expressed concern over excessive use of pesticides in apple and shared to the house his success story of managing apple root borer through application of Metarhizium in pockets of Himachal Pradesh.

3. Dr. Prabharaju Laxmi Narayan, brirfed the house about the Ag Bio company profile and its collaborative partners and highlighted need to focus on herbicide market based on his experiences. He stated that this company is mainly focusing on male annihilation, autoconfusion and microencapsulation of pheromone formulations and SPLAT Technology.

   The chairman Dr. O. P. Sharma, NCIPM, New Delhi in his remarks stated that collaboration and R&D with industry is required to solve industry short and long term problems and aim for joint contact and turn key projects.

SESSION - IX: TECHNICAL PROGRAM

Chairperson: Dr. Chandish R. Ballal
Co- Chairman: Dr. B. Ramanujam
Rapporteurs: Dr. Sunil Joshi, Dr. Richa Varshney and Dr. M. Sampath
Presenter: Dr. S. K. Jalali

Recommendations / Suggestions

1. Various suggestions given were incorporated and technical program is attached after page no. 55 and provided to all centres.

SESSION – X: PLENARY SESSION

Panel of Experts:	Dr. H. C. Sharma
	Dr. S. N. Puri
	Dr. Chandish R. Ballal
	Dr. R. J. Rabindra
	Dr. B.V. Patil
	Dr. (Ms) Anju S. Khanna
	Dr. S. K. Jalali
Rapporteurs:	Dr. J. Patil
	Dr. Richa Varshney
Speakers:	Chariman / Co-Chariman of diffirent sessions
Vote of thanks:	Dr. Chandish R. Ballal

General Recommendations:

1. There should be uniform experimental design, dosages, sampling and data analysis.
2. Study should be done on temperetaure effect on sex ratio and fecundity
3. Virulent strain for dry and hot region of the country should be explored and evaluated.
4. Studies should be conducted on climate changeeffect on bioefficecy of natural enemies.
5. All AICRP scientists are requested to participate in Internation Plant Protection conference which will be held in Hyderabad in 2019.

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ALL INDIA COORDINATED RESEARCH PROJECT ON BIOLOGICAL CONTROL OF CROP PESTS
(AICRP-BC)

Technical Programme
(2017-18 & 2018-19)

Compiled and Edited by
M Sampath Kumar; Amala, U; S K Jalali;
Richa Varshney; B Ramanujam
and Chandish R Ballal

ICAR-NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES
BANGALORE 560024, KARNATAKA

TECHNICAL PROGRAMME FOR 2017-18 & 2018-19

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

Objectives	:	To study the diversity of natural enemies of insect pests infesting crops in different agro-ecological zones catered by the AICRP center.
Centre		**Programme**
NBAIR, KAU, CPCRI, OUAT, YSRHU, TNAU		• Survey, surveillance and monitoring of rugose whitefly and their natural enemies on coconut
MPKV, PJTSAU, AAU-A, TNAU, IIVR		• Survey and surveillance of natural enemies of pinworm, *Tuta absoluta* on tomato
AAU, Anand, MPKV and TNAU		• Monitoring and record of incidence of papaya mealy bug and its natural enemies on papaya and other alternate hosts
AAU-A, MPKV, TNAU		• Survey, surveillance and collection of natural enemies including spiders in different agro-ecological zones and on different crops.
AAU-J		• Survey, surveillance and quantification of natural enemy complex including spiders in *kharif* and *rabi* rice and vegetables of Jorhat district
YSPUHF, Solan		• Biodiversity of biocontrol agents from various agro ecological zones of Himachal Pradesh on fruit and vegetable crops.
PJTSAU, Hyderabad UAS (R)		• Monitoring of sucking pest complex, Pink Boll Worm (PBW) and their natural enemies in cotton belt of Telangana state
PAU, Ludhiana		• Mapping of microbials including EPNs from various agro-ecological zones of Punjab • Diversity of insect pests and natural enemies on vegetables under poly house conditions in different agro ecological zones of Punjab • Monitoring of whitefly and its natural enemies in cotton belt of Punjab
SKUAST, Srinagar		• Biodiversity of natural enemies of pests of apple, apricot, plum, pear, peach, cherry walnut and almonds. • Monitoring of apple codling moth from various agro-ecological zones of Kashmir to see its spread.
TNAU, MPKV		• Monitoring of sugarcane woolly aphid incidence and impact assessment of natural enemies on its bio suppression. • Monitoring the diversity and outbreaks for invasive mealybug and other sap sucking pests on cotton.
KAU,OUAT, IIRR, AAU-A, AAU-J, PAU, UAS(R)	:	• Seasonal abundance of spiders in rice ecosystem by general collection, pitfall trap and sweep net method (specimens to be sent to NBAIR for identification)
IGKVV, Raipur		• Biodiversity of various bio-agents with particular reference to *Trichogramma* spp. and *Bracon* spp. • Biodiversity of coccinellid beetles in Chhattisgarh plains • Biodiversity of entomopathogenic nematodes in few

		districts of Chhattisgarh plains
MPUAT, Udaipur	:	• Biodiversity of natural enemies of pests of chickpea, tomato and maize.
IIHR, Bengaluru		• Survey, surveillance and monitoring of mealy bugs and their natural enemies on fruit crops
CISH, Lucknow		• Survey, surveillance and collection of natural enemies of major pests infesting mango
Desirable important information		Following Bioagents shall be collected as per the protocol given in earlier proceeding (*Ref. of Tech. Doc. No. 65*), and sent for identification to the NBAIR, Bangalore. The information should be collected on all aspects as given below • Name of insect / microbial agent (including scientific name) • Geographical details • Location- village, taluka, district and agro-climatic zone • Date of survey • Host crop/ sole crop/ intercrop, etc. • Stage of the crop • Stage of the insect pest • Weather parameters (max. and min. temperature, rainfall, RH, No. of rainy days) • Pesticide usage pattern

II. SURVEILLANCE FOR PEST OUTBREAK AND ALIEN INVASIVE PESTS

Name of the study/trial	:	**Surveillance for pest outbreak and alien invasive pests - Crop Pest Outbreak Report (CPOR)**
Objectives	:	To monitor and report incidence, buildup and outbreaks of insects and diseases of different crops in the region catered by the AICRP center.
Trial allotted centers	**:**	**All Centres**
Method	:	Visit, survey and surveillance and interaction with state/line department officials and local farmers.
Periodicity	:	Once in a month.
Target area	:	Covering the district where centre is located and 2-3 adjoining districts. In case of pest outbreaks, affected area may be specifically visited.
Desirable important information	:	1. Specific site & date visited-District, Mandal (Taluk), village (Give specific GPS coordinates, if available). 2. Area covered in ha 3. No. of crops specifically examined and Variety grown 4. Major insects and disease (s) noticed and natural enemy occurrence 5. Severity of damage (low, moderate, severe)
		6. Age of crop in severely damaged field(s) (in DAT/DAS and years for field and tree/ horticultural crops, respectively) 7. Plant protection measures adopted by the farmer prior to

		the visit 8. Advice given to the farmer and follow up report if any

Crop Pest Outbreak Report Proforma

Name of Centre: Date visited:

1.	Site details	Village(s) with GPS Co-ordiantes (if available): Mandal/Taluk: District:
2.	Crop details	Crop*: Variety : Age of Crop (DAS/DAT/: Years in case of perennial crop: Area cultivated (ha) :
3.	Pest Scenario: Insects Natural enemy occurrence	Name of Insect : Level of infestation: Low/Moderate/Severe Predators: (Coccinellids/Chrysopids/Spiders/Others) Parasitoids:
4.	Disease Scenario	Name of Disease: Per cent disease incidence:
5.	Plant Protection measures followed by the farmer	
6.	Advice given to the farmer	
7.	Sender's name	

*for each crop separate proforma to be used

For each insect, level of infestation, *viz*., Low/Moderate/Severe should be specified,

- **Low-**Pest is present at lower population with no significant damage to the crop
- **Moderate-**Pest population is nearing Economic Threshold Level (ETL) and needs constant monitoring to prevent economic damage
- **Severe** -Pest damage is higher and the crop needs insecticides sprays

Submission of report

- **As early as possible by e-mail (aicrp.nbaii@gmail.com, ballalchandish@gmail.com, m.kumar1@icar.gov.in, & amala.udayakumar@icar.gov.in) but not later than 5th of each month.**
- Send the insects and its natural enemies including spiders if any, desired for identification to the Director, ICAR-NBAIR, H A Farm Post, P B No 2491, Bellary Road, Hebbal, Bengaluru 560024.
- Photographs of the insect and disease damage symptoms, life stages of insects, natural enemies and field visits (wherever possible) should be sent along with this report.
- **In case of no pest outbreak in the centres for the reporting period, <u>Nil report</u> should be sent.**

III. BASIC WORK

(i) Molecular signature of promising *Trichoderma asperellum* TCMS 36, *T. harzianum* (Th14) and *Pseudomonas* (PSF 173) validated under AICRP on Biological Control (GBPUAT)

(ii) Testing the compatibility of bioagents for the consortium to increase its efficiency (GBPUAT)

Methodology		**Molecular Characterization of *Trichoderma/Pseudomonas* isolates using ITS and 16S rDNA markers** • Identification and characterization of genomic DNA • The highly conserved internal transcribed spacer (ITS) regions of the rDNA (*Trichoderma*) and 16S rDNA *(Pseudomonas*) will be used for the amplification, identification and characterization. • DNA barcoding of *Trichoderma* isolates.

