Proceedings of the XXIX Biocontrol Workers' Group Meeting

21-22 MAY, 2020

Virtual meeting conducted by ICAR-National Bureau of Agricultural Insect Resources

Compiled and Edited by

Richa Varshney, G Sivakumar, B. Ramanujam

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AICRP on Biological Control of Crop Pests

NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES

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

Karnataka

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I wish to express my deep sense of gratitude to **Dr. Trilochan Mohapatra,** honourable Director General, Indian Council of Agricultural Research and Secretary, Department of Agricultural Research & Education, New Delhi for his address and sponsoring the XXIX AICRP-Biocontrol Workers' Group Meeting held virtually from 21-22 May 2020.

I am grateful to **Dr. T. R. Sharma,** Deputy Director General (Crop Sciences), ICAR for his address and unstinted encouragement and support. I am thankful to **Dr. Rajan** ADG (PP&B), ICAR, New Delhi, for his suggestions in strengthening the biocontrol research under AICRP-BC. I am grateful to **Dr. S. K. Jha** ADG (OP) ICAR, New Delhi**,** for attending the workshop and providing valuable suggestions.

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I place on record my gratitude to Dr. B. Ramanujam, Dr. T. Venkatesan, Dr. M. Nagesh, Dr. A. N. Shylesha Principal Scientists from ICAR- NBAIR for chairing and co-chairing different sessions.

The support extended by **Dr. G. Sivakumar,** Principal scientist and **AICRP-BC cell in-charge, and NBAIR scientists Dr. Richa Varshney, Dr. Jagadeesh Patil, Dr. M. Sampath Kumar, Dr. M. Mohan, Dr. A. Kandan, Dr.T.Venkatesan, Dr.Veeresh Kumar, Dr. G.Mahendiran, Dr. U. Amala, Dr. K. Selvaraj, Mr. Jayaram**, (Technical officer) NBAIR and **Mrs. Rekha** for compilation of the reports, proceedings of 29^{h} workshop, technical programme for the year 2020-21 & 2021-22 and in the conduct of workshop is gratefully acknowledged. Special thanks to **Dr. G. Mahendiran**, NBAIR, for designing cover pages for Annual and Project Coordinator's reports.

N. Bakthavatsalam

Bengaluru
21.08.2020

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

Venue: **Virtual meet, ICAR-National Bureau of Agricultural Insect Resources, Bengaluru**
Date: **21st and 22nd May 2020**

PROGRAMME: May 21st, 2020 (Thursday)

INAUGURATION		
10.00 -10.25 am	Welcome address & Project Coordinator's report	**Dr. Chandish R. Ballal** Project Coordinator, AICRP-BC & Director, ICAR-NBAIR, Bengaluru
10.25 - 10.35am	Remarks by	**Dr. T. R. Sharma** Deputy Director General (CS), ICAR, New Delhi
10.35 -10.55 am	Address by Chief Guest	**Dr. Trilochan Mohapatra** Secretary (DARE) & Director General (ICAR), New Delhi
10.55- 11.00 am	Vote of thanks	**Dr. G. Sivakumar,** Chairman, AICRP-BC, PC cell
PRESENTATION OF PROGRESS REPORTS		
11.00 am - 01.00 pm		**SESSION I: BASIC RESEARCH ON BIODIVERSITY AND NATURAL ENEMIESOF INSECT PESTS AT NBAIR AND BIOLOGICAL CONTROL OF PLANT DISEASES**
Chaired by		**Dr. T. R. Sharma**, DDG (CS), ICAR, New Delhi **Dr. S. K. Jalali**, Former Head (Genomic Resources), ICAR- NBAIR, Bengaluru
Rapporteurs		Dr. Jagadeesh Patil, ICAR-NBAIR, Bengaluru Dr. Neelam Joshi, PAU, Ludhiana
Speakers		
Biodiversity, Biosystematics, Molecular Characterization and Biocontrol potential of bioagents(NBAIR)		Dr. Richa Varshney, ICAR-NBAIR, Bengaluru
Biodiversity and Pest Outbreak reports		Dr. M. Sampath Kumar, ICAR-NBAIR, Bengaluru
Biological Control of Plant diseases using antagonists		Dr. Roopali Sharma, GBPUAT, Pantnagar
01.00 - 01.30 pm		LUNCH
01.30 - 02.30 pm		**SESSION II: BIOLOGICAL SUPPRESSION OF PESTS OF FRUIT, VEGETABLE CROPS AND POLYHOUSE CROP PESTS**
Chaired by		**Dr. P. K. Chakrabarty**, Member, ASRB and former ADG (PP&BS), ICAR, New Delhi **Dr. Rajan**, ADG (PP&BS), ICAR, New Delhi
Rapporteurs		Dr. Amala Udayakumar, ICAR-NBAIR, Bengaluru Dr. N. Chalapathi Rao, DRYSRUH, Ambajipeta
Speakers		
Tropical and Temperate fruits		Dr. B. R. Jayanthi Mala, ICAR-IIHR, Bengaluru
Vegetables, Polyhouse crop pests & Flowers		Dr. Jaydeep Halder, ICAR-IIVR, Varanasi

