Technical Document No. 68

Proceedings of the XXV Biocontrol Workers' Group Meeting and Technical Programme for 2016-17

17th-18th May, 2016
Andhra University Campus, Visakhapatnam
Organized by
Acharya N.G.Ranga Agricultural University
Anakapalle

Compiled and Edited by

Abraham Verghese, S.K.Jalali and Richa Varshney

AICRP on Biological Control of Crop Pests

NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCESP. B. No.2491, H. A. Farm Post, Bangalore 560024
Karnataka

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Bangalore
28 May 2016

Abraham Verghese
Director & Project Coordinator
National Bureau of Agricultural Insect Resources
Bangalore

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

Venue: **Andhra University Campus, Visakhapatnam (Andhra Pradesh)**

Date **: 17th – 18th May, 2016**

PROGRAMME: May 17th, 2016 (Tuesday) 8.00 am to 10.45 am

0800-0900	**REGISTRATION**
0900-1030	**INAUGURATION**
Invocation	ICAR Song
Welcome	**Dr. N.V. Naidu** Director of Research, ANGRAU
Project Co-ordinator's Report	**Dr. Abraham Verghese** Project Co-ordinator, AICRP-BC & Director, NBAIR, Bangalore
Release of AICRP Publications	**AAU-Aand:***Tuta absoluta*: Current status and management strategy in Gujarat (Folder in English & Gujarati) **AAU-J:** 1.Bilahi khetir Samanwit Kit-patanga Niyantranor Bibasthya (IPM of Tomato) (In Assamese) 2.Bengana khetir Samanwit Kit-patanga Niyantranor Bibasthya (IPM of Brinjal) (In Assamese) **ANGRAU:** A Step towards Sustainable Organic farming of Paddy in the Tribal areas **KAU:** A decade of IPM in rice- Adat revisited **MPKV:** Success story of Biological control of decade in Maharashtra (In Marathi) **NBAIR:**Biological control of sugarcane pests **TNAU:** 1. Entomophages in crop pest management (folder in English) .2. Mass production of insect biocontrol agents (guide in Tamil for farmers)
Remarks ADG (PP), ICAR	**Dr. P. K. Chakrabarty,** ADG (PP& B), ICAR, New Delhi
Adress VC, DRYSRHU	**Dr. B.M.C.Reddy** Vice Chancellor, DRYSRHU
Vote of thanks	**Dr.N. Venugopala Rao,** ADR, ANGRAU
10.30-10.45	**TEA**
PRESENTATION OF PROGRESS REPORTS	
May 17th, 2016; 10.45-11.45hrs	**SESSION I: BASIC RESEARCH ON BIODIVERSITY AND NATURAL ENEMIES OF INESECT PESTS AT NBAIR AND BIOLOGICAL CONTROL OF PLANT DISEASES**
Chairman Co-Chairmen	Dr. P. K. Chakrabarty, ADG (PP&B), ICAR, New Delhi Dr. P.V. Krishnaiah, HOD, Entomology, ANGRAU, Bapatla
Rapporteurs	Dr.A.N. Shylesha, NBAIR, Bangalore Dr. B.L. Raghunandan, AAU-Anand
Speakers	
Biodiversity, Biosystematics, Molecular Characterization and Biocontrol potential of newer natural enemies (NBAIR)	Dr. Chandish Ballal, NBAIR, Bangalore

Biological Control of Plant diseases using antagonists	Dr. A.K. Tiwari, GBPUAT, Pantnagar
May 17th, 2016; **11.45-13.00**	**SESSION II: BIOLOGICAL SUPPRESSION OF PESTS OF SUGARCANE, COTTON, RICE, MAIZE AND SORGHUM**
Chairman Co-Chairman	Dr. N. V. Naidu, Director of Research, ANGRAU Dr. N. Venugopala Rao, ADR, RARS, Anakapalle
Rapporteurs	Dr. S. M. Galande, MPKV, Pune Dr. Madhu Subramaiam, KAU, Thrissur
Speakers	
Sugarcane & Cotton	Dr. K.S. Sangha, PAU, Ludhiana
Rice, Maize & Sorghum	Dr. S. J. Rahman, PJSTAU, Hyderabad
LUNCH	**13.00-14.00**
14.00-15.30	**SESSION III: BIOLOGICAL SUPPRESSION OF PESTS OF PULSES, OILSEEDS, TOBACCO AND COCONUT**
Chairman Co-Chairman	Dr. C.A. Viraktamath, Chairman, RAC, NBAIR Dr. Chandish Ballal, HOD, NBAIR
Rapporteurs	Dr. Arun Kumar Hosamani, UAS- Raichur Dr. P.S. Shera, PAU, Ludhiana
Speakers	
Pulses & Oilseeds	Dr. N. Sridharan, TNAU, Coimbatore
Tobacco	Dr. P. Venkateswarlu, CTRI, Guntur
Coconut	Dr. Madhu Subramaiam, KAU, Thrissur
15.30-17.30	**SESSION IV: BIOLOGICAL SUPPRESSION OF PESTS OF FRUIT AND VEGETABLE CROPS, POLYHOUSE CROP PESTS, STORAGE PESTS AND WEEDS**
Chairman Co-Chairman	Dr. T. Ramesh Babu, Dean, Agriculture, ANGRAU Dr. Sujatha, Associate Dean, DRYSRHU, Tadepallegudem
Rapporteurs	Dr .A. Saravanan, TNAU, Coimbatore Dr. Jayadeep Haldar, IIVR, Varanasi
Speakers	
Tropical and Temperate Fruits, & Mealy bugs	Dr. Jamal Ahmad, SKUAST, Srinagar
Vegetables	Dr. Jayadeep Haldar, IIVR, Varanasi
Polyhouse Crop Pests & Storage pest Biocontrol	Dr. P.L. Sharma, YSPUHF, Solan
16.30-16.45 hrs	**TEA**
May 18th, 2016 (Wednesday) **09.00-10.00**	**SESSION V: TRIBAL SUB PLAN PROGRAMME**
Chairman Co-Chairman	Chairman: Dr. Abraham Vergese, Director, NBAIR, Bangalore Co-Chairman: Dr. B. Ramanujam, NBAIR, Bangalore
	Presentation on achievements of Tribal Sub Plan programme 1. Dr. M. Visalakshi, ANGRAU, RARS, Anakapalle
10.00-11.00	**Session VI: INSTITUTE–INDUSTRY PARTNERSHIP**
Chairman Co-Chairman	Dr. K. Raja Reddy, Director of Extension, ANGRAU Dr. S.K. Jalali, HOD, NBAIR, Bangalore
Rapporteurs	Dr. S.J. Rahman, PJTSAU, Hyderabad Dr. Neelam Joshi, PAU, Ludhiana

	Speakers from Private Industry
TEA	**11.00-11.15**
1200-1700 hrs	**SESSION VI (Plenary): Presentation of Recommendations**
Rapporteurs	Dr. A. N. Shylesha NBAIR, Bangalore Dr. Richa Varsheny NBAIR, Bangalore
Presentation of Recommendations	Dr. S.K. Jalali, NBAIR, Bangalore
LUNCH	**13.30-14.00**
TEA	**1530-1545 hrs.**
Vote of Thanks	Dr. B. Ramanujam, NBAIR, Bangalore

INAUGURAL SESSION

The **XXV Biocontrol Workers' Group Meeting** was conducted under the aegis of the Indian Council of Agricultural Research, New Delhi at Andhra University Campus organized by ANGRAU, Visakhapatnam on 17th and 18th May, 2016. Delegates and invitees from ICAR Institutes, Agricultural Universities and representatives of private commercial production units attended the Inaugural Session. The programme was as follows:

Welcome Address	:	**Dr. N.V. Naidu** Director of Research, ANGRAU
Project Co-ordinator's Report	:	**Dr. Abraham Verghese** Project Co-ordinator AICRP on Biological Control
Remarks of Chief Guest	:	**Dr. P. K. Chakrabarty**, ADG (PP&B), ICAR, New Delhi
Address VC, DRYSRHU	:	**Dr. B.M.C.Reddy** Vice Chancellor, DRYSRHU
Vote of Thanks	:	**Dr.N. Venugopala Rao**, ADR, ANGRAU

The workshop was inaugurated by **Dr. P.K. Chakrabarty**, ADG (PP) ICAR. **Dr. N.V. Naidu,** Director of Research, ANGRAU welcomed the delegates. Dr. N.V. Naidu gave brief account the work carried out at on biological control at RARS Anakapalle and Tirupati centre of ANGRAU**. Dr. Abraham Verghese**, Director, NBAIR Bangalore and Project Coordinator, presented the salient achievements of the AICRP-BC for the year 2015-16. 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 importance of Molecular signatures and its role in registration of microbial and also suggested that more focus should be towards management of pathogens in vegetables, fruits and pulses under AICRP Biocontrol. NBAIR publication on "Biological control of sugarcane pests" was released along with other publications from different AICRP centres. **Dr. B.M.C.Reddy**, Vice Chancellor, DRYSRHU emphasized some challenges like capacity building & HRD for identification, release, rearing, assessment and survey of bioagents; Farmer's participation for successful implementation of biocontrol programme. He also emphasized that there is need to initiate biocontrol and other ecofriendly techniques in polyhouse to combat sucking pest problem. He also suggested that biopesticides should be availbale on time to farmers and there should be proper large scale demonstration of biocontrol techniques for easy understanding.

Dr. C.A. Viraktamath, RAC Chairman, NBAIR, **Dr. T.Ramesh Babu**, Dean Agriculture, ANGRAU, **Dr. K. Raja Reddy**, Director of Extension, ANGRAU, **Dr. N. Venugopala Rao**, ADR, ANGRAU, delegates and invitees from ICAR Institutes, Agricultural Universities and representatives of private commercial production units attended the workshop.The recommendations and the technical Programme for 2016-17 were finalized on the occasion.

SALIENT FINDINGS DURING 2015-16

Abraham Verghese
Director, NBAIR, Bangalore & Project Coordinator (AICRP on Biological Control)

1. Introduction

The technical programme for the year 2015-16 was formulated during the workshop of the XXIV Biocontrol Workers's Group Meeting on 2-3rd June, 2015 at TNAU, Coimbatore and was implemented by the twenty five centers of AICRP (14 SAUs and 11 ICAR Institutes), completing most of the mandated experiments on several field and horticultural crops. A large number of experiments and demonstrations were conducted in different centers across the country during 2015-16 and the results of these experiments as well as demonstrations are presented in this document.