Treatments	:	Twenty 1. TCMS 36 + Psf-173 2. Th-19 + Psf-173 3. Th-17 + Psf-173 4. TCMS 36 + Psf-2 5. Th-19 + Psf-2 6. Th-17 + Psf-2 7. Th-14+ Psf-2 8. Th-17+TCMS-36 9. Th-19+TCMS-36 10. Th-14+TCMS-36 11. Th-17 + Th-19 12. Th-19 + Th-14 13. Th-14+ Th-17 14. TCMS- 36 (control) 15. Th-19 (control) 16. Th-17 (control) 17. Th-14 (control) 18. Psf-2 (control) 19. Psf-173 (control) 20. Th-14 + Psf-173 (Standard check)
Methodology and observations		**Dual culture studies**: Observations: • Growth pattern, radial growth and CFU in dual culture and in check (alone). **Testing of consortium formulation (Talc based)** 1. *In-vitro* test: dilution plate method Observations: • Growth and pattern in PDA

		• CFU at 7 days interval up to 2 months. 2. In-glasshouse Crop: chickpea Method of application: Seed treatment, soil treatment and foliar application (15 and 30 DAS) Observations: • CFU on spermosphere, rhizosphere/ rhizoplane / phylloplane • Plant vigour • Disease assessment

CROP WISE PROGRAMME

CEREALS

1. RICE

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

Variety	:	Uma/Jyothi
Layout	:	Randomized Block Design.
Plot size		1 x 5 cents for each treatment, 1 cent = 8x5 m
Treatments	:	Seven T1: *Steinernema carpocapsae* (NBAIR strain) @ $1.2x10^9$ IJs ha^{-1} T2: *Heterorhabditis indica* (NBAIR strain) @ $1.2x10^9$ IJs ha^{-1} T3: *Bt* (NBAIR strain) 2g/l twice at 10 and 25 DAT T4: *Beauveria bassiana* (NBAIR strain) @$1x10^8$ spores/g-5g/l T5: *Metarhizium anisopliae* (NBAIR strain) @$1X10^8$ spores/g-5g/l T6: Flubendiamide 25g.a.i.ha^{-1} T7: Untreated control
Replications		Three
Observations		• Mean No. of dead heart/white ear/sq. m. • Mean No. of rolled leaves per sq. m. • Yield kg/plot

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

Variety	:	Any susceptible high yielding variety
Layout	:	Randomized Block Design.
Plot size		1x5 cents for each treatment, 1 cent = 8x5 m
Treatments	:	Four T1: *Beauveria bassiana* (NBAIR strain)@$1x10^8$

		spores/g-5g/l on 45th and 60th DAT applied as spray. T2: *Lecanicillium lecanii* (NBAIR strain)@1x10^8 spores/g-5g/l on 45th and 60th DAT applied as spray T3: Imidacloprid 30 g a.i. ha^{-1} T4: Untreated control
Replications	:	Five
Observations	:	• Pre and post treatment count of BPH per hill • Yield (kg/plot)

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

Variety	:	Any recommended variety
Layout	:	Randomized Block Design
Plot size		1x5 cents for each treatment, 1 cent = 8x5 m
Treatments	:	**T1: BIPM** • Recommended variety • Optimum time of sowing/transplanting • Green manuring or FYM • Optimum plant spacing • Alleyways of 30 cm after 2 m • Water management: Alternate wetting and drying • Increasing floral diversity through weeds, crops and flowers on bunds • Erection of straw bundles (spiders) @ 20/ha • Application of Azadirachtin 1500 ppm @ 2ml/litre • Application of *Metarhizium anisopliae* 1x10^8 spores/g-5g/l **T2: Farmers' practice (to be specified at the time of report)** **T3: Control**
	:	Seven
Observations	:	• The population of plant hoppers will be recorded from 50 hills selected at random at weekly interval starting from 30 days after transplanting (DAT) from each plot • The population of predators like mirids, spiders, coccinellids, dragonflies and damselflies will be also recorded at weekly intervals. • Population count of plant hoppers in light trap • Grain yield will be recorded at harvest

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

Variety	:	Region specific popular rice variety

Treatments	:	**T1 = BIPM Package** 1. Seed bio-priming *Pseudomonas fluorescens@* 10g/kg of seeds*./T. harzianum@* 15g/kg of seeds (PAU) 2. Seedling *dip with Trichoderma harzianum* 15g/litre *for few minut*es (PAU) 3. Seedling d*i*p wit*h Pseudomonas fluorescens* 2% solution. 4. Spray of azadirachtin 1500 ppm@ 3ml/litre at 45 and 65 DAT against foliar and sucking pest. 5. Erection of bird perches. 6. Spray of *Pseudomonas fluorescens* @ 1.5 kg/ha against foliar diseases 7. Release of *Trichogramma japonicum* @ 100,000/ha (6 releases to be made during season) at 10 days interval starting from 25 DAT for stem borer and leaf folder infestation. Release of *Trichogramma chilonis* and *Trichogramma japonicum* @ 100,000/ha (6 releases to be made during season) at 7 days interval starting from 30 DAT for stem borer and leaf folder infestation (for PAU only). **T2** = Farmers Practice (pesticides used by farmers' in respective centres to be mentioned) **T3** = Untreated control
Replications	:	Divide each block into 5 equal sized units, each unit to be considered as replication (each unit = one replication)
Observations	:	• Observations on pest incidence should be recorded on 10 randomly selected hills in each replication (50 hills/ each treatment), *i.e*., total of 50 hills in BIPM block & 50 hills in FP block at each observation at fortnightly interval starting from 30 DAT./ • At each observation, record total tillers, dead hearts, silver shoots, total leaves, damaged leaves, number of plant hoppers/ hill. • Record the yield from 5 places of 5x5 m area from each replication. • Cost-benefit ratio to be worked out.

1.5 Evaluation of fungal and bacterial isolates for disease management in rice (GBPUAT)

Variety	:	Pant Dhan-4
Layout	:	Randomized Block Design.
Plot size		3x2 m
Treatments	:	Fifteen 1. TCMS 36 (*T. asperelleum*) 2. PBAT-3 (*T. harzianum* + *P. fluorescence*) 3. Th-14 (*T. harzianum*) 4. Th-17 (*T. asperelleum*) 5. Th-39 (*T. asperelleum*) 6. Th-19 (*T. asperelleum*) 7. Psf-173 (*P. fluorescence*) 8. Psf-2 (*P. fluorescence*) 9. TCMS-9 (*T. asperellium*) 10. TCMS-43 (*T. asperelleum*) 11. NBAIR strains (*T. asperellium* and *T. harzianum*) 12. PAU strains 13. Commercially available product 14 Seed treatment with Carbendazim (0.1%) followed by 2-3 spray of tilt (0.05% 15. Control (without any treatment)
Replications		Three
Mode of application	:	1. Soil application with bio-agent (1kg bio-agent formulation/ton vermicompost per acre) 2. Seed bio-priming with bio-agent (10g/kg seeds), 3. Seedling dip only in case of rice (10g/lit); 1 hour before transplanting 4. Three foliar sprays of bio-agents @ 45, 70 and 95 DAS/DAT
Observations	:	• Tiller/hills • Disease assessment 90-100 DAT • Rhizosphere and rhizoplane population @ 90-100 DAT • Yield q/ha