02.30 - 03.30 pm	**SESSION III: BIOLOGICAL SUPPRESSION OF PESTS OF SUGARCANE AND COTTON**
Chaired by	**Dr. H. C. Sharma**, Former Vice Chancellor, YSPUHF, Nauni, HP and Chairman, RAC, ICAR NBAIR, Bengaluru. **Dr. B. Ramanujam**, Principal Scientist, ICAR-NBAIR, Bengaluru
Rapporteurs	Dr. S. M. Galande MPKV, Pune Dr. B. L. Raghunandan, AAU, Anand
Speakers	
Sugarcane	Dr. M. Visalakshi, ANGRAU, Anakapalle
Cotton	Dr. Jeyarajan Nelson, TNAU, Coimbatore
03.30 - 04.30 pm	**SESSION IV: BIOLOGICAL SUPPRESSION OF PESTS OF RICE, MAIZE AND SORGHUM**
Chaired by	**Dr. R. J. Rabindra**, Former Director, ICAR-NBAIR, Bengaluru **Dr. A. Krishnamurthy**, Principal Scientist (Rtd.), ICAR - IIHR, Bengaluru
Rapporteurs	Dr. P. S. Shera, PAU, Ludhiana Dr. M. Sampath Kumar, ICAR-NBAIR, Bengaluru
Speakers	
Rice	Dr. Chitra Shanker, ICAR-IIRR, Hyderabad
Maize & Sorghum	Dr. Arunkumar Hosamani, UAS, Raichur
04.30 - 05.00 pm	**SESSION V: BIOLOGICAL SUPPRESSION OF PESTS OF PULSES**
Chaired by	**Dr. H. B. Singh**, Professor (Rtd.) , BHU, Varanasi **Dr.T.Venkatesan**, Principal Scientist, ICAR-NBAIR, Bengaluru
Rapporteurs	Dr. A. Kandan, ICAR-NBAIR, Bengaluru Dr. Omprakash Navik, ICAR-NBAIR, Bengaluru
Speaker	
Pulses	Dr. B. L. Raghunandan, AAU, Anand
22 May 2020 (Friday) 10.00 - 11.00 am	**SESSION VI: BIOLOGICAL SUPPRESSION OF PESTS OF OIL SEEDS AND PLANTATION CROPS**
Chaired by	**Dr. Abraham Verghese**, Former Director, ICAR- NBAIR, Bengaluru **Dr. N. Bakthavatsalam**, HOD (Germplasm Conservation & Utilization), ICAR-NBAIR, Bengaluru
Rapporteurs	Dr. K. Selvaraj, ICAR-NBAIR, Bengaluru Dr. R. N. Borkakati, AAU- Jorhat
Speakers	
Oil seeds	Dr. S. J. Rahman, PJTSAU, Hyderabad
Coconut & Tea	Dr. A. Joseph Rajkumar, ICAR-CPCRI, Kayamkulam
11.00 am - 12.00 pm	**SESSION VII. TRIBAL SUB PLAN PROGRAMME**
Chaired by	**Dr. M. J. Chandre Gowda,** Director, ICAR-ATARI, Bengaluru