2. Mandate of AICRP on Biological control of crop pests

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

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

3. Objectives

a. Development of effective biocontrol agents for use in biological suppression of crop pests and diseases.
b. Evaluation of various methods of biological control in multi-location field trials.
c. Development of biointensive integrated pest management strategies for cotton, rice, sugarcane, pulses, oilseeds, potato, coconut and a few selected fruits and vegetable crops.
d. Demonstration of biocontrol agents and biopesticides as a component of IPM in farmers' fields

4. Setup

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

State Agricultural University–based centers

1.	Acharya N.G. Ranga Agricultural University	Anakapalle
2.	Anand Agricultural University	Anand
3.	Assam Agricultural University	Jorhat
4.	Dr. Y.S. Parmar University of Horticulture and Forestry	Solan
5.	Gobind Ballabh Pant University of Agriculture and Technology	Pantnagar
6.	Kerala Agricultural University	Thrissur
7.	Mahatma Phule Krishi Vidyapeeth	Pune
8.	Pandit Jayashankar Telangana State Agricultural University	Hyderabad
9.	Punjab Agricultural University	Ludhiana
10.	Sher-e-Kashmir University of Agricultural Science & Technology	Srinagar

11. Tamil Nadu Agricultural University	Coimbatore
12. Central Agricultural University	Pasighat
13. Maharana Pratap University of Agriculture & Technology	Udaipur
14. Orissa University of Agriculture & Technology	Bhubaneshwar
15. University of Agricultural science (Raichur)	Raichur

ICAR Institute–based centres

1. Central Institute of Subtropical Horticulture	Lucknow
2. Central Plantation Crops Research Institute	Kayangulam
3. Central Tobacco Research Institute	Rajahmundry
4. Indian Institute of Rice Research	Hyderabad
5. Directorate of Seed Research	Mau
6. Indian Institute of Millet Research	Hyderabad
7. 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

5. Brief summary of research achievements

5.1 Basic research work at National Bureau of Agricultural Insect Resources

5.1.1 Biosystematic studies on agricultural insects

5.1.1.1 Biodiversity of natural enemies of insect pests

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

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

Surveys were conducted for Platygastroidea in five states, *viz*., Tripura, Andaman and Nicobar Islands, Tamil Nadu, Kerala and Karnataka. A total of 1150 parasitoids were collected, curated and preserved for future studies. The five newly added genera are *Pardoteleia, Pleistopleura, Ptiostenius, Titta* and *Nyleta.* A new species group and fifteen new species were described. The new species group *Idris adikeshavus* group has been proposed with five new species – *Idris adikeshavus, I. brevicornis, I. deergakombus, I. teestai* and *I. lopamudra.*

5.1.1.3 Biosystematics of Trichogrammatidae (Hymenoptera)

Eight states were surveyed for Trichogrammatidae. The relatively recently described *T. rabindrai*, a species so far known only from S. India was discovered in S. Andaman. It is being bar coded. A species of *Mirufens* was collected from the Nicobar Islands for the first time from leaf galls of *Dipterocarpus* sp. A species of *Trichogrammatoidea* similar to *T. tenuigonadium* in habitus but with genitalia in males resembling other *Trichogrammatoidea* has been discovered from Karnataka. The barcode generated for this species is distinct unlike any other species in the genus thus validating its status as a new species.

5.1.1.4 Biodiversity of aphids and coccids

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

5.1.1.5 Documentation, production and utilisation of predatory anthocorids and mites

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

Four to six releases of *Blaptostethus pallescens* against broad mites (*Polyphagotarsonemus latus*) infesting capsicum could significantly reduce the pest incidence and curling symptoms and improve the plant height. *Xylocoris flavipes* and *Blaptostethus pallescens* were evaluated against *Sitophilus oryzae* infested maize seeds. This result indicates that anthocorid predators are potential bio-agents of *Sitophilus oryzae* and would be very effective if introduced as soon as seeds are stored as they would deter adult oviposition.

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

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

Different parasitoids, predators and other insects were collected from Andaman & Nicobar Islands, Srinagar, Pune, Anand, Varanasi, Dharmapuri and Bangalore and were used for DNA barcoding studies. The parasitoids belong to Braconidae, *viz*., *Glyptapanteles* sp. (Barcode: ACZ3549) (Genbank Acc. No. KR260984), *Glyptapanteles* sp. (AAI5405) **(**KT284335), *Glyptapanteles* sp. (ACZ3433) (KT25318), *Microplitis maculipennis* (ACV9232) (KP759295), *Glyptapanteles creatonoti* (AAH1199) (KR021154),

Glyptapanteles sp. (ACZ3493) (KT254316), *Glyptapanteles obliquae* (Wilkinson) (ACS3730) (KR021152), *Glyptapanteles aristolochiae* (Wilkinson) (ACZ3726) (KR021156), *Glyptapanteles cf. Spodopterae Ahamad (*ACS3730) (KR260983), *Glyptapanteles spodopterae* (ACS3730) (KR260976), *Glyptapanteles* sp. (AAH1199) (KT284334), *Glyptapanteles* sp. (ACZ3303) (KT254319), *Glyptapanteles bliquae* (Wilkinson) (AAH1199) (KR021152), *Glyptapanteles cf. amprosemae* Ahmad (ACZ3016) (KT284342) were characterized and barcodes generated. Phylogenetic analyses were performed on 38 based on mitochondrial cytochrome oxidase subunit I (COI) nucleotide sequences. Maximum likelihood and Bayesian inference methods displayed three and four major discrete *Glyptapanteles clades*, respectively. Furthermore, molecular characterization and DNA barcodes were generated for 103 agriculturally important parasitoids, predators and other insects based on COI gene & ITS-2 and deposited in GenBank and BOLD and obtained accession numbers.

5.1.3. Monitoring of invasive pests

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

Tuta absoluta (Meyrick 1917), a lepidopteran tomato leaf miner also called as pin borer is considered as one of the most devastating tomato pests in the countries it has invaded so far. It has originated from Peru (South America) and then invaded many other countries in South America, Europe, Africa and Asia. The pest was detected and identified in October 2014 from Pune, Maharashtra in India by the Scientists of ICAR and now poses most serious threat to tomato cultivation in the country. The damage of this pest on tomato crops has been reported from Gujarat, Maharashtra, Telangana, Andhra Pradesh, Karnataka and Tamil Nadu. The other potential host plants for *T. absoluta* in India are brinjal and potato apart from other solanaceous weed hosts.

5.1.3.2 Extent of damage on tomato crop by *T. absoluta* in different

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

5.1.3.3 Natural enemies of *Tuta absoluta*

Cage studies were conducted to evaluate *Trichogramma* species against eggs of *Tuta absoluta* infesting tomato plant. Parasitism by *Trichogramma achaeae* was 28.8% followed by *T. pretiosum* (thelytokous) (22.7%) and *Trichogrammatoidea bactrae* (12.5%). Anthocorid predators, *Amphiareus constrictus* and *Blaptostethus pallescens* were observed to be efficient predators of *Tuta absoluta* eggs, feeding on 90 to 100% of the eggs when released in a ratio of 1 predator: 10 eggs.

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

Four NBAIR *Bt* isolates along with standard MTCC-8997 expressing the coleopteran specific proteins were tested against early second instar larvae of *Tuta absoluta* by tomato

leaf dip methodology. The most toxic isolate was NBAIR-4 with LC_{50} 301.3 ppm, followed by NBAIR-1with LC_{50} as 373.7 ppm Laboratory bioassay with three isolates each of *B. bassiana* (Bb-5a, Bb-19 and Bb-23) and *M. anisopliae* (Ma-4, Ma-6 and Ma-35) against *T. absoluta* indicated very low mycosis (6.7 to 26.7%).

5.1.3.5 Studies on papaya mealybug

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

Parasitism: A high level of parasitism was recorded from all the samples collected. *Acerophagus papayae* was the predominant parasitoid exercising control in addition *Pseudleptomastix mexicana* was recorded in all the samples with parasitism ranging from 5.0 to 20.0%. None of the samples recorded from any area was free from parasitoids showing their wide spread presence and their adaptability to Indian conditions. parasitism of *Acerophagus papayae* by hyper parasitoids was recorded to the extent of 6-7% by *Chartocerus* sp. and 2-3% by *Marietta leopardina*.

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

5.1.3.7 Invasive whitefly *Aleurothrixus trachoides*

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

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

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

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

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

5.1.3.10 Survey for invasive thrips, *Frankliniella occidentalis*

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

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

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

5.1.3.12 Erythrina gall wasp managment

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

5.1.3.13 Incidence of invasive leaf miner, *Chromatomyia syngenisiae*

Severe outbreak of invasive leaf miner, *Chromatomyia syngenisiae* was recorded in chrysanthemum in poly houses from Coonor, Ooty and nearby areas including Nilgiri hills and Coimbatore. The incidence occurred in > 80.0% of the plants in the sampled area and the yellow traps were full by the end of the day of installation with adult flies. *Herbertia* sp. (Hymenoptera: Pteromalidae) was collected from the mummified puparium of the leaf miners.

5.1.3.14 new invasives and host extensions

- Banana skipper, *Erionota thrax* (Lepidoptera: Hespiridae) severity has come down.
- Root mealybugs on pepper, *Formicococcus polysperes* Williams and other species have become severe in Coorg and Chickmagalur area.
- The skipper, common banded awl, *Hasora chromus* (Cramer) (Lepidoptera: Hesperiidae), upsurge was recorded on *Pongamia pinnata* in and around Bangalore. The trees were entirely defoliated. Many insectivorous birds were seen feeding on the caterpillars.
- A looper (*Cleora* sp.) (Lepidoptera: Geometridae) was found to feed extensively on neem trees in a few villages of Samsthan Narayanpur Mandal of Nalgonda district in Telangana during October/November 2015. Previously this was recorded as a pest of pigeon pea from Hyderabad.

5.1.4. Biosystematics and diversity of entomogenous nematodes in India

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

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

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

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

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

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

A total of 86 soil and insect samples collected from Western Ghats were analysed during the year and 25 isolates of *Bacillus thuringiensis* isolates expressed bipyrmadal crystals. Soil samples from Greater Nicobar Islands yielded 4 isolates of *Bt* expressing bipyramal and spherical crystals. The trypsin activated Vip3A protein (4 hrs IPTG induction) at 500 µg concentration caused 100% mortality of *Plutella xylostella* after 48 hours. The LC_{50} value was calculated as 53.676 µg/ ml. Cry8A expressing *B. thuringiensis* (NBAIR-BTAN4) was tested against the potato grub and 100.0% mortality recorded in 48 hrs.

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

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

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

In maize, oil formulations of endophytic isolates of *Beauveria bassiana* (NBAIR-Bb-5a, 7, 14, 19, 23 and 45) were evaluated against *Chilo partellus*. Bb-5a isolate showed significantly lower dead hearts (10.2 and 7.1% during kharif and rabi seasons respectively), lowest no. of exit holes (1.80 and 1.07/plant) and stem tunneling (1.23 and 2.21 cm/plant) as compared to untreated control which showed higher dead hearts (23.6 and 26.8%), exit holes (7.2 and 4.07/plant) and stem tunneling (5.2 and 7.8 cm/plant).

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

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

5.2.1 Biodiversity of biocontrol agents from various agro ecological zones

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

AAU-J: Coccinellids collected on different *rabi* vegetables infested by aphids, mealybugs and whiteflies were identified as *Coccinella septempunctata*, *C. transversalis*, *Brumoides suturalis* and *Micraspis* spp. Different types of spiders were collected from different habitats. The most dominant spider species collected from rice ecosystem were *Oxyopes* sp., *Tetragnatha* sp., *Lycosa pseudoannulata* and *Argiope catenulata*.

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

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

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

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

SKUAST: Surveys on different horticultural crops were conducted in Kashmir valley and Ladakh. Among important natural enemies, aphelinid parasitoids, *Encarsia perniciosi*,

Aphytis proclia, *Ablerus* sp. and coccinellid predator, *Chilocorous infernalis* were found on San Jose scale exclusively in unmanaged orchards. *Aphelinus mali* was found actively associated with apple woolly aphid, *Eriosoma lanigerum.* Nine natural enemies were recorded for the first time from Kashmir in association with different fruit pests.