2. MAIZE

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

Variety	:	Any susceptible high yielding variety
Layout	:	Randomized Block Design.
Plot size		1x5 cents for each treatment, 1 cent = 8x5 m
Variety	:	Recommended variety at each place
Treatments	:	Seven T1: *Beauveria bassiana* (NBAIR strain) 1x 10^8 spores

		/ml)-5 ml/lt. T2: *Metarhizium anisopliae* (NBAIR strain) 1x 10^8 spores /ml)-5 ml/lt. T3: Two sprays of *Bt* formulation (commercial)@ 1250 ml/ha on 10 and 25 days old crop T4: Two sprays of *Bt* formulation (NBAIR formulation) @ 2% on 10 and 25 days old crop T5: Chemical control (region specific for maize crop as per university recommended / as per label claim) T6: Release of *T. chilonis* 1 lakhs/ha, 3 releases at weekly interval from 15-20 days after germination T7: Control
Replications		Three
Observations		• Dead heart count at weekly interval starting from from 20 randomly selected plants at 30 and 45 DAS. • Leaf damage at weekly interval starting from initial incidence of stem borer. • Number of exit holes/plant. • Grain Yield at harvest

2.2 Biological control of maize stem borer, *Chilo partellus* using *Trichogramma chilonis* [ANGRAU (5 ha); PAU (120 ha); MPUAT (1 acre)]

Variety	:	Location specific recommended variety
Treatments	:	Three T1: Three releases of *Trichogramma chilonis* @ 100,000/ha/release at 15, 22 and 29 days after crop germination T2: Farmers' practice (to be recorded at each location) T3: Untreated control
Replications	:	Divide each block into 8 equal sized units, each unit to be considered as replication (each unit = one replication)
Observations		• Dead hearts from 20 randomly selected plants at 30 DAS • Yield (t/ha) and incremental benefit cost ratio

PULSES

3. PIGEON PEA

3.1 Evaluation of NBAIR Bt formulation on pigeon pea against pod borer complex [PAU (2 ha); MPKV (2 ha); ANGRAU (2 ha); TNAU (1 ac only as intercrop in groundnut ecosystem); UAS-R (2 ha)]

Variety	:	Location specific recommended variety
Treatments	:	Three T1: NBAII BtG4 2% @ 2.0 ml/lt - 3 sprays at pre

		flowering, post Flowering and pod formation stage. T2: Chemical control (as per recommendation of respective university) T3: Control
Replications	:	Divide each block into 8 equal sized units, each unit to be considered as replication (each unit = one replication)
Observations	:	• No. of gram and legume/pod borer complex(spotted pod borer, plume moth, slug caterpillar, etc) / plant • Per cent pod damage • Grain yield (kg/ha)

4. MUNGBEAN

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

Variety	:	Any recommended variety.
Layout	:	Randomized Block Design.
Plot size		1x3 cents for each treatment, 1 cent = 8x5 m
Replications	:	seven
Treatments		Eight (1st & 2nd Spray) T1: *Bt* (commercial formulation) @1.25 lt/ha & Azadirachtin 1500 ppm @ 500 ml/ha T2: *Bt* (commercial formulation) @1.25 lt/ha- 2 sprays T3: Azadirachtin 1500 ppm @ 500 ml/ha & *Bt* (commercial formulation) @1.25 lt/ha T4: Azadirachtin 1500 ppm @ 500 ml/ha - 2 Sprays T5: *Bt* (commercial formulation) @ 1.25 lt/ha & spinosad 45SC @ 150ml/ha T6: Azadirachtin 1500ppm @ 500 ml/ha & spinosad 45SC @ 150ml/ha T7: Spinosad 45SC @ 150ml/ha - 2 sprays T8: Untreated control **Spray schedule**: Two sprays (1st at initiation of pod formation & 2nd at 15 days later
Observations	:	• Number of webs (*Maruca vitrata*) from 5 tagged plants before and 7 days after spray. • Number of *Spodoptera litura* and *H. armigera* larvae before, 5 and 10 days after spray in each plot • Total and damaged pods at harvest • Record natural enemies from 5 plants in each plot • Pod yield will be recorded on whole plot basis

5. COWPEA

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

Variety	:	Location specific recommended variety
Layout	:	Completely Randomized Design
Plot size		1x3 cents for each treatment, 1 cent = 8x5 m
Treatments	:	T1: *Beauveria bassiana* (NBAIR strain) @1x10^8 spores/g 5g/lt. at 10 days intervals T2: *M. anisopliae* (NBAIR strain) @1x10^8 spores/g 5g/lt. at 15 days intervals T3: Thiacloprid 30 g a.i ha^{-1} at 10,15 and 20 days intervals T4: Untreated control
Replications	:	Six
Observations	:	Pre and post treatment count of damaged pods /plant Yield (kg/plot)

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

Variety	:	Location specific recommended variety
Layout	:	Randomized Block Design.
Plot size		1x5 cents for each treatment, 1 cent = 8x5 m
Treatments	:	T1: *Pichia guilliermondi* (NBAIR strain) @ 2x10^8 spores/ml – 10ml/lt T2: *Trichoderma harzianum* (NBAIR strain) @ 1x10^8 spores/g – 10g/lt T3: *Pseudomonas fluorescens* (KAU strain) @ 1x10^8 spores/ml T4: *Pseudomonas fluorescens* (NBAIR strain) T5: Carbendazim @ 2g/kg T6: Untreated control
Replications		Four
Mode of application	:	Seed treatment with bioagents followed by foliar spray @15, 30 and 45 DAS
Observations	:	Pre and post treatment disease incidence count of damaged pods /plant, Yield (kg/plot)

5.3 Evaluation of potential isolates of *Pseudomonas, Trichoderma, Bacillus* and microbial consortia against major diseases of cowpea (KAU, Kumarakom – 2nd year trial)

Variety	:	Location specific recommended variety
Layout	:	Randomized Block Design.
Plot size		1x5 cents for each treatment, 1 cent = 8x5 m
Treatments	:	T1: *Pseudomonas fluorescens* KAU strains seed treatment

		(10g/kg) followed by foliar spray and soil drenching (2%) 15, 30 and 45 days of seedling emergence T2: *Trichoderma viride* KAU strains seed treatment (4g/kg) followed by foliar spray and soil drenching (2%) 15, 30 and 45 days of seedling emergence T3: PGPR mix II KAU strains seed treatment (10g/kg) followed by foliar spray and soil drenching (2%) 15, 30 and 45 days of seedling emergence T4: PGPM seed treatment (10g/kg) followed by foliar spray and soil drenching (2%) 15, 30 and 45 days of seedling emergence T5: Standard check- carbendazim seed treatment (2g/kg) followed by foliar spray (0.1%) 15, 30 and 45 days of seedling emergence T6: Control
Replications		Four
Mode of application	:	Seed treatment with bioagents followed by foliar spray @15, 30 and 45 DAS
Observations	:	Pre and post treatment disease incidence count of damaged pods /plant, Yield (kg/plot)

5.4 Evaluation of microbial agents for the management of major pests of cow pea (KAU, Kumarakom – 2nd year trial)

Variety	:	Lola
Layout	:	Randomized Block Design.
Plot size		8x5 m
Treatments	:	T1 = *Lecanicillium lecanii* 10 gm/l (10^8 spores/ml) T2 = *Beauveria bassiana* 10 gm/l (10^8 spores/ml) T3 = Spiromesifen 22.9 SC @ 96 g ai ha^{-1} T4 = Control
Replications		Five
Observations	:	Observation on pest and natural enemy incidence will be taken at fortnightly intervals before and after sprayings from the treated plants. Yield data will also be recorded.