	Dr. A. N. Shylesha, Principal Scientist, ICAR-NBAIR, Bengaluru
Rapporteurs	Dr. Roopali Sharma, GBPUAT, Pantnagar Dr. P. L. Sharma, YSPUHF, Solan
Speaker	
TSP of all centres	Dr. Jayalakshmi Ganguli, IGKV, Raipur
12.00 pm - 1.30 pm	**Session VIII: TECHNICAL PROGRAMME FOR 2020-21 &2021-22**
Speaker	
Technical Programme for 2020-21 & 2021-22	Dr. Jagadeesh Patil, ICAR-NBAIR, Bengaluru
Chaired by	**Dr. Chandish R. Ballal, Director**, ICAR- NBAIR, Bengaluru **Dr. S. K. Jalali**, Former HOD (Genomic Resources), ICAR- NBAIR, Bengaluru **Dr. B. Ramanujam**, ICAR-NBAIR, Bengaluru **Dr. G. Sivakumar**, ICAR-NBAIR, Bengaluru
Rapporteurs	Dr. M. Sampath Kumar, ICAR-NBAIR, Bengaluru Dr. K. Selvaraj, ICAR-NBAIR, Bengaluru Dr. Amala Udayakumar, ICAR-NBAIR, Bengaluru Dr. Richa Varshney, ICAR-NBAIR, Bengaluru
01.30 - 02.00 pm	**LUNCH**
02.00 - 03.30 pm	**SESSION IX: INSTITUTE-INDUSTRY-DEPARTMENT PARTNERSHIPS**
Panelists	**Dr. T. M. Manjunath**, Former Director, M/s. Monsanto, Bengaluru **Dr. M. S. Rao**, Principal Scientist (Rtd.), ICAR-IIHR, Bengaluru **Dr. M. Nagesh, HOD (Genomic Resources),** ICAR-NBAIR, Bengaluru
Rapporteurs	Dr. Jaydeep Halder, ICAR- IIVR, Varanasi Dr. Richa Varshney, ICAR- NBAIR, Bengaluru
Speakers	
Biocontrol based technologies	Dr.T.Venkatesan, Principal Scientist, ICAR- NBAIR, Bengaluru
Sharing of experience	Representatives from Govt. organizations & Private industries (5 minutes each) No ppt presentation 1. Dr. Sithanantham, Sun Agro, Chennai 2. Dr. Dinesh Shetty, Ponalab, Bengaluru 3. Mr.Narayanan, UPL,Chennai 4. Dr. S. K. Ghosh, Multiplex Biotech Pvt ltd Bengaluru 5. Mr.S.Kumar, Multiplex Biotech Pvt ltd Bengaluru 6. Mr.Khandelwal, Khandelwal Biofertilizers, Belgaum 7. Mr.Lakshman Dole, Godavari biofertilizers,Nashik 8. Mrs.Mini, State Biocontrol Laboratories, Thrissur,Kerala 9. Mr. Gopikrishna Veppala, Nalanda Agro Naturals,Kerala

	Concluding Remarks : Dr. T. M. Manjunath Dr. M. S. Rao Dr.M.Nagesh
03.30 - 05.00 pm	**SESSION X: Valedictory and Plenary: Presentation of recommendations and Finalization of technical programme for the year 2020-21 &2021- 22**
Presentations / recommendations of technical sessions ((I to IX)	**Chairs / Rapporteurs of sessions**
Felicitation of Retiring Scientists	**Dr. Chandish R. Ballal,** PC, AICRP-BC &**Dr. N. Bakthavatsalam**, HOD (GCU), ICAR- NBAIR
Address by Chief guests	**Dr. Rajan**, ADG (PP&BS), ICAR, New Delhi **Dr. H. C. Sharma**, Former Vice Chancellor, YSPUHF, Nauni, HP and Chairman, RAC, ICAR- NBAIR,Bengaluru **Dr. T. R.Sharma,** Deputy Director General (CS), ICAR, New Delhi
Rapporteurs	Dr. Jagadeesh Patil, ICAR- NBAIR, Bengaluru Dr. M. Sampath Kumar, ICAR-NBAIR,Bengaluru Dr. K. Selvaraj, ICAR-NBAIR, Bengaluru Dr. Amala Udayakumar, ICAR- NBAIR, Bengaluru Dr. Richa Varshney, ICAR- NBAIR, Bengaluru
Vote of Thanks	Dr. G. Sivakumar, Chairman, AICRP- BC, PC cell

INAUGURAL SESSION

DG ICAR inaugurates the Virtual XXIX Annual Workshop of All India Coordinated Research Project on Biological Control of Crop Pests organised by ICAR – NBAIR, Bengaluru

21 - 22 May, 2020, Bengaluru,Karnataka

The ICAR-National Bureau of Agricultural Insect Resources, Bengaluru organized the Virtual XXIX Annual Workshop of All India Coordinated Research Project on Biological Control of Crop Pests.

Dr(Ms) Chandish R. Ballal, Director, ICAR-NBAIR, Bengaluru &Project Coordinator, AICRP on Biological control welcomed the dignitaries and participants. She briefly presented the highlights of the project for the period 2019-20, which included the development, validation and commercialisation of promising bioagents by the project and area covered through the adoption of biocontrol modules. She also presented the monitoring and management of the recent invasive pests and preparedness to tackle the invasive attacks.