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

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

5.2.1.1 Surveillance for alien invasive pests

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

5.2.2 Biological suppression of plant diseases

5.2.2.1 Biological control of diseases of rice, pea and chickpea

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

5.2.2.2 Biological control of chilli anthracnose diseases

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

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

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

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

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

5.2.3 Biological suppression of sugarcane pests

5.2.3.1 Monitoring of sugarcane woolly aphid and its natural enemies

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

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

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

5.2.4 Cotton

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

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

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

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

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

5.2.4.3 Monitoring biodiversity and outbreaks for invasive mealybugs on cotton

PAU: Regular surveys revealed only one mealybug species, *Phenacoccus solenopsis* on cotton. However, coccinellid predators such as *C. sexmaculata, C. septempunctata* and *B. suturalis* and green lace wing, *Chrysoperla zastrowi sillemi* were noticed feeding on mealybug. The parasitism by parasitoids under field conditions varied from 40.0 to 68.2%, out of which endoparasitoid, *Aenasius arizonensis* (73.2%) was predominant, which in turn was hyperparasitised by *Promuscideaun fasciativentris* to the extent of 26.8%.

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

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

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

PAU: Regular observations showed that the incidence of sucking pests was less in sprayed condition as compared to unsprayed condition. However, on non-Bt cotton the mean larval population, damage in freshly shed fruiting bodies, green boll damage was comparatively more under unsprayed condition as against sprayed condition. The predator population (spiders, coccinellids, *Chrysoperla*, *Geocoris* sp. and *Zanchius* sp.) was more in unsprayed conditions as against sprayed conditions on both Bt and non-Bt cotton. During 2015, epidemics of whitefly, *Bemisia tabaci* was recorded in cotton belt of Punjab.

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

5.2.5. Rice

5.2.5.1 Seasonal abundance of predatory spiders in rice ecosystem:

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

5.2.6 Maize

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

5.2.7 Sorghum

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

UAS-Raichur: After 10 days of spray, *B. bassiana* -45 @ 1.5 ml/l was recorded minimum dead hearts (7.58/ plot) which was at par with *M. anisopliae* - 35 @ 1.5 ml/l which recorded 7.88 dead hearts per plot. Untreated control recorded 12.16/ plot dead hearts. Similar trend was noticed on 20 days after spray. Minimum tunnelling of 12.78 cm was noticed in *B. bassiana* -45 @ 1.5 ml/l and it was at par with *M. anisopliae* - 35 which recorded 15.83 cm tunnelling while untreated control recorded the highest tunnelling of 64.17 cm. The highest grain yield of 10.05 q/ha was recorded in *B. bassiana* -45 and it was at par with *M. anisopliae* - 35 which recorded 9.88 q/ha grain yield. Untreated control recorded 7.46 grain yield.

5.2.8 Pulses

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

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

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

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

5.2.9 Tropical Fruits

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

TNAU: Maximum fruit set of 3.2 fruits/inflorescence was recorded in liquid formulation of *M. anisopliae* treatment whereas the least fruit set of 2.3/inflorescence was noted in untreated check.

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

AAU-A: Regular surveys revealed that nine fields in seven villages were infested with the mealybug

MPKV: The incidence of papaya mealy bug was noticed in all districts of western Maharashtra (1.0 to 13.3%). The highest incidence of PMB (13.3%) was recorded in Sahada and Taloda tahsils of Nandurbar district. The average pest population density was relatively low during this year as compared to previous year.

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

5.2.10 Temperate Fruits

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

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

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

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

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

SKUAST: Two year investigation confirmed the superiority of *Trichogramma cacoeciae* over *T. embryophagum* with increased reduction in fruit damage. Integrated management involving one spray of Chlorpyriphos 20 EC @ 1.5 ml/lit. + sequential releases of *T. cacoeciae* + one spray of NSKE + trunk banding + disposal of infested fruits + pheromone traps resulted in 52.9% reduction in damage over control.

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

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

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

SKUAST: Average consumption of TRS eggs / nymph/day was 7.7, 9.1, 10.8 and 10.9 eggs/day in relation to predator: prey ratio of 1: 10, 1: 15: 1: 20 and 1: 25, respectively. Consumption rate of adult female of *B. pallescens* was worked out as 9.7, 11.8, 13.1 and 13.6 eggs/ day in relation to identical predator prey ratio.

5.2.11 Vegetables

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

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

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

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

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

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

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

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

MPKV: The leaf and fruit damage by pinworm was 28.6 and 12.5%, respectively, with the peak incidence being recorded in March, 2016.

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

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

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

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

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

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

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

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

PAU: BIPM module consisting release of *T. chilonis* @ 50,000 parasitoids/ha followed by spraying of NSKE 5% and *B. thuringiensis* @ 1 lit/ha twice at weekly interval was the next best treatment showing with 278.4 q/ha yield after treatment having three sprays of profenophos 0.05% at fortnightly interval .

5.2.11.7 Biological control of brinjal mealybug, *Coccidohystrix insolitus*

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

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

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

5.2.11.9 Role of habitat manipulation on natural enemies of cabbage pests

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

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

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

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

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

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

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

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

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

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

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

5.2.12 Biological suppression of polyhouse crop pests

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

TNAU: Survey on the pests of *Chrysanthemum* grown in poly house revealed occurrence of whitefly (*Bemisia tabaci*), serpentine leaf miner (*Liriomyza trifolii*) and tetranychid mite (*Tetranychus urticae*).

5.2.12.2 Evaluation of efficacy of predators against cabbage aphids in polyhouse

SKUAST: *Coccinella septempunctata* was found superior to *C. z. sillemi* in terms of pest suppression, as evident from statistically significant differences in aphid densities after second release of predators. Per cent reduction in aphid density was 76.5 and 63.1 for *C. septempunctata* and *C. z. sillemi*, respectively, over control.

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

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

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

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

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

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

5.2.13 Biological suppression of storage pests

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

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

5.2.14 Large-scale adoption of proven biocontrol technologies

5.2.14.1 Rice

AAU-J: Large scale demonstration of bio control based IPM package in rice was carried out in the farmers' field at village Borholla in Jorhat district. The incidence of dead hearts (3.4%) and damaged leaves (2.5%) due to *Cnaphalocrocis* sp. was significantly high in farmers' practice plots compared to BIPM. In case of white ear heads, the per cent incidence was 1.99 in BIPM plots, which was significantly lesser to farmers' practice plots (2.8) @ 125 DAT. Maximum yields of 4126.0 kg/ha was registered in BIPM package, which was at par with farmers' practice (3984.4 kg/ha). The population of natural enemies like spiders and coccinellids were significantly high in BIPM compared to farmers' practice.

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

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

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

5.2.14.2 Sugarcane

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

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

Large scale demonstration of effectiveness of *T. japonicum* @ 50,000/ha @ 10 days interval during mid-April to June end, 2015 (eight releases) against top borer, *Scirpophaga*

excerptalis over an area of 190 acres in collaboration with two sugar mills indicated 53.6% reduction of top borer.

5.2.14.3 Maize

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

5.2.14.4 Brinjal

OUAT: Large scale demonstration of BIPM in brinjal covering 100 acres in the village of Karatapeta in Angul district of Odisha was carried out. The shoot borer and fruit borer incidence was significantly low in BIPM plots recording 12.8 and 21.9% respectively, whereas it was 29.1 and 43.7% in farmers' practice plots. Consequently, the yield was also higher in the BIPM plots (20,321 kg/ha) with the cost: benefit ratio of 1: 5.1, whereas the yield in farmers' practice plot was 12,209 kg/ha with C: B ratio of 1: 1.22. The BIPM practice produced a net return of Rs. 162,240/- over the farmers practice.

5.2.14.5 Pea

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

5.2.15 Tribal Sub Plan Programme (TSP)

ANGRAU-Anakapalle: Organic farming of Paddy

Front line demonstrations on Paddy Organic farming techniques in 40 acres area at two villages *i.e.*, Kothavalasa and Gunjariguda, Dumbriguda mandal, Araku valley, Visakhapatnam district, Andhra Pradesh were conducted during kharif and rabi, 2015-16. About 50 farmers are successfully cultivated paddy and obtained good yields due to adoption of organic farming practices in paddy.

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

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

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

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

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

TNAU: Biocontrol methods for vegetable pest management in Tamil Nadu

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

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

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

6. Publications: During the year 2015-16, a total of **325** Research papers/symposium papers/reviews/technical bulletins, etc., were published by the different centres

Centre	Research papers in journals	Papers in Symposia/Seminars	Books/ Book Chapters /Tech. Bulletins/ Popular articles	Total
NBAIR, Bangalore	108	34	40	182
AAU, Anand	-	-	5	5
AAU, Jorhat	1	-	9	10
ANGRAU, Anakapalle	8	3	1	12
GBPUAT, Pantnagar	4	6	4	14
KAU, Thrissur	1	-	-	1
MPKV, Pune	1	1	3	5
PAU, Ludhiana	10	7	8	25
PJTSAU, Hyderabad	1	-	7	8
SKUAST, Srinagar	2	3	1	6
TNAU, Coimbatore	10	6	4	20
YSPUHF, Solan	7	5	-	12
MPUAT, Udaipur	3	-	-	3
UAS ,Raichur	-	-	2	2
IGKV , Raipur	10	-	6	16
IIVR	2	2	-	4
Total	**168**	**67**	**90**	**325**

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

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

PROCEEDINGS OF THE TECHNICAL SESSIONS

The results of the experiments from each centre were presented through six sessions. In the VI session on Institute-industry/Public private partnership, **Sri. Balbir Singh from DSCL, Sugar Lucknow and Sri. Anil Karalaman gate from Bio-Bee, Bengaluru** discussed about the critical needs of industry and the need for collaboration with research institutes. The meeting concluded with a plenary session chaired by **Dr.Abraham Verghese**, Director, NBAIR and **Dr. B. Ramanujam**, NBAIR and the Technical Programme for 2016-17 for various AICRP centers were finalized.

SESSION I: BASIC RESEARCH AT NBAIR & BIOLOGICAL CONTROL OF PLANT DISEASES

Chairman	:	Dr. P. K. Chakrabarty, ADG (PP&B), ICAR, New Delhi
Co-Chairman	:	Dr. P.V. Krishnaiah, HOD, Entomology, ANGRAU, Bapatla
Rapporteurs	:	Dr.A.N. Shylesha, NBAIR, Bangalore
		Dr. B.L. Raghunandan, AAU-Anand

Speakers and topics :

1. **Dr. Chandish R Ballal, NBAIR, Bangalore:** Biodiversity, Biosystematics, Molecular Characterization and Biocontrol potential of newer natural enemies (NBAIR)

Achievements :

- First phylogenetic study resolved a diverse and geographically realistic subset of species within the genus *Glyptapanteles* (Hymenoptera: Braconidae). A species of *Mirufens* was collected from the Nicobar Islands for the first time from leaf galls of *Dipterocarpus* sp.
- *Aphis* (*Bursaphis*) *solitaria* and *Brachycaudus* (*Brachycaudina*) *napelli*; mealybug, *viz*., *Formicococcus formicarii* and scale, *Anomalococcus crematogastri* were recorded for the first time in the country.
- Four to six releases of *Blaptostethus pallescens* against broad mites (*Polyphagotarsonemus latus*) infesting capsicum could significantly reduce the pest incidence and curling symptoms and improve the plant height.
- DNA barcodes for more than 210 insect pests, natural enemies and beneficial insects were developed.
- Severe incidence of *Tuta absoluta* was recorded in Tamil Nadu, Andhra Pradesh and Gujarat ranged from 10.0 - 64.3%. *Trichogramma achaeae* parasitized was 28.8% eggs, while *Amphiareus constrictus* and *Blaptostethus pallescens* were observed to feed on 90 to 100% of the under laboratory conditions.
- Severe outbreak of invasive leaf miner, *Chromatomyia syngenisiae* up to > 80.0% of the plants in the sampled from Coonor, Ooty and Coimbatore. No parasitoids were.
- Among the EPN species tested against house fly, *Musca domestica*, *S. carpocapsae* caused significantly greater mortality (81.2 to 100.0%).
- The trypsin activated Vip3A protein (4 hrs IPTG induction) at 500 µg concentration caused 100% mortality of *Plutella xylostella* after 48 hours. The LC_{50} value was calculated as 53.676 µg/ ml.
- In maize, significantly lower dead hearts, exit holes and stem tunneling compared to untreated control was recorded in *Beauveria bassiana* (Bb-5a isolate), which showed promise as an endophyte.