6. CHICKPEA

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

Variety	:	Location specific recommended variety
Layout	:	Randomized Block Design.
Plot size		1x3 cents for each treatment, 1 cent = 8x5 m
Replications	:	Three
Treatments		Eight (1st & 2nd Spray) T1: *Bt* (commercial formulation) @1.25 lt/ha &

		Azadirachtin 1500 ppm @ 500 ml/ha T2: *Bt* (commercial formulation) @1.25 lt/ha- 2 sprays T3: Azadirachtin 1500 ppm @ 500 ml/ha & *Bt* (commercial formulation) @1.25 lt/ha T4: Azadirachtin 1500 ppm @ 500 ml/ha - 2 Sprays T5: *Bt* (commercial formulation) @ 1.25 lt/ha & spinosad 45SC @ 150ml/ha T6: Azadirachtin 1500 ppm @ 500 ml/ha & spinosad 45SC @ 150ml/ha T7: Spinosad 45SC @ 150ml/ha - 2 sprays T8: Untreated control **Spray schedule**: Two sprays (1st at initiation of pod formation & 2nd at 15 days later
Observations	:	• Number of larvae/ m row length before spray and 3, 7, 10 and 15 days after spray • Total and damaged pods at harvest. • Record natural enemies from 5 plants in each plot. • Pod yield will be recorded on whole plot basis.

6.2 Management of *Helicoverpa armigera* by *Hear*NPV on chickpea (NBAIR in collaboration with UAS-R – 1 acre)

Variety	:	Location specific recommended variety
Layout	:	Randomized Block Design.
Plot size		1 acre
Treatments		T1: Spray of HearNPV NBAIR strain ($1.5x10^{12}$ POBS/ha) twice during the early pod formation stage at 15 days interval T2: Spray of HearNPV UAS, Gulbarga strain ($1.5x10^{12}$ POBS/ha) twice during the early pod formation stage at 15 days interval T2: Farmers' practice (to be specified in report)
Replications	:	Divide each block into 8 equal sized units, each unit to be considered as replication (each unit = one replication)
Observations		No. of pods damaged, no. of infected larvae and yield (kg/plot), Cot-benefit ratio

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

Variety	:	Location specific recommended variety
Layout	:	Randomized Block Design.
Plot size		1 cent = 8x5 m
Treatments		T1: **Beauveria bassiana *@ $1x10^8$ conidia /gm @ 5 gm/l at 7 day interval, at pod initiation stage, 2 sprays*** T2: *Bacillus thuriengiensis* @ 1 Kg/*ha* ***at 7 day interval, at pod initiation stage, 2 sprays***

		T3: Quinalphos 25 EC @ 250g a.i/ha, ***at pod initiation stage, 2 sprays*** T4: Untreated control
Replications	:	Five
Observations		• Number of larvae/ m row length before spray and 3, 7, 10 and 15 days after spray • Total and damaged pods at harvest. • Record natural enemies from 5 plants in each plot. • Pod yield will be recorded on whole plot basis.

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

Variety	:	PG-186
Layout	:	Randomized Block Design.
Plot size		1x3 cents for each treatment, 1 cent = 8x5 m
Treatments	:	**Fifteen** 1. TCMS-36 (*T. asperelleum*) 2. TCMS-9 (*T. asperelleum*) 3. Th-17 (*T. asperelleum*) 4. Th-14 (*T. harzianum*) 5. Th-19 (*T. asperelleum*) 6. Th-3 (*T. asperelleum*) 7. PBAT-3 (*T. harzianum* + *P. fluorescence*) 8. Psf-2 (*P. fluorescence*) 9. Psf-173 (*P. fluorescence*) 10. Bacillus N18 (*Bacillus* sp.) 11. NBAIR strains (*T. harzianum* and *P. fluorescence*) 12. BARC strains 13. Commercially available strains 14. Seed treatment with carbendazim (0.1%) followed by 2-3 spray 15. Control (without any treatment)
Replications		Three
Mode of application	:	1. Soil application with bio-agent (1kg bio-agent formulation/ton vermicompost per acre) 2. Seed bio-priming with bio-agent (10g/kg seeds), 3. Seedling dip only in case of rice (10g/lit); 1hour before transplanting 4. 2-3 foliar sprays of bio-agents at 45 and 60 DAS i.e. at 15 days interval
Observations	:	• Seed and Plant mortality @ 30 , 30&75 DAS respectively • Rhizosphere and rhizoplane population @ 45 & 90 DAS and Yield q/ha

7. SOYBEAN

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

Variety	:	Location specific recommended variety
Treatments	:	T1: Need based 1-2 applications of *N. rileyi* T2: Farmers' practice (insecticides used by farmers to be specified)
Observations	:	Mass production of *N. rileyi* will be undertaken in the Biocontrol laboratory, AC, Pune and MPKV, Rahuri. Application of *N. rileyi* will be followed after appearence of the pest and 1-2 sprays will be given at fortnightly interval. 1. Surviving larval population of *S. litura* / m row length. 2. Larval mortality / mycosis due to fungal infection 3.Yield of soybean

COMMERCIAL CROPS

8. COTTON

8.1 Management of pink bollworm by using *Trichogrmmatoidea bactrae* on *Bt* cotton (UAS-R; PJTSAU; NBAIR)

Variety		Grow early maturing varieties recommended for each centre so that the cotton bolls mature before the heavy population of pink bollworm builds up.
Plot size		Three Each treatment consisting of 0.5 ha, except untreated control which can be of 5 cent size (1 cent = 8x5 m).
Layout	:	Randomised Block design
Treatments	:	Three Each treatment consisting of 0.5 ha, however, untreated control to be of 5 cent size (1 cent = 8x5 m). T1: Standard practice of plant protection till 55th day or appearance of PBW. The following inputs to be provided for PBW. i) Erection of pheromone traps (Funnel type) @ 10/ plot. ii) Releases of *Trichogrammatoidea bactrae* 100,000/ha/release, 6-8 releases starting from 55 days after germination. iii) Application of azadirachtin 1500 ppm at ETL T2: Spraying of insecticides as per label claim for PBW / SAUs at each centre during PBW infestation. T3: Control
Replications	:	Totally 8 quadrants will be made in 0.5 ha of land. Further each quadrant will serve as replications.
Methodology and observations:	:	• No. of good open bolls and bad open bolls (at least 100 balls to be observed & five observation/plot) and

		number of pink bollworm larvae. • No. of rosette flowers • No. of green bolls • No. of eggs recorded & no. of parasitized eggs (at least 20-50 eggs will collected in each observation) and yield at harvest.

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

Variety	:	Any recommended *Bt* cotton hybrid at each centre
Plot size	:	40 sq m x 4 for each treatment
Layout	:	Randomized Block Design
Treatments	:	Six T1: *Metarhizium anisopliae* ($1x10^8$ spores/g) @ 5 g /lit. T2: *Lecanicillium lecanii* ($1x10^8$ spores/g) @ 5g/lit. T3: *Beauveria bassiana* ($1 x 10^8$ spores/g) @ 5g/lit. T4: Azadirachtin 1500ppm @ 2 ml/lit. T5: As per label claim or as recommended by respective SAU T6: Untreated control
Replications	:	Four
observations:	:	• Average number of sucking pest population / 3 leaves, *viz.*, Aphids, Jassids, whiteflies and thrips will be counted and recorded. • Number of whitefly adults from 3 leaves (top, middle and lower canopy) of 5 randomly selected plants in each plot will be recorded before spray, 3 and 7 days after spray. • Cadavers without apparent sporulation along with leaves will be brought in the laboratory and incubated under optimal condition. After 5 days cadavers were observed for signs of fungal infection and sporulation. • The population of other sucking pests will also be recorded. • Yield (q/ha) to be recorded.