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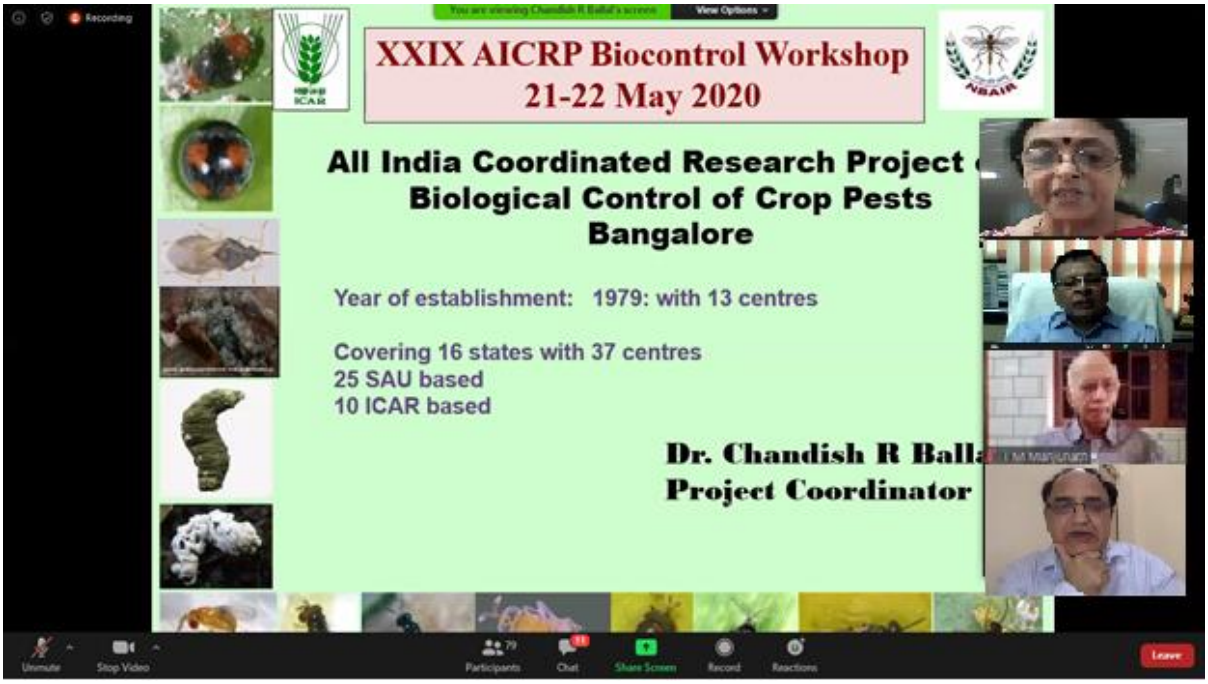

Honourable Secretary (DARE) & DG (ICAR) Dr TrilochanMohapatra inaugurated the workshop and stated that for effective implementation of programmes, half yearly workshops could be conducted on virtual platform. He appreciated the participation of representatives of private companies and requested the centres to capitalize the companies' interest. He added that the research organisations should go beyond commercialization, by strengtheningthe partnershipswith private companies to test,validate and registerthepotential biocontrol products. Measures should be explored to advise the companies to reduce pesticide applications. Government funding should be explored for generation of toxicological data to register the biopesticideproducts. Companies should be allowed to promote the products after adequate field testing and registration. Dr Mohapatrastressed onthe need for all centres to share their promising materials with other relevant centres. A study has to be taken up to quantify the area covered and reduction in consumption of pesticides through adoption of biocontrol modules. Active collaboration has to be established with State Govt. and KVKs to conduct more field demonstrations and trainings. Feld trials on biological control have to be conducted in North Eastern states, especially in Sikkim. Comprehensive programmes should be initiated to bring about quick and tangible solutions for the management of locusts.Dr Mohapatra highlighted the importance of generating molecular signatures for the promising bioagentsand depositing the same in recognised nodal centres. He emphasized that the project should also concentrate on biocontrol of plant diseases and effect of climate change on the population and behaviour of natural enemies in different regions.