R**ecommendations :**

- The ADG (PP) reemphasized the importance for registration of entomopathogenic fungi, mainly *Metarrhizium* and *Bacillus thuringiensis* for commercialization (NBAIR).
- Dr.Viraktamath made his remarks on basic research at NBAIR and appreciated the work being carried out at the main centre and he suggested identifying strains of anthocorid bug (predator) for management of specific pests, *viz*., thrips, mites, etc.

2. **Dr. A.K. Tiwari, GBPUAT, Pantna**gar: Biological Control of Plant diseases using antagonists

Achievements :

- In rice, among different *Trichoderma* isolates tested, TCMS 9 and PBAT 3 were found effective in improving plant health, reducing sheath blight and brown spot diseases and in increasing yield. In pea, TCMS 9, PBAT 3 and PSF 173 reduced seed and plant mortality in field. In chickpea, PSF 2 and PBAT 3 were found very promising in reducing seed as well plant mortality in the field.
- Among the different biocontrol treatments tested against chilli anthracnose diseases, *Pichia guilliermondii* (Y12) seed treatment, seedling dip and foliar spray ($2x10^8$cfu ml^{-1}) was found superior to all with the minimum disease intensity (13.6%) and the maximum yield (38.2 q/ha).
- Lowest per cent of chilli fruit rot (19.2%) was recorded in chemical control, which was followed by *P. guilliermondii* (22.1%) and *Trichoderma harzianum* (24.2%) treatments. Highest yield of 67.7q / acre was recorded in chemical treatment followed by *P. guilliermondii and T. harzianum* treatments with a yield of 58.5 and 56.7q / acre, respectively.

Recommendations :

- Dr.AbrahamVerghese, Director, NBAIR suggested using consortium formulations for better efficiency of the bio-control agents.
- The ADG (PP) gave advice to take the trials to compare the quality and efficiency of the standard, commercially available bio-control agents with that of native biocontrol agents.
- The ADG (PP) highlighted the importance of molecular signatures/ fingerprinting of native biocontrol isolates for authentication and validation.

SESSION II: BIOLOGICAL SUPPRESSION OF PESTS OF SUGARCANE, COTTON, RICE, MAIZE AND SORGHUM

Chairman	:	Dr. N. V. Naidu, Director of Research, ANGRAU
Co-Chairman	:	Dr. N. Venugopala Rao, ADR, RARS, Anakapalle
Rapporteurs	:	Dr. S. M. Galande, MPKV, Pune
		Dr. Madhu Subramaiam, KAU, Thrissur

Speakers and topics :

1. **Dr. K. S. Sangha, PAU, Ludhiana** : Sugarcane and Cotton

Achievements :

- Monitoring of sugarcane woolly aphid (SWA) incidence revealed very low to patchy incidence in Punjab, Tamil Nadu and Telangana. Consequently, low populations of all natural enemies like *Encarsia flavoscutellum, Dipha aphidivora, Micromus igorotus, Eupeodes confrator* and spiders were observed.
- On cotton, significantly minimum number of jassids (0.6/leaf), whiteflies (2.5/leaf), aphids (5.2/leaf) and thrips (1.2/leaf) were registered in the treatment *Lecanicillium lecanii* @ 40 g/ 10 litre. However, none of the tested microbial insecticides found superior to chemical pesticide.
- The peak activity of *Phenacoccus solenopsis* was noticed during second week of February on cotton at Raichur (Karnataka) with an average population of 85.42 mealybugs/plant, which also coincided with the peak activity of its primary parasitoid, *Aenasius arizonensis* (18.05/plant). The peak activity of *Anagyrus dactylopii* was noticed during second fortnight of January.

Recommendations:

- Surveillance for natural enemies of whiteflies in other hosts to be carried out.
- Monitoring the populations of pink boll worm in Bt Cotton should be taken up by centres.
- Sirsa (Haryana) may also be included in surveillance for whitefly and its natural enemies by PAU.
- Recording of the abiotic parameters and agronomic calendar should be attempted to precisely identify censes of outbreak of whitefly in cotton.
- The role of the private sector in biocontrol of Sugarcane with emphasis on economic impact should be assessed.

2. **Dr. S. J. Rahman, PTSTAU, Hyderabad** : Rice, Maize and Sorghum

Achievements :

- Regular surveys to study the diversity of spiders from rice growing areas in Punjab showed that *Neoscona* sp. was the predominant species (78.11%) at all the locations followed by *Tetragnatha* sp (14.98%). Species diversity (0.867) was calculated as per Shannon-Weiner index of diversity. Species evenness (0.377) and dominance index (0.623) was worked out as per formulae given by Krebs and Southwood, respectively.
- The yield of sorghum grains in the experimental plot with treatment of *Metarhizium anisopliae* (Ma 35 and Ma 36) was 4.16 and 4.25 kg/ plot, respectively as compared to control (2.85 kg/plot0, however, in carbofuran whorl application yield recorded was significantly superior (4.32 kg/plot), but was on par with the strain *M. anisopliae* treatments.

Recommendations : Nil

SESSION III. BIOLOGICAL SUPPRESSION OF PESTS OF PULSES, OILSEEDS AND COCONUT

Chairman	:	Dr. C.A. Viraktamath, Chairman, RAC, NBAIR
Co-Chairperson	:	Dr. Chandish R. Ballal, HOD, NBAIR
Rapporteurs	:	Dr. Arun Kumar Hosamani, UAS- Raichur
		Dr. P.S. Shera, PAU, Ludhiana

Speakers and topics :

1. **Dr. N. Sridharan, TNAU, Coimbatore** : Pulses and Oilseeds

Achievements :

- At Punjab, PDBC-BT1 (2%) and Delfin (1 or 2 kg /ha) treatments gave the lowest pod damage by *Helicoverpa armigera* and *Maruca testulalis* in moong bean, which were at par with each other, followed by chlorpyriphos 20 EC @ 1.5 l/acre.
- Lower incidence of *H. armigera* larvae (0.5 to 0.6 /plant), damage on pod (6.8 to 7.6%) and grain (8.0 to 10.0%) were noticed in NBAII liquid formulation Bt formulations on pigeon pea as against farmers' practices in anand, Gujarat.

Recommendations:

- NBAII BTG4 is performing better in red gram ecosystem against pod borers and economically feasible. Hence, house suggested to recommend the NBAII BTG4 and the technology may be shared / passed to NCIPM, New Delhi.
- In mungbean, BIPM was effective and the house suggested to workout the cost benefit ratio.
- The trial on mustard aphid may be implemented wherever the incidence is more and four centres, *viz.*, PAU, Ludhiana; MPAUT, Udaipur; AAU, Anand and OUAT, Odisha, were identified to implement the trial.

2. **Dr. P. Venkateswarlu, CTRI, Guntur** : Tobacco

Recommendations:

- In tobacco BIPM, apart from aphids the data may be generated on incidence of other pests, *viz*., whitefly and viruses.

3. **Dr. Madhu Subramainam, KAU, Trichur** : Coconut

Recommendations:

- Comparisionof performance of EPN against red palm weevil should be made with *H. indica* of NBAIR with that of local isolate of the same species instead of comparing with *H.bactriophora.*
- KAU, Trichur, to take up the EPN evaluation against red palm weevil in Kerala.
- CPCRI, Kayamkulam, can continue to do the surveillance of pests and invasive.

SESSION IV: BIOLOGICAL SUPPRESSION OF PESTS OF FRUITS AND VEGETABLE CROPS, POLYHOUSE CROP PESTS, STORAGE PESTS AND WEEDS

Chairman	:	Dr. T. Ramesh Babu, Dean, Agriculture, ANGRAU
Co-Chairperson	:	Dr. Sujatha, Associate Dean, DRYSRHU
Rapporteurs	:	Dr. A. Saravanan, TNAU, Coimbatore
		Dr. Joydeep Haldar, IIVR, Varanasi

Speakers and topics :

1. **Dr. Jamal Ahmad, SKUAST, Srinagar** : Tropical and Temperate Fruits, & Mealybugs

Achievements:

Mango

- Maximum fruit set of 3.2 fruits/inflorescence was recorded in liquid formulation of *M. anisopliae* (1 ml/2L) of IIHR strain treatment whereas the least fruit set of 2.3/inflorescence was noted in untreated check. Though superior performance of imidacloprid in checking the hopper population was noted, the fruit set was comparable with *M. anisopliae* liquid formulation. The order of efficacy among the different formulations of *M. anisopliae* in checking the hopper population was liquid formulations > talc formulation > oil formulation (TNAU).

Papaya

- Regular surveys to monitor *Paracoccus marginatus* in papaya growing areas of middle Gujarat revealed that nine fields in seven villages were infested with the papaya mealybug (AAU-A).
- The incidence of papaya mealy bug was noticed in all districts of western Maharashtra (1.0 to 13.3%). The highest incidence of PMB (13.3%) was recorded in Sahada and Taloda tahsils of Nandurbar district. However, *Acerophagus papaya*, *Pseudleptomastix mexicana* and *Spalgis epius* was found associated with PMB. The average pest population density was relatively low during this year as compared to previous year (MPKV).
- Among the eight districts surveyed, maximum incidence and prevalence was noted in Erode district followed by Tirupur and Coimbatore. The incidence was noticed from April 2015 which escalated to a maximum of 8.6% in August 2015 (Erode) followed 7.4% in September 2015 (Erode). The occurrence of mealybug was absent in November and December, 2015 (TNAU).
- In Kerala, survey showed that the parasitoid established very well in Kerala. Stray incidences of PMB infestations were observed in two locations in Thrissur district (KAU).
- Incidence of papaya mealybug was recorded below pest level in all the areas surveyed. A high level of parasitization was recorded in all the samples collected. Parasitization of *Acerophagus papayae* by hyper parasitoids is increasing in Karnataka. The samples collected from Nelamangala, Chamarajnagar, and Maddur had 6-7% hyperparasitization by *Chartocerus sp*. and 2-3% by *Marietta leopardina* (NBAIR).

Citrus

- Field evaluation on bioefficacy of EPNs through stem injection @ 50 IJs/ml of water and as cadaver application against citrus trunk borer, *Pseudonemophas versteegi* was carried

out at two locations *viz.* Pasighat and Rengging of Arunachal Pradesh. Among the EPN treatments, CAU-1 stem injection (38.00% and 33.45% reduction at Pasighat and Rengging, respectively) and CAUH-1 stem injection (32.50% and 34.22% reduction at Pasighat and Rengging, respectively) were observed as the best treatments. The stem injections of the EPNs were found more effective than their respective cadaver treatments **(CAU)**.

Banana

- Field evaluation of two entomopathogenic fungi, namely, *Metarhizium anisopliae* and *Beauveria bassiana* for the management of the banana pseudostem borer *Odoiporus longicollis* was carried out. In all the treatments, banana pseudostem infestation was nil (KAU).

Pineapple

- Field evaluation of *Lecanicillium lecanii* against pineapple mealybug *Dysmicoccus brevipes* was carried out and it was found that imidacloprid (0.3 ml/l) with mean bug population of 1.0/plant recorded the lowest population at fifteen days after second round of treatment application and was on par with *L. lecanii* @ 10^9 spores/ml (4.67 bugs/per plant) (KAU).