8.3 Bio-intensive pest management in *Bt* cotton [AAU-A (2 ha), UAS-R (2ha)]

Variety	:	Any recommended *Bt* cotton hybrid
Plot size	:	2 ha
Treatments	:	T1: BIPM package • Seed treatment with *Trichoderma harzianum* @ 10g/kg of seeds. • Maize as border crop • Pheromone traps @ 10/ha for bollworms. • Release of *Trichogrammatoidea bactrae* @ 100,000/ha (6-8 releases starting from 55th DAG or with appearance of PBW). • Application of Azadirachtin 1500 ppm @ 5 ml/ lit for sucking pests. • Spray of *Lecanicillium lecanii* (1x10^8 spores/g) @ 5g/lit. • Spray of *Pseudomonas fluorescence* 2% solution against foliar diseases. T2: Farmers' Practice (pesticides used by farmers to be mentioned both insect pests and diseases).
Replications	:	Totally 8 quadrants will be made of plot. Further each quadrant will serve as replications.
Observations	:	• No. of good open bolls and bad open bolls (at least 100 balls to be observed & five observation/plot) and number of pink bollworm larvae. • Average number of sucking pest population / 3 leaves, *viz.*, Aphids, Jassids, whiteflies and thrips will be counted and recorded. • Number of whitefly adults from 3 leaves (top, middle and lower canopy) of 5 randomly selected plants in each plot will be recorded before spray, 3 and 7 days after spray. • Disease incidence to be recorded. • Yield (q/ha) to be recorded. • Generate data on natural enemies and pest incidence in high density planting-UAS Raichur

8.4. Habitat manipulation for the management of whitefly on Bt cotton (PAU - 2nd year trial)

Variety	:	Any recommended *Bt* cotton hybrid
Plot size	:	0.4 ha
Treatments	:	**T1: BIPM package** • Cultivation of recommended Bt cotton hybrid • Recommended time of sowing (April – 15 May) with optimum plant spacing • Growing two rows of sorghum/maize as a barrier crop

		around cotton fields. • Recommended fertilizers will be applied • Deploying yellow sticky traps @ 100 per ha during initial phase of the cotton crop (end- May to 1st week of June) to check early infestation of whitefly. • Augmentative releases of *Chrysoperla* sp. @ 10000 /ha from end June onwards • Monitoring and surveillance for insect pests and diseases at weekly intervals (to determine ETH level) • Weekly application of botanicals/ microbials (first spray will be initiated based on ETH level) ➢ Azadirachtin 10000 ppm @ 2 ml/litre ➢ *Lecanicillium lecanii* (1 x 10^8) @ 5 g/litre ➢ *Metarhizium anisopliae* (1 x 10^8) @ 5 g/litre **T2: Farmers' Practice** (pesticides used by farmers to be mentioned both insect pests and diseases). T3: Untreated control
Replications	:	Totally 8 quadrants will be made of plot. Further each quadrant will serve as replications.
Observations	:	• Number of whitefly adults from 3 leaves (top, middle and lower canopy) at weekly interval through our the cropping season • The population of predators will also be recorded at weekly interval • Leaves infested with whitefly nymphs and pupae will be brought back to laboratory to record the emergence of parasitoids • The population of other sucking pests will also be recorded. • Seed cotton yield (q/ha)

9. SUGARCANE

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

Variety	:	Region specific popular sugarcane variety
Treatments	:	T1: *Heterorhabditis indica* WP (NBAIR) @12 kg/ha in 250 kg FYM per ha. Applied at the time of larval emergence T2: *Metarhizium anisopliae* (NBAIR) @2.5 kg/ ha in 250 kg FYM per ha. T3: Chemical control (Chlorantraniliprole 18.5SC @ 0.3 ml / lit) T4: Untreated control
Replications	:	Totally 8 quadrants will be made of plot. Further each quadrant will serve as replications.
Observations	:	• Plant damage due to white grub was recorded for three

		rows of 10 meter length in each treatment at monthly interval till harvest and damage index was prepared. • White grub population per 10 meter row in the root zone for three rows in each treatment was recorded by digging standard pit of 0.5x0.5x0.5 metre under clump in each damage category at monthly interval till harvest. • Number of miliable canes, cane yield and juice quality was recorded at harvest.

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

Variety	:	Region specific popular variety
Treatments	:	T1: Releases of *T. chilonis* (**temperature tolerant strain of *T. chilonis* should be released**) @ 50,000/ha at 10 days intervals 10-12 releases will be made from mid 45 days old crop to 6 months old crop for early shoot borer/stalk borer/internode borer. In centres where only early shoot borer is problem, only 8release to be made from April to June end. In centres where top shoot borer is problem, *T. japonicum* @ 50,000/ha at 10 days interval from 60 days old crop to 5 months crop. 8 releases to be made. T2: Farmers' practice (as per sprays recommended insecticide at each place as per university recommendation or label claim). T3: Untreated control
Replications	:	Divide each block into 8 equal sized units (each unit = one replication)
Observations	:	Record the following observations • Pre-release infestation, *i.e.*, per cent dead hearts / water shoots due to ESB and other borers • Post-release count of percent dead hearts at fortnight interval from initiation of parasitoid release up to 4 months • Per cent cane attacked at harvest • Cane yield data • Number of millable canes, juice quality and incremental benefit cost ratio estimated post harvest.

OILSEEDS

10. MUSTARD

10.1 Bio-efficacy of entomopathogenic fungus against mustard aphid (AAU-J; OUAT; AAU-A; PAU – 2nd year trial)

Variety	:	Location specific variety
Layout	:	Randomized Block Design
Plot Size		8x5 m
Treatments	:	T1: *Beauveria bassiana* (AAU-J Culture) @1x10^8 spore/g-5g/lit T2: *Metarhizium anisopliae* (AAU-J Culture) @1X10^8 spore /g-5g/lit ***T3:*** *Lecanicillium lecanii* (AAU-J Culture) @1X10^8 spore/g -5g/lit T4*:Lecanicillium lecanii* (NBAIR) @1X10^8spore/g-5g/lit T5: Azadirachtin 1500ppm @ 2ml/lit T6: Insecticide as per university recommendation at each centre T7: Untreated control
Replications	:	Four
Observations	:	Counts of aphids to be made before treatment and 7 days after each treatment. 1. Aphid population at weekly interval on randomly selected 10 plants (terminal shoot) per plot up to maturity will be recorded from each plot. 2. Yield per plot

FRUIT CROPS

11. BANANA

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

Variety	:	Cavendish (CV Jahaji)
Layout	:	Randomized Block Design.
Treatments	:	T1: Four spray of Neem product (Azadiractin 1500) @ 2ml/lt at 15 days interval. T2: Four time filling of Leaf axil with *Beauveria bassiana* (AAU J Culture) @1x10^8 spore / g at 15 days interval. T3: Four spray of *Beauveria bassiana* (AAU J Culture) @1X 10^8 spore / g at 15 days interval. T4: Bunch covering with plastic bags. T5:Sprays of insecticides as per label claim or recommended by the University at 15 days interval

		T6: Untreated control (Spray will be imposed after bunch formation)
Replications	:	Five trees per treatment
Observations	:	• Number of **N.** *subcostatum* per plant will be recorded at 3 days after the treatment by counting on leaves including those hidden inside the crown leaves. • Number of leaf scares on leaf surface will be recorded from 5 sq. cm. on 3 different areas of the youngest leaves. • Observations on the number of healthy and infested fingers per bunch will be recorded and used for computing the mean finger infestation after harvesting the crop. • Influence of various treatments on finger weight of banana will be calculated after harvesting the crop. • Yield data from each treatment will be recorded

12. PAPAYA

12.1 Biological control of Papaya/mulberry mealybug/ complex with *Acerophagus papayae* & *Cryptolaemus montrouzieri* (TNAU, NBAIR – 0.5 ha each)

Layout	:	Randomized Block Design.
Treatments	:	T1: Releases of *Acerophagus papayae* if incidence of PMB is observed. T2: Releases of *Cryptolaemus montrouzieri* grubs in 2nd instar @ 20 grubs / tree if incidence of other mealybugs is observed. T3: Natural control
Replications	:	Divide each block into 8 equal sized units (each unit = one replication)
Methodology and observations		i. The incidence of various species will be recorded. For identification of number of species, send specimens to NBAIR. i. Record natural enemies of mealybug complex on papaya at fortnightly interval and weather factors to work out correlation. • Mealy bug incidence will be recorded as percent incidence based on random selection of 25 plants from each orchards visited. • Pest intensity rating (1-5 scale) will be recorded from 5 plants/ orchard. • Record natural enemies species-wise from two leaves/ plant and 5 plants/ orchard.

13. POMEGRANATE

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

Variety	:	Local variety for culturing fruit borer
Layout	:	CRD
Treatments		T1 = *Trichogramma chilonis* T2 = *Trichogramma pretiosum* T3= *Trichogrmmatoidea bactrae* T4= *Trichogramma achaeae* T5 = Untreated control
Replications	:	Four
Methodology and observations	:	The eggs of fruit borer anar butterfly *Deudorix Isocrates* will be allowed for parasitisation by *Trichogramma sp.* The data on the percentage parasitisation and adult emergence and time period from parasitisation to adult emergence.