Dr.Tilak Raj Sharma, Deputy Director General (Crop science), ICAR appreciated the progress made in the project and emphasized on the need to use local isolates of bioagents and to study the impact of the local isolates through socio economic expert analysis. Market share of the bioagents in comparison with chemical insecticides has to be studied. He also stressed on the need to conduct research on plant – pest - microorganism interactions and stability and host range of bioagents. He also focussed upon the need to develop nano carriers for biopesticidesand drones to apply bioagents. He urged the biocontrol workers to study the association of microbes with entomopathogenic nematodes and to develop methods to upscale the production of bioagents. He urged the centres to also focus on plant disease management, especially on alien invasive plant pathogens and to develop integrated pest and disease management strategies. He advised AICRP BC to collaborate with NIBSM, IARI and NCIPM.

Dr.P.K.Chakarbathy, Member ASRB & former ADG (PP&Biosafety) and Dr Rajan, present ADG incharge (PP&Biosafety) shared their knowledge and experiences on registration of microbial biopesticideproducts.Experts nominated by ICAR: Dr H C Sharma, Dr H B Singh and Dr S K Jalali; former directors of NBAIR Dr R J Rabindra and Dr Abraham Verghese;Director ATARI Dr Chandre Gowda and senior retired biocontrol workers Dr T M Manjunath, Dr Sithanantham, Dr A Krishnamurthy and Dr M S Rao actively participated in the workshop. Around89 scientists and nine company representatives from different parts of the country participated in the XXIX Virtual AICRP BC Workshop. During the valedictory session, the finalised recommendations were presented. Dr G Sivakumar, PS, NBAIR & in-charge, AICRP BC cell proposed the vote of thanks.

(Source: ICAR- ICAR-National Bureau of Agricultural Insect Resources,Bengaluru)

SALIENT ACHIEVEMENTS OF AICRP-BIOCONTROL DURING 2019-20

Chnadish R. Ballal
Project Coordinator, AICRP-Biological Control

1. Introduction

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

Diversity of natural enemies, nematodes, entomopathogens and plant disease antagonists have received maximum attention. Collection and cataloguing of agriculturally important insects have been carried out covering vast geographical areas. Efficient protocols have been developed for mass multiplication of parasitoids, predators and pathogens against insect pests and antagonists, plant pathogens and plant parasitic nematodes. Cultures of biocontrol agents have been supplied to the commercial producers, state departments of Agriculture/Horticulture KVKs, researchers, students and farmers along with training on mass production and application technologies. Several agencies are now supplying biocontrol agents to the needy farmers. The field demonstrations through AICRP centers have created awareness amongst farmers regarding the usefulness of biological control in IPM modules.

The potential bioagents/biopescticides developed at ICAR-NBAIR and the other AICRP biocontrol centres are being validated under the AICRP-BC network. The success achieved in the biological control of papaya mealybug, sugar cane woolly aphid, eucalyptus gall wasp, root grubs and several others notorious indigenous and exotic pests is being successfully sustained through constant monitoring and redistribution/conservation of biocontrol agents. The AICRP BC has played a prominent role in monitoring the entry and spread of invasive pests. The recent invasive managed through AICRP-BC initatives are tomato pinworm, *Tuta absoluta*, the rugose spiraling whitefly, *Aleurodicus rugioperculatus* and the fall armyworm (FAW) *Spodoptera frugiperda* infesting maize. The main centre of AICRP-BC at NBAIR and its centres were responsible for alerting not only the nation but also the neighboring countries on the entry of FAW and in recommending sustainable management advisories and providing biocontrol inputs.
During the current EFC for the period 2017-2020, the AICRP-BC which earlier comprised of 16 centres with funding has been strengthened through addition of 16 centres, thus currently having a strong network of 32 centres (with funding for 28 centres) plus the PC cell.

2. Mandate of AICRP on Biological control of crop pests

- To evolve effective biological control strategies for important insect pests, plant pathogens and nematodes.
- To co-ordinate research on biological control aspects at national level.

- To serve as nodal agency for introduction, exchange and conservation of biological control agents at national level.
- To disseminate information and impart training on biological control

3. Setup

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

State Agricultural University–based centres

1. Acharya N.G. Ranga Agricultural University, Anakapalle
2. Anand Agricultural University, Anand
3. Assam Agricultural University, Jorhat
4. Dr. Y.S. Parmar University of Horticulture and Forestry, Solan
5. Govind Ballabh Pant University of Agriculture and Technology, Pantnagar
6. Kerala Agricultural University, Thrissur
7. Mahatma Phule Krishi Vidyapeeth, Pune
8. Pandit Jayashankar Telangana State Agricultural University, Hyderabad
9. Punjab Agricultural University, Ludhiana
10. Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar
11. Tamil Nadu Agricultural University, Coimbatore
12. Central Agricultural University, Pasighat
13. Maharana Pratap University of Agriculture & Technology, Udaipur
14. Orissa University of Agriculture & Technology, Bhubaneswar
15. University of Agricultural Sciences, Raichur
16. Indira Gandhi Krishi Viswavidhyalaya, Raipur
17. KAU-Regional Agricultural Research Station, Kumarakom
18. KAU-Regional Agricultural Research Station, Vellayani
19. Dr. Y S R Horticultural University, Ambajipeta
20. Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal

ICAR Institute–based centres

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

Voluntary Centres

1. Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
2. Sun Agro biotech Chennai

3. School of Agriculture Science & Rural Development, Medziphema Campus, Nagaland University
4. Sher-e-Kashmir University of Agricultural Science & Technology, Jammu
5. National Institute of Plant health Management, Hyderabad

The results from the various experiments conducted at centres across the country during the year 2019-20 are presented below.

4. BRIEF SUMMARY OF RESEARCH ACHIEVEMENTS

4.1 BASIC RESEARCH WORK AT NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES

4.1.1 Taxonomic and biodiversity studies on parasitic Ichneumonid and chalcid wasps

Field surveys conducted in the maize fields infested with *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) in Karnataka, Tamil Nadu, Rajasthan and Meghalaya revealed *Cotesia ruficrus* (Haliday) (Hymenoptera: Braconidae) as the common gregarious larval parasitoid in the maize fields parasitizing *S. frugiperda*. This is the first report of *C. ruficrus* parasitizing *S. frugiperda* in India, earlier reports being from Trinidad and Tobago. *Coccygidium* (Braconidae) was also recorded as a new addition to *S. frugiperda* parasitoid complex. It is the first report of a host for *C. transcaspicum* and the first report of *C. transcaspicum* as a parasitoid of *S. frugiperda* across the globe. An egg-larval parasitoid, *Chelonus formosanus* Sonan (Hymenoptera: Braconidae) parasitizing *S. frugiperda* in India (in natural field conditions) was also recorded and this is amenable to mass production (in laboratory conditions).

4.1.2 Diversity of Trichogrammatids

A total of 876 trichogrammatids were collected from the states *viz*., Karnataka, Maharashtra, Tamil Nadu, Gujarat and Meghalaya. Eight genera of trichogrammatids, Chaetostricha, LathromeroideaMegaphragma, Oligosita, Paracentrobia, Trichogramma, Trichogrammatoidea and Tumidiclava were collected. The genera Megaphragma Timberlake was collected for the first time from Maharashtra. Parasitism of *Trichogramma chilonis* Ishii was recorded on *Spodoptera frugiperda* (J.E. Smith) for the first time on eggs of fall armyworm infesting maize. Trichogramma achaeae, T. chilonis and Trichogrammatoidea bactrae were recorded on the eggs of *T. absoluta* infesting tomato in Karnataka. Nine releases of *T. achaeae* were made to control the *Tuta absoluta* infesting tomato field in Karnataka. The field parasitism of *T. achaeae* ranged from 17.97 to 47.5% and reduced the population of larvae, pupae and number of leaf mine of *T. absoluta.*

4.1.3 Spider diversity and biocontrol potential of social spider

More than 530 spider specimens were collected from 7 states (15 locations) in different agro –ecosystems. One hundred and fifty two species identified up to the genus level and 53 species confirmed their identity at species level. Eighty one spider species from families (Salticidae, Thomisidae, Tetragnathidae, Araneidae and Gnaphosidae) were newly added into

the collection. *Peucetia yogeshi* Gajbe (Oxyopidae: Araneae) the green lynx spider was redescribed. It has new distribution record to Karnataka (Gangavathi).

4.1.4 Predator prey interaction of mirids, geocorids, anthocorids and mites

Evaluation of predatory mirid, *Dortus primarius* against *Tuta absoluta*

Dortus primarius was evaluated against *Tuta absoluta*. Both male and female were able to prey around 22–24eggs and nymph could consume 16-20 eggs per day with a continuous daily offer of 30 eggs. Among larval instars of *T. absoluta* both sexes of the predator accepted only 1st-instar larvae as preys.

Evaluation of Predatory mite, *Neoseiulus indicus* against broad mite in mulberry

Neoseiulus indicus was evaluated against broad mite, *Polyphagotarsonemus latus* (Banks) in mulberry. 88.07% reduction in mite population was observed after three releases of this predatory mite.