Guava

- Field evaluation of IIHR liquid formulation of *Beauveria bassiana* against tea mosquito bug in Guava was carried out and it was observed that after four sprays, the fruit damage in the newly harvested fruits was 9.3% in treated trees. But in unsprayed trees, the fruit damage recorded 28.7% at the same period of observation (TNAU).

Apple

- Among different biopesticides, *Metarhizium anisopliae* (10^6 conidia/ cm^2) was the most effective resulting in 70.4% mortality of the grubs and there is no significant difference between *M. anisopliae* and chlorpyriphos (0.06%) treatment where 85.8 per cent grub mortality was recorded (YSPUHF).
- Two year investigation confirmed the superiority of *Trichogramma cacoeciae* over *T. embryophagum* with increased reduction in fruit damage. Integrated management involving one spray of Chlorpyriphos 20 EC @ 1.5 ml/lit. + sequential releases of *T. cacoeciae* + one spray of NSKE + trunk banding + disposal of infested fruits + pheromone traps resulted in 52.9% reduction in damage over control (SKUAST).
- Evaluation of predatory bug, *Blaptostethus pallescens* against European red mite (ERM), *Panonychus ulmi* on apple was carried out. Average consumption of ERM eggs / nymph/day was 4.7, 6.2, 8.9 and 9.2 in relation to predator: prey ratio of 1: 5, 1: 10, 1: 15 and 1: 20, respectively. Consumption rate of adult female of *B. pallescens* was worked out as 5.0, 8.7, 11.6 and 11.9 eggs of ERM/ day in relation to identical predator prey ratio. Difference in fecundity potential between nymphs and adults was found statistically significant (**SKUAST).**
- Field evaluation of anthocorid bug, *Blaptostethus pallescens* against two spotted red spider mite (TRS), *Tetranychus urticae* on apple was carried out. Average consumption of TRS eggs / nymph/day was 7.7, 9.1, 10.8 and 10.9 eggs/day in relation to predator: prey ratio of 1: 10, 1: 15: 1: 20 and 1: 25, respectively. Positive correlation between feeding and predator density was observed both in nymphs (r= 0.91**) as well as adult females (r= 0.89**). Difference between rate of consumption between nymphs and adults was worked out to be statistically significant (**SKUAST)**.

Mealybugs

- Survey was made in the agroecosystem in and around Bhubaneswar during *kharif* and *rabi* of 2015-16 for the host range and biocontrol agents of *Phenacoccus solenopsis* (OUAT*).*

- Extensive surveys were conducted in and around Varanasi revealed the occurrence of two mealy bug species *viz*., *Phenacoccus solenopsis* (Tinsley) and *Centrococcus insolitus* (Green) (Pseudococcidae: Homoptera) infesting major vegetables from April, 2015 to March, 2016 (IIVR).

Recommendations:

- It is suggested that all AICRP Centres should mass multiply the locally available important natural enemies. They also should impart training to KVKs, NGOs and Self Help Groups (SHG).
- Economics of most effective natural enemies should be worked out.

2. **Dr. Jaydeep Haldar, IIVR, Varanasi** : Vegetables

Achievement:

Tomato

- BIPM package and chemical control treatments were equally effective in reducing the sucking pests and *Helicoverpa armigera*. The highest yield was recorded in BIPM package (291.9 q/ ha), followed by chemical control plot (287.0 q/ha) (AAU-J).
- Among different biocontrol agents/bio-pesticide evaluated against the greenhouse whitefly, Azadirachtin (1500 ppm; 3 ml/L) was the most effective resulting in 60.2 per cent reduction in the whitefly nymph population over control which was, however, statistically on par with *Lecanicillium lecanii* (5 g/L of 10^8 conidia/g) and *Chrysoperla* (1 larva/plant) where the reduction was 57 and 50%, respectively (YSPUHF).
- The population of sucking pests and fruit borer damage were significantly low in BIPM plot as compared to plots of farmer's practice with four insecticide sprays. The cost to benefit ratio recorded 1:3.2 in BIPM plot was superior as compared to farmer's practice which involved four insecticide sprays and showed 1: 2.7 (TNAU).
- IPM module comprised of five weekly releases of *T. chilonis* @ 1 lakh/ha followed with 2 sprays of *Ha* NPV, resulted that the fruit damage was significantly low in IPM modules (13.8%) as against 20.6% fruit damage observed in farmer' practice fields. The yield observed in IPM module was higher (232.34 q/ha) (MPUAT).
- The incidence of *T. absoluta* to the tune of 8.0 to 90.0% (AAU-A). The leaf and fruit damage by pinworm was 28.6 and 12.5%, respectively, with the peak incidence being recorded in March, 2016 (MPKV). The peak activity of pin worm was observed during second fortnight of January with the highest moth traps (2221.1 moths/ trap) (UAS-R). *T. absoluta* was recorded on tomato leaves, flowers, terminal shoots and fruits at Nauni, Solan. Mirid bug, *Nesidiocoris tenuis* (Reuter) (Hemiptera: Miridae) was found associated with the pest (YSPUHF).
- Among the different biological control agents evaluated, *Metarhizium anisopliae* @ 1.5 ml/l was the most effective one with the minimum number of larvae (2.9 larvae/ top five leaves) and fruit damage (5.3%). The highest fruit yield (25.8 t/ha) was also recorded on *Metarhizium anisopliae* @ 1.5 ml/l (UAS-R).

Brinjal

- The experiment on biological control of brinjal mealybug, *Coccidohystrix insolitus* was carried out. The insecticide treated plot showed minimum number of mealybug per plant (1.4) after 15 days of first spray and 1.8 mealybugs/ plant after 15 days of second spray with an yield of 70 t/ha. The next best treatment was release of

Cryptolaemus @ 1500/ha with a population of mealybugs of 32.4/plant after 15 days of 1st release and 5.3/plant after 15 days of second release with yield of 67.8 t/ha. Highest number of predators were found in the treatment with *Cryptolaemus* @ 1500/ha (5.3 and 8.6/10 plants after 1st and 2nd release, respectively) (TNAU).

- Different BIPM modules were validated against shoot and fruit borer, *Leucinodes orbonalis* in brinjal. Three sprays of profenophos 0.05% at fortnightly interval was effective with the least shoot damage (5.2%) and fruit damage (7.1%) and gave maximum yield (313.9 q/ha). However, the BIPM module consisting release of *T. chilonis* @ 50,000 parasitoids/ha followed by spraying of NSKE 5% and *B. thuringiensis* @ 1 lit/ha twice at weekly interval was the next best treatment showing with 278.4 q/ha yield (PAU).
- The damage of shoots (9.5%) and fruits (17.7%) caused by *Leucinodes orbanalis* was minimum in BIPM package as compared to chemical control plots (13.0 and 20.0%, respectively). The yield of BIPM package was 203.5 q/ha as against 208.7 q/ha in chemical control plot and both were found to be on par with each other (AAU-A).
- A field trial to evaluate the EPN formulations of NBAIR against ash weevil in brinjal was conducted. The reduction of adult weevil population over control was maximum (84.06%) in chlorpyriphos drenching followed by soil application of EPN along with *Metarhizium anisopliae* IPL (International Panacea Limited) formulation (76.36%) followed *Metarhizium anisopliae* NBAIR formulation (74.32%) (TNAU).

Cabbage

- Role of habitat manipulation on natural enemies of cabbage pests was studied. Minimum larval population of *Plutella xyllostella* (1.90/plant) and maximum number of coccinelids (1.77/plant) were observed in cabbage intercropped with mustard and cowpea, with highest yield of 174.9 q/ha (AAU-J).

Cauliflower

- Three rounds of *Bt* strains of PDBC BT1 and NBAII BTG 4 were applied as 1 and 2% concentrations at 15 days interval. After three rounds of spraying, the *Bt* strains were able to reduce the larval population of DBM up to 84.0% (NBAII BTG 4 @ 2%) as compared to 90.0% reduction of larval population in insecticide treated plot. The curd yield was maximum in insecticide treated plot (12.4 t/ha) as compared to 11.3 to 11.9 t/ha in *Bt* strains treated plots (TNAU).

Chilli

- Among all the entomopathogens, *Beauveria bassiana* (Bb-83) IIVR strain was found most promising against yellow mites with highest per cent reduction (44.34%) over the control followed by *Metarhizium anisopliae* (Ma-35) NBAIR strain (39.41 PROC). However, amongst all the treatments, Imidacloprid was the best with highest PROC (49.75) and lowest mites population (3.06 / leaf). Similar trend was followed in case of thrips (IIVR).
- The mean population of *Aphis gossypi* and *Scirtothrips dorsalis* was 6.3 and 2.7% /10 leaves in imidacloprid treated plot followed by NBAIR Bb 5a strain with 8.0 and 3.6/ 10 leaves after third spray. Highest yield of hot chilli (50.7 q/ha) was recorded in imidacloprid @ 20 g a.i/ha treated plot. This was followed by NBAIR-Bb5a with yield of 42.0 q/ha (AAU-J).

Okra

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

Cassava

- The implementation of BIPM module effectively reduced the spiralling whitefly population (86.3 whiteflies/ plant) as compared to 380.5 whiteflies/ plant in insecticide sprays (TNAU).

Capsicum

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

Recommendations:

- All the AICRP Centres should indicate the Azadirachtin concentration of neem formulation avoiding commercial or trade names. Avoid local recommendations like NSKE.

3. **Dr. P. L. Sharma, YSPUHF, Solan** : Polyhouse Crop & Storage pest Biocontrol

Achievement

Polyhouse crop pest

- *Coccinella septempunctata* was found superior to *C. z. sillemi* in terms of cabbage aphid suppression. Per cent reduction in aphid density was 76.5 and 63.1 for *C. septempunctata* and *C. z. sillemi*, respectively, over control (SKUAST).
- Release of predatory mite, *N. longispinosus* at 1: 10 predator: prey ratio resulted in 74.2% reduction of mite population over control, which was on par with fenazaquin (0.0025%) treatment resulting 85.2% reduction of mites (YSPUHF).
- Azadirachtin (1500 ppm; 3 ml/L) resulted in the highest reduction (79.9%) in rose aphid population over control followed by *Coccinella septempunctata* (68.8% reduction) when released @ 10 beetels/plant (YSPUHF).
- Four releases of preadatory mites @ 10 per plant at weekly interval and three sprays of *H. thomsonii* (1 x 10^8 conidia/g) @ 5 g/litre were the best treatments after abamectin showing average 18.22 and 20.89 mites/ 10 compound leaves/ rose plant, respectively (MPKV).
- The release of *B. pallescens* @ 30 nymphs/ m row was found to be the most effective in suppressing the spider mite population (7.7 mites /plant) in okra and it was statistically at par with chemical control (4.2 mites/ plant) (PAU).
- Among predator treatments, the release of *B. pallescens* at 30 nymphs/m row was found in suppression of spide mite population (1/sq. cm) after 15 DAR in cucumber which was similar to chemical control (NCIPM).

Storage pest

- The results of evaluation of *Uscana* sp. (Trichogrammatidae) against *Callosobruchus* sp. the experiments showed that the highest parasitism of 42% and lowest seed infestation was observed in the treatment (*Uscana* sp. 40 were released). The germination of pigeon pea seeds was highest in the treatment of *Uscana* sp. 40 released (82.33%) compared to 75% seed germination in control (Dir. Seed research).

Recommendations:

- OUAT Bhubaneshwar centre agreed to take up the experiment on *Uscana* sp. on *Callosobruchus* on pulses.