14. APPLE

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

Variety	:	Red delicious
Plot size / No. of plants to be treated		50 trees for MD traps 50 trees for T2, T3 & T4 in MD area
Layout	:	Randomized Block Design.
Treatments	:	T1: Installation of mating disruption traps T2: Release of *T. cacoeciae* @2.5 lakh/ha. (4 releases/ season) + Trunk banding + disposal of infested fruits + spray of **Heterorhabditis pakistanensis** (NBAIR) T3: Farmers practice of the region. T4: Control
Replications	:	Five, each set of ten trees as replication
Observations	:	• Per cent fruit damage • Per cent reduction in damage over control • Larval mortality caused by EPN. • Yield

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

Variety	:	Red delicious
Plot size / No. of plants to be treated		10 per treatment
Layout	:	Randomized Block Design.
Treatments	:	T1: 100 nymphs/ tree @ two release /week T2: 200 nymphs/ tree @ two release /week T3: Chemical control with recommended insecticide as per university recommendation or label claim. T4: Control
Replications	:	Each tree to serve as replication
Methodology and observations	:	• Two field releases of anthocorid bugs @ 100 (T1) and 200 (T2) / plant when number of ERM crosses 10/leaf • *In situ* observations on population density of motile ERM/ leaf on 3rd and 7th day after the treatments • Comparison of the treatments for the efficacy of the bugs against Control(T4) • % Decline in mites' population • Effect of dosage on per cent reduction in motile stages of mites • Comparison of data with untreated check

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

Treatments	:	T1: *Tricogramma achaeae* T2: *Tricogramma pretiosum* T3: *Tricogramma chilonis* T4: *Tricogramma pieridis* T5: *Tricogramma embryophagum*
Replications	:	Three, in each 100 eggs to be exposed @ 30 eggs / female for 24 hours, preferably on eggs laid on apple twigs to observe response of host-plant effect on parasitizing behaviour of different trichogrammatids.
Observations	:	Per cent parasitism, % adult emergence, adult longevity, % females and developmental period

14.4 Management of apple root borer using *Metarhizium anisopliae* (YSPUHF 10 orchards covering 5ha)

Variety	:	Apple variety in different orchards to be noted
Treatments	:	T1: *Metarhizium anisopliae* (NBAIR) $1x10^8$ spores/g @ 30g per tree mixed with enriched FYM 1.5 kg /tree, as soil application during July- August i.e at the time

		of emergence of new grubs) T2: Farmers' practice (as per university recommendation or as per label claim).
Replications	:	Each orchard to serve as replication.
Observations	:	• Number of live and dead larvae will be counted at the time of basin preparation and percent mortality will be calculated

15. MANGO

15.1 Effect of biopesticides for the management of Mango hopper, pests *Idioscopus* spp. in field condition (KAU, Vellayani – 2nd year trial, DRYSRHU)

Variety	:	Popular variety
No. of trees		10 trees per treatment
Layout	:	Randomized Block Design.
Treatments	:	T1: *Beauveria bassiana* (KAU culture) @1x10^8 spores/g-5gl/lit T2: *Metarhizium anisopliae* (NBAIR culture) @1x10^8 spores/g-5g/lit T3: Azadirachtin 1500 ppm @ 2ml/lt T4: Malathion 0.1% (KAU POP) T5: Untreated control
Replications	:	Each tree to serve as replication
Methodology and observations	:	Observation will be taken at different intervals after application; No of hoppers/ inflorescence; No of hoppers/ sweep net; Natural enemies, if any

15.2 Effect of biopesticides for the management of Mango shoot webber, pests *Orthaga* spp in field condition (KAU, Vellayani – 2nd year trial)

Variety	:	Popular variety
No. of trees		10 trees per treatment
Layout	:	Randomized Block Design.
Treatments	:	T1: *Beauveria bassiana* (KAU culture) @1x10^8 spores/g-5g/lit T2: *Metarhizium anisopliae* (NBAIR culture) @1x10^8 spores/g-5g/lit T3: Azadirachtin 1500 ppm @ 2ml/lt T4: Malathion 0.1% (KAU POP) T5: Untreated control
Replications	:	Each tree to serve as replication
Methodology and observations	:	Observation will be taken at different intervals after application No of webbers/ inflorescence Natural enemies if any

16. PLUM

16.1 The feeding potential of *Chilocorus infernalis* against *Lecanium* scale of plum in the laboratory (SKUAST)

Methodology	:	• Collection of scale infested twigs from plum. • Sending infesting twigs to NBAIR for identification of scale. • Culturing of scale on pumpkin or on potted plants or any other suitable material. This will ensure same age and known number of scale insects. • Collection of grubs and adults of *Chilocorus infernalis* from plum • Evaluation and comparison of feeding efficiency of grubs and adults against plum scale.
Observations	:	• Feeding potential of individual grub and adult of the predator • To study the important biological parameters of the predator such as life cycle, fecundity, % hatching and survival ability of the predator on plum scale • Overall effect of predator on the *Lecanium* scale
Note: Experiment to initiate after determination of identity. Selection of predator to depend of kind of scale insect.		

17. COCOA

17.1 Evaluation of microbial insecticides against bagworm, *Pteroma plagiophelps* in cocoa (DRYSRHU)

Variety	:	Local
Plot size / No. of plants to be treated		5 trees per treatment
Layout	:	Randomized Block Design.
Treatments	:	T1: *Beauveria bassiana* (NBAIR) $1x10^8$ spore/g @ 5 g/ L T2: *Metarrhizium. anisopliae* (NBAIR) $1x10^8$ spore/g @5 g /L T4: Azadirachtin 1500 ppm @ 3 ml/L T5: Lamada cyhalothrin 0.5ml/litre (chemical check) T6: Untreated control
Replications	:	Each tree to serve as replication
Methodology and observations	:	At 10 days interval after initial population is observed and number of sprays will be carried out as per the need. i. No. of bag worms/5 leaves before treatment ii. No. of bagworms/5 leaves /pods after every treatment

PLANTATION CROPS

18. COCONUT

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

Variety	:	Any dwarf variety of the region
	:	• Observations on whitefly incidence will be made at monthly intervals from three gardens. • Five palms will be selected at random in each garden • The infestation will be graded as low (Three leaflets infested/leaf), medium (four to seven leaflets infested/leaf), High (>10 leaflets infested/leaf) and severe ((>10 leaflets infested/leaf along with sooty mould) • Five leaflets will be collected per garden and brought to laboratory for assessment of natural enemies and pest stages • Information on the management practices followed by the farmer will also be collected • Information on alternated hosts if any will be documented.

18.2 Management of Coconut black headed caterpillar using *Goniozus nephantidis* and *Bracon brevicornis* in endemic areas of Karnataka / Tamil Nadu (NBAIR - 0.5 ha)

Variety	:	To be recorded at each location.
Treatments	:	T1: Release of *Goniozus nephantidis* @ 20 female parasitoids/palm T2: Release of *Bracon brevicornis* @ 30 female parasitoids/palm T3: Release of *Goniozus nephantidis* @ 10 female parasitoids/palm and *Bracon brevicornis* @ 20 females parasitoids/palm T4: Control (Farmers practice)
Replications	:	Divide 0.5 ha block into 5 equal sized units, each unit should further be divided into 5 units that serves as replication.
Methodology		Trees of uniform height (10-20 feet) will be selected for the study. 10% of the total number of palms in 1 ha will be randomly selected for initial observation and pre treatment sampling. The pre release sampling will be done for each palm by collecting and examining 20 leaflets. The larvae, pupae and adult stages of the pest from each leaflet will be counted to arrive at the number of *Opisina arinosella* per leaflet. If majority of the pest

		population is in the larval stage (2^{nd} to 7^{th} instar), we will go for the release of the larval parasitoids. Four releases of the parasitoids will be made at fortnightly intervals. Each treatment will be separated by two rows and treated and untreated plots by four rows of coconut palms.
Observations	:	To determine the impact of parasitoids, post release count on the number of larvae, pupae and larval parasitoids per 10 leaflets/ palm will be compared with pre release counts. Monthly observations on the population of pest and larval parasitoids will be taken.