Evaluation of Predatory mite, *Neoseiulus indicus* and anthocorid bug, *Blaptostethus pallescens* against red spider mites in rose

Neoseiulus indicus and *Blaptostethus pallescens* were evaluated against red spider mites in roses. *Neoseiulus indicus* could reduce spider mite population by 88% followed by *B. pallescens* where 46% reduction in mite population was observed.

4.1.5 Studies on Fall Armyworm, *Spodoptera frugiperda*

Molecular Characterization of FAW:

Around **40 populations of *Spodoptera frugiperda*** were received from different parts of the country and Nepal were identified using **CO1**, **CO1B, TPI markers.** All the populations and its natural enemies were molecularly characterized & the sequences were deposited in **NCBI & ACC. Nos & DNA barcodes were obtained.**

Studies on the effect of Entomopathogenic fungi on maize fall armyworm (FAW) *Spodoptera frugiperda*

Field evaluation of *B. bassiana* (ICAR-NBAIR Bb-45) and *M. anisopliae* (ICAR-NBAIR Ma-35) against *S. frugiperda* in maize during *kharif* in NBAIR Research farm-Attur and during *rabi* in Dandeganahalli in Chikkaballapur district. Three foliar sprays @ 5g/litre ($1x10^8$ CFU/g) at 20, 30 & 40 days of the crop age were given. ICAR-NBAIR Ma-35 and ICAR-NBAIR-Bb-45 showed 62-86% of pest reduction in maize, respectively.

Evaluation of *Trichogramma pretiosum* (Th) and *Telenomus remus* against FAW eggs.

When FAW eggs were exposed to both parasitoids, *T. remus* resulted in 92.73 percent parasitism and *T. pretiosum* caused 45.51 percent parasitism. Percent adult emergence in case of *T. remus* was 95.01 percent while 68.13 percent adults were emerged from *T. pretiosum* parasitized FAW eggs. *Trichogramma pretiosum* (Th) was released (four releases @ 50,000/ha) in FAW infested field at Chikballapur, Karnataka along with other IPM interventions (pheromone traps, entomopathogenic fungi and entomopathogenic bacteria) and resulted in 76.14 percent reduction in FAW egg mass at 60 days after first release.

Evaluation of NBAIR BT-25 against FAW

Three field trails in Maize were conducted at farmer's field Chikkaballapura, NBAIR research farm and Hindupur showed 85%,88% and 76% decrease in pest incidence over control, respectively.

Laboratory and field evaluation of Spfr NPV

Laboratory bioassays revealed that all the early three instar larvae were equally susceptible (LC50 2.61 to 4.21 POB/mm2) to infection by SpfrNPV. Field experiment data revealed that prophylactic spray of aqueous suspension of SpfrNPV NBAIR1@ 4ml per litre twice with the concentration of 1.5x 10^{12} POBs/ ha at 20 and 35 days after sowing was found effective in reducing FAW population by 68.96 to 82.85% during the Kharif and Rabi seasons. Laboratory protocol for the production of *Spodoptera frugiperda* nucleopolyhedrovirus (SpfrNPV) was also developed.

4.1.7 Endophytic establishment of *Beauveria bassiana* (Bb-5a & Bb-45) and *Metarhizium anisopliae* (Ma-4 & Ma-35) in cabbage for management of diamond back moth (*Plutella xylostella* (L.)

In glass house studies, the endophytic isolates of *B. bassiana* (ICAR-NBAIR Bb-5a & Bb-45) and *M. anisopliae* (ICAR-NBAIR-Ma-4 & Ma-35) caused 8.4-76% mortality on second instar larvae of *Plutella xylostella* when applied through different inoculation methods. Among the isolates tested, Ma-35 isolate caused highest mortality on *P. xylostella* in all the application methods.

In field experiment, among the four isolates tested, NBAIR Ma-35 isolate caused highest pest reduction 93.5% when applied through a foliar spray (1x10^8cfu/ml) after 10days of transplanting of cabbage seedlings and rest of the isolates caused 56-81% of pest reduction over untreated control.

4.1.10 Molecular Characterization and DNA barcoding of agriculturally important parasitoids, predators and other insects

Different parasitoids, predators and other insects were collected from various crops in Tripura, Tamilnadu, Karnataka, Maharastra, West Bengal, Telangana, Delhi, Gujarat, Kerala, Assam (10 states) and Nepal and were used for DNA barcoding studies. Molecular variation between native and exotic *Trichogrmma* species, *Glyptapanteles, Parapanteles*, whiteflies, *Microplitis maculipennis* and veterinary insect pests was determined using CO1 & ITS-2 markers.