SESSION V: TRIBAL SUB PLAN PROGRAMME

Chairman : Dr. Abraham Vergese, Director, NBAIR, Bangalore
Co-Chairman : Dr. B. Ramanujam, NBAIR, Bangalore

Speakers and topics :

Presentation on achievements of Tribal Sub Plan programme

1. **Dr. M. Visalakshi, ANGRAU, RARS, Anakapalle**

Achievement

- Farmers of Panchmahal and Mahisagar districts of Gujarat were provided with *Trichoderma viride*, pheromone traps and neem based azadirachtin formulation as inputs to manage the pests and diseases. With the use of biocontrol based IPM techniques in pigeon pea, an increase of 15-20% yield and decrease in pest and disease incidence by 60-70% was recorded (AAU-A) .
- Arakuvalley Tribal Farmers with small land holdings of half an acre to one acre are benefited by conducting Front line demonstrations on Paddy Organic farming techniques in 40 acres area at two villages *i.e*., Kothavalasa and Gunjariguda, Dumbriguda mandal, Araku valley, Visakhapatnam district. Supplied the paddy variety 2 kg per each farmer; issued *Pseudomonas flourescens* @ 250 g/ 30 kg seeds/acre. Conducted method demonstration on seed treatment with *P. flourescens* for @ 5 g/kg seed, Issued liquid Biofertilizers – *Azospirillum* and Phosphobacteria @ 500 ml per farmer. Trichocards (*Trichogramma chilonis*) for 4 releases @ 40,000 egg parasitoids per acre were also supplied. Tribal farmers realized the use of biofertilizers application with good tillering and more productive tillers (8-10 tillers/hill). Organic farming FLD farmers recorded higher yields (4025 kg/ ha) compared to 2100 kg/ha in farmers practice of without using fertilizer application and plant protection (ANGRAU, Anakapalle).
- TSP was implemented in three villages (Poh, Tabo & Lari) in the Lahaul and Spiti district of Himachal Pradesh. 150 tribal farmers cultivating apple, apricot, peas, beans, cauliflower and cabbage in area of 275 ha were benefited. Inputs like, *Metarhizium anisopliae*, Yellow sticky traps, Blue sticky traps, Azadirachtin, *Helicoverpa* pheromone lure, *Spodoptera* pheromone lure, DBM pheromone lure, *Trichoderma viridae* and *Pseudomonas* were provided. Training to these farmers were provided and exposed to the use of biopesticides for pest management for the first time. On peas, beans and cole crops there was a reduction of 2-3 sprays of chemical pesticides (YSPUHF).
- Tribal dominating areas of Harsul and Daltpatpur in the Taluka Trimbak of Nasik district in Maharashtra were selected for implementation TSP. The inputs like biofertilizers, bio pesticides (*Trichoderma*, *Paecilomyces*, *Pseudomonas*, *Metarhizium anisopliae*, *Lecaniicillium lecanii*, *Beauveria bassiana*, fruit fly and yellow sticky traps were supplied to fifty selected tribal farmers. A participatory

demonstration of technology was organized Dalpatpur, Trimbakeshwar, Nashik, wherein farmers were exposed to enriching of FYM with biofertizers and biopesticides and use of *Pseudomonas, Metarhizium anisopliae* in the fruit trees. The total farmers covered were 120 and training was imparted to 150 farmers and area covered was 150 acres (MPKV).

- Under the TSP, three trainings to tribal farmers were organised during the period under report. In Kolli hills of Namakkal district, thirty tribal farmers were trained on the establishment of kitchen garden and its utility on nutritional security with free supply of vegetable seeds and other inputs. They were explained about the bio intensive pest management of vegetable crop to obtain pesticide-free vegetables. Demonstrations were carried out to explain the preparation of neem oil emulsion, neem seed kernel extract, seed treatment, use of sticky traps, pheromone traps and release of tricho cards, *Chrysoperla* and *Cryptolaemus* predators. The total beneficiaries were 90 farmers at Kolli Hills, Bargur Hills and at Pokkapuram (TNAU).

Recommendations:

1. Tricho cards of *Trichogramma chilonis* and *T. japonicum* should be supplied.
2. Economics and Cost Benefit Ratio has to workout
3. ICAR will give more budgets for TSP if AICRP Centres require and funds possibly can be released by June.

SESSION –VI: INSTITUTE - INDUSTRY PARTNERSHIP

Chairman	:	Dr.K.Raja Reddy, Director of Extension, ANGRAU
Co-Chairman	:	Dr. B. Ramanujam, NBAIR, Bangalore

Speakers and topics :

1. Mr. Balbir Singh, DSCL Sugars, Lucknow
2. Mr. Anil Karalaman gate from Bio-bee, Bengaluru.

These points emerged from discussion

- Technical assistant to Industry pele is required.
- Local production must not be discouraged in view of efforts of importation by multinational production units.

General Recommendations:

- Technical proposal may be submitted by YSR Horticultural University, Ambajipeta; RARS, Kumarakam; College of Agri. Velleyani; Department of Agi., Vadakehnchery to be included as AICRP-BC Voluntary centre / Co-opted centre.
- Dr. Rana informed house that next workshop can be orgniazed at MPUAT, Udiapur, which was accepted by the house.
- In all field trials recommended fertilizer dosages as per soil fertility map of each state should be used. The information can be obtained from the Director, ICAR-NBSS&LUP, Nagpur & the Director, ICAR-IISS, Nagpur. This is for very strict compliance.

Technical Programme for different centers of AICRP on Biological Control of Crop Pests & for the year 2016-17 is given below.

Annexure-II

Centre-wise Technical Programme-2016-17

Centre	Projects									
	1	2	3	4	5	6	7	8	9	10
AAU-A	Biodiversity-Spiders & EPN mapping	Biological control of chilli anthracnose	Bio-efficacy of microbial insecticides against sucking pest in *Bt* cotton	Large scale demonstration of NBAII liquid formulations (PDBC-BT1 and NBAIR-BTG4) against pigeon pea pod borer (*Helicoverpa armigera*)	Large scale demonstration of BIPM technology for management of *Helicoverpa armigera* in tomato	Survey and monitoring of papaya mealybug *Paracoccus marginatus*	Bio efficacy of microbial insecticide against *Spodoptera litura in* cabbage	TSP on Biocontrol Technologies for Management of *Fusarium* wilt in chick pea /pigeon pea	Survey of *Tuta absoluta* in solaneceous crops	Biological suppression of mustard aphid, *Lipaphis erysimi* **(New) (2016-17)**
	Biological suppression of American pinworm, *Tuta absoluta* on tomato									
AAU-J	Biodiversity of *Trichogramma, Chrysoperla* and *Coccinellids*	Evaluation of entomopthogenic Fungi (EPF) against sucking pests of chillies	Demonstration of bio intensive package for the pest of tomato	Evaluation of *B. bassiana* against tea mosquito bug	Large scale demonstration of proven biocontrol technologies in rice	Role of habitat manupulation on natural enemies of cabbage pest	Development of Bio-control base IPM module against *Leucinodes orbanalis* of Brinjal	Survey of *Tuta absoluta* in solaneceous crops	Field demonstration of BIPM package for the management of key pests of Tomato	
ANGRAU Anakapalle	Biodiversity of natural enemies of Sugarcane, Rice and Maize pests.	IPM module for the sustainable management of early shoot borer (*Chilo infuscatellus*) and internode borer (*Chilo sacchariphagusindicus*) in sugarcane:	Management of White grub, *Holotrichia consanguinea*Blanch in sugarcane using Bioagents.	Bioefficacy of (EPF) and ento mopathogenic Nematodes (EPN) in suppression of termite incidence in sugarcane	Bio suppression of *Chilo partellus* with *Trichogramma chilonis* on rabi Maize.	Evaluation of NBAII entomop athogenic strains against maize stem borer	Tribal Sub Plan Technology adopted Organic Paddy cultivation	Evaluation of NBAIR entomopathogenic strains against sugarcane stem borer	Popularization of Eco friendly Biocontrol for pest management in paddy, sugarcane and maize	Evaluation of *Trichogramma chilonis* (Temparature tolerant strain) for the management of stem borer in paddy and shoot borers in sugarcane

ANGRAU Anakapalle	*Trichogramma chilonis* production on Eri silkworm eggs in laboratory and in Tribal areas (n									
GBPUAT	Biological control of chilli anthracnose	Field evaluation of promising *Trichoderma /Pseudomonas/Bacillus* isolates for the management of soil-borne diseases and improved crop growth of Rice, Pea and Chickpea	Large scale demonstration of Biocontrol technologies in rice & pea	Evaluation of potential isolates of *Trichoderma*, *Pseudomonas* and *Bacillus* for the management of pre & post-emergence damping-off and improved growth in Vegetable Nursery beds.	Molecular signature of promising *Trichoderma* isolates validated under AICRP biological control at Pantnagar. **(New) (2016-17)**	Development of consortium using promising *Trichoderma* and *Pseudomonas* isolates in vitro compatibility testing. **(New) (2016-17)**				
KAU Thrissur	Biodiversity of Natural enemies of Banana Weevil & Aphid, root mealy bugs of pepper	Laboratory and Field evaluation of EPF against Rice Gundhi bug	Laboratory evaluation of EPF against pepper root mealy bug *Formicoccus polysperes*	Monitoring invasive mealybugs on major horticultural crops	Field evaluation of EPF against banana Pseudostem weevil	Field evaluation of EPF against pineapple Mealy bugs	Laboratory evaluation of EPF against banana root mealybug- *Geococcus citrinus*	Large scale demonstration of proven biocontrol technologies in rice	Survey and surveillance for natural enemies of South American Pin Worm Tuta absoluta	Entomopathogenic nematodes for management of Red palm weevil (*Rhynchophorus ferrugineus)* (**New) (2016-17)**
MPKV	Biodiversity of Biocontrol agents from various agro-ecological zones	Monitoring the sugarcane woolly aphid incidence and impact assessment of natural enemies on its bio suppression	Monitoring biodiversity and outbreaks of invasive mealy bugs on cotton	Monitoring biodiversity and outbreaks of sap sucking pests including, mirids and their natural enemies in *Bt* cotton	Monitoring& record of Papaya Mealy bug & natural enemies on alternate hosts	Biological suppression of American pinworm, *Tuta absoluta* on tomato	Biological suppression of sap sucking pests on Bt cotton	Biological suppression of shoot and fruit borer, *Leucinodes orbonalis* iin brinjal	Biological suppression of fruit borer, *Earias vitella* in okra	TSP on Management of insect pests and diseases in horticultural plantation in tribal area
MPKV	Survey and Surveillance of natural enemies of pin worm, *Tuta*	Biological management of red spider mite *Tetranychus*								