VEGETABLE CROPS

19. TOMATO

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

Variety	:	Location specific popular variety
Plot size	:	8x5 m^2
Layout	:	Randomized Block Design.
Treatments	:	**T1 = BIPM** Seed treatment with *Trichoderma harzianum* @ 10g/kg of seeds. Raising marigold as trap crop Use of NBAIR pheromone traps @ 1 trap per plot. *Trichogramma achaeae / Trichogramma pretiosum* @ 50,000 per release (6 releases) Azadirachtin 1500 ppm @ 2 ml/lit. *Lecanicillium lecanii* (NBAIR) 1x 10^8 spores/ g @ 5g/lt for sucking pests **T2 = Chemical control** Chlorantraniliprole 18.5% SC for *Tuta* and indoxacarb 14.5 SC for other pests **T3 = Untreated Control**
Replications	:	Five
Methodology and observations	:	The treatment applications will be started at initial occurrence of American pin worm. Six releases of parasitoids at weekly interval and three sprays of biopesticides will be given during evening hours at fortnightly interval. • Randomly select 10 plants/40m^2 crop area and observe all the leaves for presence of leaf mine / sucking pests caused by the larva. • Randomly select 10 plants/ 40m^2 crop area and

		observe all the fruits for presence of holes/ damage caused by the larva. • Observations will be recorded at fortnightly interval from fruit formation to last harvest. • Fruit damage percentage and yield. • Cost-benefit ratio.

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

Variety	:	Location specific popular variety
Plot size	:	2 ha
Layout	:	Randomized Block Design.
Treatments	:	**T1 = BIPM** Seed treatment with *Trichoderma harzianum* @ 10g/kg of seeds. Azadirachtin 1500 ppm @ 2 ml/lit. **Beauveria bassiana *@ 1x10^8 conidia /gm*,** @ 5g/lt – 2 sprays at 15 days interval Spray of HearNPV ($1.5x10^{12}$ POBS/ha) twice during the peak flowering and at fruit setting stage at 15 days interval. *Bacillus thuringiensis* @ 1kg/ha^{-1} two times during season at 15 days interval **T2 = Chemical control** Spinosad 45 SC @ 0.25 ml/***l*** **T3 = Untreated Control**
Replications	:	Divide entire block into 8 equal sized units, each unit should further be divided into 8 units that serves as replications.
Methodology and observations	:	The treatment applications will be started at initial occurrence of *H. armigera* infestation sprays of biopesticides will be given during evening hours at fortnightly interval. • Randomly select 10 plants/ 40m^2 crop area and observe all the fruits for presence of holes/ damage caused by the larva. • Observations will be recorded at fortnightly interval from fruit formation to last harvest. • Fruit damage percentage and yield. • Cost-benefit ratio.

20. BRINJAL

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

Variety	:	Local
Layout	:	RBD
Treatments	:	Four T1: Brinjal intercropped with Coriander and Carrot /radish or beetroot (TNAU) as border crop. T2: Brinjal intercropped with Carrot/radish or beetroot (TNAU) and Cowpea as border crop. T3: Brinjal intercropped with Cowpea and Coriander as border crop. T4: Brinjal as sole crop.
Replications		Five
Methodology		Divide block into 5 equal sized units, each unit should serve as replication. The observation on the nematode population before, during and after cropping will be assessed. The population of natural enemies and pest insects will also be assessed at periodical intervals

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

Variety	:	Variety will be selected as per the university recommendation
Plot size	:	8x5 m
Layout	:	Randomized Block Design.
Treatments	:	T1 = BIPM **For sucking pests** Azadirachtin 1500 ppm @ 2ml/lt *Lecanicillium lecanii* (NBAIR strain) 1x 10^8 spores/ml @ 5g/lt **For BSFB** Release of *Trichogramma chilonis* multiple insecticide tolerant strain @100,000/ha, 8-10 releases at weekly interval from initiation of flowering. *Bacillus thuringiensis* NBAII BtG4 2% (not for AAU-J) **For Ash weevil** Entomopathogenic nematode (NBAIR strain) @ 2 billion IJs / ha, twice during season. **For mealybug** *Cryptolaemus montrouzieri* @ 5 grubs / plants or 1500/ha, twice at 15 days interval. T2 = Chemical Control Based on each university recommendation for insect pest

		on brinjal. 4-6 sprays depending upon pest species. T3: Untreated control
Replications	:	Eight
Methodology and observations	:	1. Pre-treatment incidence on shoot infestation and catches from pheromone traps. 2. Post treatment counts of infestation at shoot and fruit stage of crop at fortnightly interval. 3. Yield of healthy marketable fruits and cost-benefit ratio.

21. OKRA

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

Variety	:	Variety will be selected as per the university recommendation
Plot size	:	8 x 5 m
Layout	:	Randomized Block Design.
Treatments	:	T1: *Metarhizium anisopliae* (NBAIR) $1x10^8$ spores/ g @ 5g/lt T2: *Beauveria bassiana* (NBAIR) $1x10^8$ spores/ g @ 5g/lt T3: *Trichogramma chilonis* @50,000 parasitoids/ha, 6 releases at weekly interval. T4: *Bacillus thuringiensis* @ 1 kg/ha T5: Azadirachtin 1500 ppm@ 2 ml/lit T6: University recommended insecticide, 2-4 sprays. T7: Untreated control
Replications	:	Three
Methodology and observations	:	Releases of parasitoids at weekly interval and three sprays of entomopathogens, and azadirachtin will be followed at fortnightly interval. The observations will be recorded on five randomly selected plants/ plot. 1. Pre and post- treatment counts on fruit infestation at weekly interval. 2. Yield of healthy marketable fruits at each picking.

21.2 Effect of biopesticides for the management of shoot and fruit borers, *Earias vittella* in bhindi (KAU, Vellayani – 2nd year trial)

Variety	:	Variety will be selected as per the university recommendation
Plot size	:	8 x 5 m
Layout	:	Randomized Block Design.
Treatments	:	T1: *Beauveria bassiana* (KAU culture) $1x10^8$ spores/ g @ 5g/lt T2: *Numurea rileyi* (NBAIR culture) $1x10^8$ spores/ g @

		5g/lt T3: *Metarhizium anisopliae* (NBAIR culture) $1x10^8$ spores/ g @ 5g/lt T4: Malathion 0.1% (KAU POP) T5: Untreated control
Replications	:	Three
Methodology and observations	:	Observation will be taken at different intervals after application No of borer infested fruits/ plant Record of natural enemies, if any Yield /plant

22. CABBAGE

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

Variety	:	Local variety
Plot	:	8x5 m
Layout	:	Randomized Block Design
Treatments	:	T1: *S. carpocapsae* @ 2.5 lakh IJs/sq. mt. 2-3 sprays depending on pest infestation. T2: *H.indica* @ 2.5 lakh IJs/sq.mt 2-3 sprays depending on pest infestation. T3: Insecticide as per label claim / University recommendation T4: Control
Replications	:	Four
Observations	:	• Average population of active IJs/ plant after 24 hours • Larval mortality after 72 and 96 hrs of each treatment • Yield (Average yield of IJs from 1^{st}, 2^{nd}, 3^{rd} and 4^{th} larva) • Crop yield in treated and untreated micro plot

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

Crop/Variety	:	Local popular variety
Area	:	0.4 to 1.0 ha
Layout	:	Randomized Block Design
Treatments	:	T1: Raising of mustard as intercrop (TNAU & CAU), Release of MITS of *Trichogramma chilonis* @ 100,000/release against *Plutella xylostella*, 6 releases to be made at 30 days after transplanting, release of *Chrysoperla zastrowi sillemi* @ 2000/ release, 2 releases to be made at 15 days interval against cabbage aphid, *L. lecani*-$1x10^8$ spore/ ml @ 5ml/lt and *Bt* (NBAIR) three sprays and *Bacillus*

		thuringiensis NBAII BtG4 2%. T2 : Farmers practices (to be specified by each centre)
Replications	:	Divide block into 5 equal sized units, each unit should serve as replication.
Observations	:	• Pre- release observation – No. of holes on the leaves, No. of larvae, such 5 spot to be selected for observation including 10 plants each spot, observation will be taken 4 times at 15 days interval • Collection of eggs, about 100 eggs to be collected to check parasitisation, observation will be recorded 4 times. • Aphid – observation to be recorded in 5 random spots including 10 plant each spot for aphid infestation and total number of infested plant to be counted. Five observation to be taken on the aphid colony infesting leaves by using the 1cm window, • Yield data