	absoluta on tomato	*urticae* in rose in polyhouse conditions								
PAU	Diversity of biocontrol agents from various agro-ecological zones& EPN mapping Isolation of entomopathogens from soil samples collected from different districts of Punjab	Screening of temperature tolerance in cotton mealy bug parasitoid, *Aenasius arizonenesis* (Girault) (=*bambawalei* Hayat)	Monitoring biodiversity and outbreaks of sap sucking pests including, mirids and their natural enemies in *Bt* cotton	Seasonal abundance of Rice – Predatory Spiders	Evaluation of microbial agents for management of Lepidopteran pests on Moong bean (*Spodoptera litura, Helicoverpa armigera*)	Validation of different BIPM modules against shoot and fruit borer, *Leucinodes orbonalis* in brinjal	Field evaluation of IPM Module for cabbage pests	Survey and surveillance of natural enemies of Pin worm, *Tuta absoluta* on tomato	Evaluation of anthocorid predators against spider mites, *Tetranychus urticae* under insect net cage condition (Brinjal, Chilli, Okra)	Evaluation of EPF against spider mite, *T. urticae* on capsicum /bell pepper under protected condition
PAU	Large scale demonstration of proven biocontrol technologies in basmati rice	Large scale demonstration of proven biocontrol technologies against sugarcane stalk borer *Chilo auricilius*	Large scale demonstration against maize stem borer with *T. chilonis* & *Cotesia flavites*	Evaluation of promising biocontrol agents against chilli anthracnose disease	Large scale demonstrations of proven biocontrol technologies against sugarcane early shoot borer, *Chilo infuscatellus*	Large scale demonstration of proven biocontrol technologies against sugarcane top borer, *Scirpophaga excerptalis*	Natural enemy complex of yellow rice stem borer and leaf folder	Diversity of insect pests and their natural enemies in organic and conventional rice	Diversity of sucking pests, bollworms and their natural enemies in transgenic *Bt* and non- *Bt* cotton	Monitoring of whitefly, its natural enemies and pink boll worm in cotton including Sirsa (**New) (2016-17)**
PAU	Biological suppression of mustard aphid, *Lipaphis erysimi* **New) (2016-17)**	Habitat manipulation for the management of *Bemisia tabaci* (Gennadius) on cotton.**(New) (2016-17)**								
PJTSAU	Survey, collection and diversity analysis of *Trichogramma, Chrysoperla, Goniozus* and *Braconid* species, *Cryptolaemus*, Spiders, entomopathogens from Telengana state.	Monitoring the sugarcane woolly aphid incidence and impact assessment of natural enemies on its bio suppression	Monitoring biodiversity and outbreaks for invasive mealy bugs on cotton Survey for incidence of mealy bugs on cotton and collection of their natural enemies.	Monitoring the biodiversity and outbreaks of sap sucking pests, mirids and their natural enemies in *Bt* cotton ecosystem	Evaluation of NBAII entomopathogenic strains against maize stem borer	Survey and Surveillance of Natural enemies of Pin Worm, *Tuta absoluta* on Tomato	Biological suppression of American pinworm, *Tuta absoluta* on tomato			

SKUAST	Biodiversity of Natural enemies of pests of apple apricot, plum, pear, peach, cherry, walnut & almonds	Survey for identification of suitable natural enemies of codling moth	Field evaluation of *Trichogramma embryophagum* and *T. cacoeciae* against Codling moth, *Cydia pomonella* on apple	Evaluation of predatory bug, *Blaptostethus pallescens* against European Red mite *Panonychus ulmi* on apple)	Survey and Surveillance of Ne's of Pin Worm, *Tuta absoluta* on Tomato :	Laboratory evaluation of feeding potential of *Chrysoperla infernalis* against *Lecanium* scale on plum	Field evaluation of anthocorid bug, *Blaptostethus pallescens* against two spotted spider mite, *Tetranychus urticae* on apple		,	
TNAU	Survey and collection of natural enemies of different crop pests, *Trichogramma, Chrysoperla, and Cryptolaemus*	Monitoring of sugarcane woolly aphid incidence and impact assessment of natural enemies on its bio suppression	Monitoring the diversity and outbreaks for invasive mealy bug and other sap sucking pests on Cotton	Monitoring and record of incidence of papaya mealy bug and its natural enemies on papaya and other alternate hosts	Monitoring the invasive South American tomato pinworm, *Tuta absoluta*	Monitoring the diversity of pests and natural enemies in Chrysanthemum under polyhouse conditions	Bio-efficacy evaluation of EPN formulations of NBAIR against ash weevil in brinjal	Biological control of brinjal mealy bug *Coccidohystrix insolitus*	Field demonstration of BIPM to check the major pests of curryleaf	Tribal sub plan
TNAU	Evaluation of Bio-intensive IPM module against *Aleurodicus solenopsi* on cassava	Biological Suppression of Bud Worm (*Hendeca*sis sp) and Blossom Midge (*Contarinia* sp) in Jasmine	Field evaluation of *Beauveria bassiana* liquid formulation against tea mosquito bug in Guava							
YSPUHF	Diversity of bio-control agents from various agro-ecological zones: Surveillance for alien invasive pests *Aleyrodicus digessi, Phenacoccus manihoti, Paracoccus marginatus, Phenacoccus madeirensis, Tuta*	Evaluation of EPF and EPNs for the suppression of Apple root borer, *Dorysthenes hugelii* under field conditions	Bio intensive management of insect of pests of tomato under field conditions	Survey and Surveillance of Pin Worm, *Tuta absoluta* on Tomato	Development of bio-intensive IPM package for the suppression of insect pests of capsicum under field conditions	Biological suppression of American pinworm, *Tuta absoluta* on tomato	Evaluation of biocontrol agents against sap sucking insect pests of ornamental/ vegetables in poly houses	TSP on Use of ecofriendly methods of pest management for apple and vegetable crop pests		

	absoluta and others									
CAU	Management of bacterial wilt of brinjal with *P. fluorescens*	Bioefficacy of EPN against Citrus trunk borer								
OUAT	Survey for the host range, damage intensity and bio control agents of the solenopsis mealy bug in Odisha.	Large scale demonstration of BIPM in paddy.	Large scale demonstration of BIPM in brinjal.	Large scale demonstration of BIPM in sugarcane.	BIPM in okra	Demonstration on bio intensive pest management in brinjal at Kandhamal and Keonjhar districts(TSP)	Biological suppression of mustard aphid, *Lipaphis erysimi* **(New) (2016-17)**			
MPUAT	Validation of HaNPV against *H. armigera i*n tomato	Evaluation of IPM Module of Green gram	Biological suppression of mustard aphid, *Lipaphis erysimi* **(New) (2016-17)**							
UAS-R	Survey and collection of *Trichogramma*, *Chrysoperla* and *Cryptolaemus*	Monitoring biodiversity and outbreaks for invasive mealy bugs on cotton	Monitoring the biodiversity and outbreaks of sap sucking pests, mirids and their natural enemies in Bt cotton ecosystems	Biological suppression of sap sucking pests on Bt cotton	Field evaluation of NBAII entomopathogenic strains against sugarcane stem borer, *Chilo partellus* (Swinhoe) in Rabi sorghum	Demonstration of NBAII liquid formulation (PDBC) BT1 AND NBAII BTG4) against pigeon pea pod borer (*Helicoverpa armigera*)	Survey and Surveillance of Ne's of Pin Worm, *Tuta absoluta* on Tomato	Biological suppression of American pinworm, *Tuta absoluta* on tomato	Monitoring and biological suppression of pink bollworm, *Pectinophora gossypiella*	
IGKV	To study the biodiversity of bio-control agents from various Agro-ecological areas of Chhattisgarh	Monitoring the activity of adult moths through pheromone traps:-	Monitoring crop damage	Incidence of tamarind fruit and seed borer in Chhattisgarh state with their natural enemies						

IARI	To evaluate the collected *Trichogramma* strains for searching efficiency, temperature tolerance and fecundity. Breeding of better performing strains *Trichogramma chilonis* under laboratory conditions	To breed the better performing strains under laboratory conditions. Breeding of *Trichogramma chilonis* for temperature tolerance)	To carry out greenhouse/net house trials for evaluating the performance of improved *Trichogramma chilonis* strains on cole crop insect pests (viz., cauliflower and cabbage)-	-	-
IIHR	Evaluation of biological control agents against ***Tuta absoluta*** on tomato (microbial agents , egg parasitoids	Effect of Host Plants on Successful Parasitism by *Apanteles stantoni*(Hymenoptera: Braconidae) on *Diaphania indica* (Lepidoptera: Pyralidae)	Survey and monitoring of mealy bugs and their natural enemies on fruit crops **(New)(2016-17)**		-
IIVR	Survey, collection and identification of mealy bug infesting major vegetable crops and its natural enemies	Survey and Surveillance of NEs of Pin Worm, *Tuta absoluta* on Tomato	Evaluation of fungal pathogens against sucking pests of chilli	-	-
NCIPM	Evaluation of anthocorid predator, *Blaptosthetus pallescens* against spider mites in poly houses		-	-	-
IIMR	Evaluation of entomofungal formulations of *B. bassiana* and *M. anisopliae* against stem borer *Chilo partellus* (Swinhoe) in sorghum during Kharif 2015				
IIRR	Survey and collection of natural enemies of rice pests	Evaluation of *Amphiareus constrictus* an anthocorid predator, for the biocontrol of brown plant hopper *Nilparvata lugens* (Stal.) on rice			
CTRI	Bio-intensive integrated management of tobacco aphid, *Myzus nicotianae* Blackman in Central Black Soils of Andhra Pradesh				
CPCRI	Bio-suppression of red palm weevil through entomopathogenic nematodes				

CISH	Entomopathogenic fungi *Beauveria bassiana* infesting guava bark eating caterpillar, *Inderbela* sp. from different locations in Uttar Pradesh.				
KAU Vellayani	Effect of biopesticides for the management of Moringa stem borer *Batocera rufomaculata in* Moringa (**New)(2016-17)**	Effect of biopesticides for the management of Mango hopper, pests *Idioscopus* spp in field condition (**New)(2016-17)**	Effect of biopesticides for the management of shoot and fruit borers, *Earias vitella* in Bhindi (**New)(2016-17)**	Effect of biopesticides for the management of fruit and shoot borers, *Leucinodes orbonalis* in Brinjal (**New)(2016-17)**	Effect of biopesticides for the management of Pseudostem borer, *Odoiporus longicollis* in Banana (**New)(2016-17)**
KAU Vellayani	Effect of biopesticides for the management of Mango shoot webber, pests *Orthaga* spp in field condition (**New)(2016-17)**				
KAU, RARS Kumarakom	Monitoring diversity of pests and natural enemies of yard long bean (*Vigna unguiculata*) under poly house conditions and their management **(New) (2016-17)**	Evaluation of potential isolates of *Pseudomonas, Trichoderma, Bacillus* and microbial consortia against major diseases of cowpea **(New)(2016-17)**			
DRYSRHU Venkataramannagudem	Survey, Collection and Identification of natural enemies from Mango Ecosystem in coastal Andhra Pradesh and field evaluation of bio pesticide formulations against mango hoppers **(New)(2016-17)**	Evaluation of microbial insecticides against aphids of cole crop (*viz.*, cauliflower / cabbage) in green house **(New)(2016-17)**			

TECHNICAL PROGRAMME 2016-17

I. BIODIVERSITY OF BIOCONTROL AGENTS FROM VARIOUS AGRO ECOLOGICAL ZONES

PAU: Monitoring of whitefly, its natural enemies and pink boll worm in cotton belt of Punjab including Sirsa **(**Haryana**).**

IIHR: Survey and monitoring of mealybugs and their natural enemies on fruit crops.