POLYHOUSE INSECT PESTS

23.1 Management of cucumber sucking pests using anthocorid predator, *Blaptostethus pallescens* under polyhouse condition (KAU)

Variety	:	Any recommended variety
Plot size in polyhouse	:	2x2 m
Layout	:	Randomized Block Design.
Treatments	:	T1: *Blastostethus pallescens* @ 10 nymphs/m row twice at 15 days interval T2: *Blastostethus pallescens* @ 20 nymphs/ m row twice at 15 days interval T3: Spiromesifen 45SC @100g.a.i ha^{-1} twice at 15 days interval or recommended insecticide for use in polyhouse T4: Control
Replications	:	Five
Observations	:	1. Pre treatment count of thrips and mites 2. Post treatment count of thrips and mites at 7 and 14 DAT 3. Number of leaves with symptoms of infestation 4. Yield

23.2 Management of red spider mite *Tetranychus urticae* infesting rose in polyhouse conditions (MPKV)

Variety	:	Variety will be selected as per the university recommendation
Micro Plot size	:	2x2 m
Layout	:	Randomized Block Design.
Treatments	:	T1: *Lecanicillium lecanii* (NBAIR) $1x10^8$ spores/ g @ 5g/lt T2: *Beauveria bassiana* (NBAIR) $1x10^8$ spores/ g @ 5g/lt T3: *Metarhizium anisopliae* (NBAIR) $1x10^8$ spores/ g @ 5g/lt T4: Predatory mites *Neoselus* sp. @ 20 per plant T5: Insecticide as per label claim / University recommendation T6: Untreated control
Replications	:	Four
Methodology and observations	:	Planting of seedlings in raised beds/plastic pots. Apply organic manure as per recommendations. Initial mite population /plant on 3 leaves from 10 plants. Record mite population 7 days after each spray. Yield parameters.

23.3 Evaluation of biocontrol agents for the control of sucking pests in capsicum under polyhouse (YSPUHF, PAU)

Variety	:	Variety will be selected as per the university recommendation
Plot size	:	2x2 m
Layout	:	Randomized Block Design.
Treatments	:	T1: *Metarhizium anisopliae* (NBAIR) $1X10^8$ spore/ g @ 5g/lt T2: *Lecanicillium lecanii* (NBAIR) $1X10^8$ spore/ g @ 5g/lt T3: *Beauveria bassiana* (NBAIR) $1X10^8$ spore/ g @ 5g/lt T4: *Chrysoperla zastrowi sillemi* @ 4 larvae / plant, 2-3 releases(weekly) to be made. T5: Five (weekly) releases of *Blaptostethus pallescens* @ 30 nymphs/ m row length T6: Azadirachtin @ 2ml/L of 1500ppm T7: Insecticide as per label claim / University recommendation T8: Control
Replications	:	Three
observations	:	2-3 sprays will be made at 10 days interval on appearance of pest

		Population of sucking pests from 10 randomly selected plants before spray / release of predator, 5, 7 and 10 days after spray / release of predator. Marketable yield

23.4 Evaluation of microbial insecticides against aphids of cole crop (*viz.*, cauliflower / cabbage) in green house (DRYSRHU – 2nd year trial)

Variety	:	Variety will be selected as per the university recommendation
Plot size	:	2x5 m
Layout	:	Randomized Block Design.
Treatments	:	T1: *Metarhizium anisopliae* (NBAIR) $1x10^8$ spores/ g @ 5g/lt T2: *Lecanicillium lecanii* (NBAIR) $1x10^8$ spores/ g @ 5g/lt T3: *Beauveria bassiana* (NBAIR) $1x10^8$ spores/ g @ 5g/lt T4: Azadirachtin 1500 ppm @ 2ml/L T5: Methyl demeton (0.025%) (chemical check) T6: Control
Replications	:	Four
Observations	:	i. No. of aphids/ 5 leaves before treatment ii. No. of aphids/ 5 leaves after every treatment iii. Per cent leaf infestation/ 5 plants iv. Yield at harvest

FLOWERS

24. JASMINE

24.1 Management of bud worm, blossom midge and whitefly on jasmine (TNAU)

Variety	:	Ramnad local
Plot size	:	8x5 m
Layout	:	Randomized block design

Treatments	:	T1 - Azadirachtin 1500 ppm @ 2ml/L; three times starting from bud initiation stage at 10 days interval T2 -Release of *T. chilonis* @ 50,000/ acre at 10 days interval for two months from bud initiation based on light trap monitoring + release of *Chrosoperla zastrowi sillemi* 5000 nos/ha from bud initiation T3 - T2+ three rounds of spraying with *Beauveria bassiana* NBAIR formulation ($1x10^8$ spores/g) @ 5g / litre at 10 days interval T4 - T2+ three rounds of spraying with *Metarhizium anisopliae* NBAIR formulation ($1x10^8$ spores/g) @ 5g / litre at 10 days interval T5 - Soil drenching with *Metarhizium anisopliae* 10^9 spores/ha- two times at fifteen days interval T6 - Soil application of Neem cake @250 kg/ha two times per year T7- Soil application of Carbofuran 3G @ 20 gm/plant T8- Control
Replications	:	Three
Methodology and observations	:	• No. of plants per treatment: 10 • No. of Replications: 3 • 3 branches / plant / replication • No. of infested buds/ flowers will be counted on 7 days after each application • Per cent damage will be worked out

25. CROP DISEASE MANAGEMENT

Large scale field demonstration trials (GBPUAT),
Rice-100 ha
Pea-50 ha
Chickpea-25 ha

ICAR- CPCRI will undertake the following technical programme under AICRP-biological control during 2017-18

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

Treatments: Three (4AT2, BTAN4, 4Aa1) graded dozes 10^{-1} to 10^{-4}
Replicates : 10 grubs per treatments

Observation: mortality of grubs at 24 hr interval till pupation, weight loss, external symptoms specific to Bt infection

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

Treatments: Three (4AT2, BTAN4, 4Aa1) graded dozes 10^{-1} to 10^{-4}
Replicates : 10 grubs per treatments
Observation: mortality of grubs at 24 hr interval till pupation, weight loss, external symptoms specific to Bt infection

RARS, Kumarakom, KAU

a) Survey and documentation of pests and diseases of yard long bean under polyhouse conditions

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

Variety	Lola
Layout	Randomized Block Design.
Plot size	8x5 m
Treatments	T1- *Lecanicillium lecanii* NBAIR 1 % (10^8 spores/ml) T2- *Lecanicillium lecanii* NBAIR 1 % (10^9 spores/ml) T3- *Beauveria bassiana* NBAIR 1 % (10^8 spores/ml) T4- *Beauveria bassiana* NBAIR 1 % (10^9 spores/ml) T5 -Spiromesifen 22.9 SC @ 96 g ai ha^{-1} T6- Control
Replications	Five
Observations	Observation on pest and natural enemy incidence will be taken at fortnightly intervals before and after sprayings from the treated plants. Yield data will also be recorded.

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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ACRONYMS

AAU-A	Anand Agricultural University, Anand
AAU-J	Assam Agricultural University, Jorhat
ANGRAU	Acharya N.G.Ranga Agricultural University, Anakapalle
CAU	Central Agricultural University, Pasighat
GBPUAT	Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar
KAU	Kerala Agricultural University, Thrissur
MPKV	Mahatma Phule Krishi Vidyapeeth, Pune
MPUAT	Maharana Pratap University of Agriculture & Technology, Udaipur
OUAT	Orissa University of Agriculture & Technology, Bhubaneswar
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
UAS-R	University of Agricultural Sciences, Raichur
YSPUHF	Y.S. Parmar University of Horticultural and Forestry, Solan
IGKV	Indira Gandhi Krishi Viswavidhyalaya, Raipur
RRS	KAU-Regional Agricultural Rersearch Station, Kumarakom
RRS	Kerala Agricultural University, 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, Kayankulam
CTRI	Central Tobacco Research Institute, Rajahmundry
IIRR	Indian Institute of Rice Research, Hyderabad
DSR	Directorate of Seed Research, Mau
IIMR	Indian Institute of Millet Research, Hyderabad
IARI	Indian Agricultural Research Institute, New Delhi
IIHR	Indian Institute of Horticultural Research, Bangalore
IIVR	Indian Institute of Vegetable Research, Varanasi
NCIPM	National Centre for Integrated Pest Management, New Delhi