DRYSRHU : Survey, Collection and Identification of natural enemies from Mango Ecosystem in coastal Andhra Pradesh and field evaluation of bio pesticide formulations against mango hoppers

II. BIOLOGICAL SUPPRESSION OF PEST AND DISEASES IN FIELD

1. PLANT DISEASES AND NEMATODES

1. Molecular signature of promising *Trichoderma* isolates validated under AICRP biological control at Pantnagar (GBPUAT)

A. **Characterization of *Trichoderma* isolates using BIOLOG Microstation System**

Following steps would be applied for the identification.

a) Isolation of pure culture on Biolog media
b) Preparation of inoculum at specified cell density
c) **Inoculation and incubation of microplate:** Specified amount of cell suspension would be pipetted into the microplate and incubated under the same conditions of temperature and atmosphere used to culture the microorganism.
d) **Reading the microplate and identification of *Trichoderma* isolates up to species level:** After an appropriate incubation time, microplates would be read either by eye or using the microstation reader. In either case, the pattern formed in the wells would be entered into the software, which searches the database and identify the *Trichoderma* isolates up to species level

B. Molecular Characterization of *Trichoderma* isolates using ITS markers

C.

a) **Extraction of fungal DNA:** CTAB method to be used for DNA extraction
b) **Quantification and characterization of genomic DNA:** The highly conserved internal transcribed spacer (ITS) regions of the rDNA would be used for the amplification and characterization.

2. Development of consortium using promising *Trichoderma* and *Pseudomonas* isolates - in vitro compatibility testing. (GBPUAT)

Treatment:

i. TCMS 9 + Psf 2
ii. TCMS 36 + Psf2
iii. TCMS 43+ Psf2
iv. TCMS 36 + SBIT 32
v. TCMS 36+TCMS 43
vi. TCMS 9+ TCMS 36
vii. TCMS 9 (Control)
viii. TCMS 36 (Control)
ix. TCMS 43 (Control)
x. SBIT 32 (Control)
xi. Psf2 (Control)

Methods:

a. Dual culture studies:

Observations:

- Growth pattern, dia. of mycelia growth in dual culture as compared to lone culture.
- CFU/ 5mm discs (7 days actively growing mycelia / 5 days actively growing bacterial cells) in dual culture as compared to lone culture.

b. Preparation of consortium formulation (Talc-based)

Observations:

- Growth pattern and dia. of mycelial growth in PDA in consortium formulation as compared to lone culture
- CFU of *Trichoderma and Pseudomonas* /g powder just after preparation and at 15 days interval up to 2 months in consortium formulation as compared to lone culture

2. COTTON

1. Habitat manipulation for the management of *Bemisia tabaci* (Gennadius) on cotton (PAU)

Treatments

A. BIPM

- 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)
  - Neem oil @ 10 ml/litre
  - *Lecanicillium lecanii* (1 x 10^8) @ 10 g/litre
  - *Beauveria bassiana* (1 x 10^8) @ 10 g/litre
  - *Metarhizium anisopliae* (1 x 10^8) @ 10 g/litre

B. Farmer's practice

C. Untreated control

Plot size: 1 acre (divided into 3 blocks)

Observations:

1. Number of whitefly adults from 3 leaves (top, middle and lower canopy) at weekly interval through our the cropping season
2. The population of predators will also be recorded at weekly interval
3. Leaves infested with whitefly nymphs and pupae will be brought back to laboratory to record the emergence of parasitoids
4. The population of other sucking pests will also be recorded.
5. Seed cotton yield

3. OIL SEEDS

1. Biological suppression of mustard aphid, *Lipaphis erysimi* (PAU Ludhiana; MPAUT Udaipur; AAU Anand and OUAT Orissa)

Treatments:

T1: *Metarhizium anisopliae* (2x10^8 spores/g) @5g/litre
T2: *Lecanicillum lecanii*(2x10^8 spores/g) @5g/litre
T3:*Beauveria bassiana* (2x10^8 spores/g) @5g/litre
T4: NSKE @ 5% suspension
T5:*L. lecanii+M. anisopliae*(2x10^8 spores/g) @5g/litre
T6:Dimethoate @ 0.06% spray
T7: Control

Methodology and observations: The trial will be laid out in RBD with 3 replications.Plot size: 5x8 m; Treatment applications will be started at initial occurrence of aphid colonies. In all, three sprays will be given during evening hours at fortnightly interval.

Observations:

1.Aphid population before treatment as pre-count and post count 5, 7 and 10 days after each spray (Aphid population will be recorded on 5 cm apical twig per plant from 5 randomly selected plants per plot)
2. Record seed yield per plot.

4. COCONUT:

1. Entomopathogenic nematodes for management of Red palm weevil (*Rhynchophorus ferrugineus*) (CPCRI, KAU Thrissur (New)).

Isolation, pathogenicity studies &Field testing of EPN

Protocol:

T1: *H. indica* NBAIR strain talc formulation 100g/palm
T2: *S. carpocapsae* NBAIR strain talc formulation 100g/palm
T3: *S. abbasi* NBAIR strain talc formulation 100g/palm
T4: *H. Indica* CPCRI talc formulation 100g/palm
T5: *S. carpocapsae* CPCRI strain talc formulation 100g/palm
T6: Chemical recommendation
NBAIR to provide EPN formulations for the trials
Replications: 10 plants each
Treatments to be imposed as per the entomological requirements. Observe for infected grubs/adults 7-10 days after treatment.

5. VEGETABLES:

1. Evaluation of potential isolates of *Pseudomonas, Trichoderma, Bacillus* and microbial consortia against major diseases of cowpea (KAU, kumarakom)

Technical programme
Location : RARS, Kumarakom
Design : RBD
Variety : Lola
Replications : 5
Treatments : 6
Season : July to October and November to February

Treatments
1. *Pseudomonas fluorescens* KAU strains seed treatment (10g/kg) followed by foliar spray and soil drenching (2%) 15, 30 and 45 days of seedling emergence
2. *Trichoderma viride* KAU strains seed treatment (4g/kg) followed by foliar spray and soil drenching (2%) 15, 30 and 45 days of seedling emergence
3. 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
4. PGPM seed treatment (10g/kg) followed by foliar spray and soil drenching (2%) 15, 30 and 45 days of seedling emergence
5. Standard check- carbendazim seed treatment (2g/kg) followed by foliar spray (0.1%) 15, 30 and 45 days of seedling emergence
6. Control

Observations to be recorded
- Disease intensity
- Yield

2. Effect of biopesticides for the management of shoot and fruit borers, *Earias vitella* in Bhindi (KAU, vellayani)

Crop: bhindi
Treatments: T1 : *Beauveria bassiana ITCC6063 (KAU culture)*
T2 *Paecilomyces lilacinus ITCC 6064 (KAU culture)*
T3 : *Numurea rileyi (NBAIR culture)*
T4 *Metarhizium anisopliae (NBAIR culture)*

T5 : Neem seed kernel extract (NSKE 5%)
T6 : Malathion 0.1% (KAU POP)
T7 : check
Replication: 4

Observations:
Observation will be taken atdifferent intervals aft er application
No of borer infested fruits/ plant
Yield /plant
Natural enemies if any

3. Effect of biopesticides for the management of fruit and shoot borers, *Leucinodes orbonalis* in Brinjal (KAU, vellayani)

Treatments:
T1 : *Beauveria bassiana ITCC6063 (KAU culture)*
T2 : *Paecilomyces lilacinus ITCC6064 (KAU culture)*
T3 : Neem seed kernel extract (5%
T4 : Malathion 0.1% (KAU POP)
T5 : check
Replication: 4

Observations:
Observation will be taken at different intervals after application
No of borer infested fruits/ plant
Yield /plant
Natural enemies if any

6. TROPICAL FRUITS:

1. Effect of biopesticides for the management of Mango hopper, pests *Idioscopus* spp in field condition (KAU, vellayani)

Treatments:
T1 : *Beauveria bassiana ITCC 6063* (KAU culture)
T2 : *Metarhizium anisopliae* (NBAIR culture)
T3 : Azadirachtin0. 003%
T4 : Malathion 0.1% (KAU POP)
T5 : check
Replication: 4

Observations :
Observation will be taken at different intervals after application
No of hoppers/ inflorescence
No of hoppers/ sweep net
Natural enemies if any

2. Effect of biopesticides for the management of Mango shoot webber, pests *Orthaga* spp in field condition (KAU, vellayani)

Treatments: T1 : *Beauveria bassiana ITCC 6063* (KAU culture)
T2 : *Metarhizium anisopliae* (NBAIR culture)
T3 : Azadirachtin1%
T4 : Malathion 0.1% (KAU POP)
T5 : check
Replication: 4

Observations:

Observation will be taken at different intervals aft er application
No of webs/plant
No of larvae/web
Natural enemies if any

3. Effect of biopesticides for the management of Pseudostem borer, *Odoiporus longicollis* in Banana (KAU, vellayani)

Treatments:
T1 : *Beauveria bassiana (ITCC6063*(KAU culture)
T2 : *Metarhizium anisopliae* (NBAIR culture)
T3 : Azadirachtin 0.003%
T4 : chlorpyrifos 0.05% (KAU POP)
T5 : check
Replication: 4

Observations:

Observation will be taken at different intervals after application
borer infested plants/plot/ treatment
No of bore holes/plant
Yield /plant

4. Effect of biopesticides for the management of Moringa stem borer *Batocera rufomaculata in* Moringa (KAU, vellayani)

Treatments:
T1 : *Beauveria bassiana ITCC 6063* (KAU culture)
T2 : *Metarhizium anisopliae* (NBAIR culture)
T3 : Azadirachtin 0.003%
T5 : check
Replication: 4

Observation will be taken at different intervals after application

Observations:

No of bore holes/plant
Dead larvae /plant
Crop stand after treatment

7. BIOLOGICAL SUPPRESSION OF POLYHOUSE CROP PEST

1. Survey and documentation of pests and natural enemies of cowpea. (KAU, kumarakom)

Survey will be conducted in five polyhouses in different locations of Kottayam district at biweekly intervals and population of pests and natural enemies will be recorded as per standard procedure.

2. Evaluation of microbial agents for the management of major pests of cow pea. (KAU, kumarakom)

Location : RARS, Kumarakom
Design : RBD
Variety : Lola
Replications : 5
Treatments : 6
No. of sprays: 3 (15 days intervals)
Season : July to October and November to February

Treatments

1. *Lecanicillium lecanii* 10 gm/l(10^8 spores/ml)
2. *Lecanicillium lecanii* 10 gm/l(10^9 spores/ml)
3. *Beauveria bassiana* 10 gm/l(10^8 spores/ml)
4. *Beauveria bassiana* 10 gm/l(10^9 spores/ml)
5. Spiromesifen 22.9 SC @ 96 g ai ha^{-1}
6. Control

Observations :

1. Observation on pest and natural enemy incidence will be taken at fortnightly intervals before and after sprayings from the treated plants.
2. Yield data will also be recorded.

3. Evaluation of microbial insecticides against aphids of cole crop (*viz.*, cauliflower / cabbage) in green house (DRYSRHU)

Experimental details

Season and year **:** *Rabi* 2016
Design: RBD
Plot size: 2x5m
Treatments: 6
Replications: 4
Target pest: Aphids

Treatment details

T1 : *Beauveria bassiana* @ 5 g/ L
T2: *Metarrhizium. anisopliae* @5 g /L
T3 : *Lecanicillium lecanii* @ 5 g /L

T4 : Azadirachtin 1500 ppm @ 3 ml/L
T5 : Methyl demeton (0.025%) (chemical check)
T6 : Untreated control

Frequency of spray : At 10 days interval after initial population is observed

Observations to be recorded :
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

.

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CPCRI	Central Plantation Crops Research Institute, Kayangulam
CTRI	Central Tobacco Research Institute, Hunsur
CAU	Cental Agricultural University, Pasighat
CISH	Central Institute of Sub-Tropical Horticulture
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IARI	Indian Agricultural Research Institute, New Delhi
ICAR	Indian Council of Agricultural Research, New Delhi
IIHR	Indian Institute of Horticultural Research, Bangalore
IIMR	Indian Institute of Millet Research, Hyderabad
IIRR	Indian Institute of Rice Research, Hyderabad
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