4.1.11 Evaluation of entomopathogens biopesticides for the management of sucking pest *Thrips palmi* in watermelon var. *Arka manik* and suppression of watermelon bud necrosis tospovirus under field conditions

Effective use of entomopathogenic biopesticides under field conditions viz., *Metarhizium anisopliae* strain NBAIR-MaCB, *Pseudomonas entomophila* strain NBAIR-PEOWN, *Pseudomonas fluorescens* strain NBAIR-PFDWD and *Bacillus albus* strain NBAIR-BATP either individually or in consortia form could effectively manage *Thrips palmi* on watermelon compared to untreated control. These biopesticides were on par with the chemical control

imidacloprid but the yield was at appreciable level in *B. albus*, followed by *P. entomophila*, *P. fluorescens*, chemical check and *M. anisopliae*. Consortia of *B. albus* with *P. fluorescens* is very effective in *T. palmi* management compared to other treatments.

4.2 ALL INDIA COORDINATED RESEARCH PROJECT ON BIOLOGICAL CONTROL OF CROP PESTS

4.2.1 BIODIVERSITY OF BIOCONTROL AGENTS FROM VARIOUS AGRO ECOLOGICAL ZONES

AAU-J: One hundred and thirty-eight numbers (138) of spiders from 6 different families (Lycosidae, Oxyopidae, Tetragnathidae, Araneidae, Uluboridae and Salticidae) were collected from different rice fields of Jorhat district. Fifty-six (56) number of Odonate species were collected from rice ecosystem and the most dominant was dragonfly (18) and damselfly (22) species were *Brachythemis contaminata* and *Agrionemis femina* in all rice growing seasons. Eighty-two numbers of coccinellids predators were recorded from August to Nov' 2019 from rice field. In vegetable ecosystem, 183 numbers of different types of predators along with parasitoids viz., *Cotesia glomerata*, *Campoletis chlorideae*, *Trichogramma chilonis*, *Bracon* spp. parasitizing *Helicoverpa armigera*, *Diaeretiella* sp from aphid, *Encarsia* sp.from whitefly and *Phanerotoma* sp. (Larval) from brinjal fruit an shoot borer were recorded.

AAU-A: *Trichogramma chilonis* was the major *Trichogrammatid* recorded cotton, okra, maize, rice and tomato fields. *Cheilomenes sexmaculatus* Fabricius was found to be the predominant species. A total 86 spider specimens belonging to five families namely Araneidae, Oxyopidae, Salticidae, Tetragnathidae and Thomisidae were collected from paddy fields. Out of 86 specimens, 29 turned to be *Agriope* sp. and 31 were *Neoscona theisi*. Six soil samples were found positive for EPN. From the soil samples collected, four strains of *Metarhizium* sp. have been isolated and identified. During the survey of invasive pest *Spodopetra frugiperda*, NPV infected larvae were collected. NPV occlusion bodies (OBs) were isolated and pathogenicity of the virus was confirmed.

CISH: Coccinellids population recorded as high as 3.45 adults/ tree at some point in 15^{th} SMW. Peak population of hoverflies were observed through 19^{th} SMW, registering with 4.8/tree, and peak Chrysopid population was noticed during 17^{th} SMW which was recorded as 1.7 adults /tree.

PAU: Sixteen species of natural enemies were recorded including 7 species of insect predators; 2 species of parasitoids and 7 species of spiders during regular surveys in cotton growing areas of Punjab. Among predators, *Chrysoperla* was the predominant species. The mean parasitization of whitefly by *Encarsia* spp. in different cotton growing areas of Punjab was 7.51 per cent (range = 0.90 to 24.1%). Out of thirty-nine soil samples collected from different crops from different zones of Punjab for the isolation of entomopathogens, two *Bacillus* bacteria were isolated.

CAU Pasighat: Five species of spiders and one species of lady bird beetle has been collected from different crops.

TNAU: The natural enemies *viz*., *Trichogramma* sp., *Cryptolaemus montrouzieri*, *Chrysoperla zastrowi sillemi* and parasitoids of papaya mealybug were collected. The egg parasitoid of maize fall army worm was identified as *Trichogramma* sp. The activity of *Chelonus* sp was observed on maize fall army worm eggs in field coditions. Staphylinids and spiders were also observed in maize fields. A predator *Mallada boninensis* was seen in coconut trees infested with rugose spiralling whitefly.

KAU Thrissur: Spiders were collected from rice ecosystem in Thrissur and Palakkad districts by pit fall trap and sweep net methods and 165 specimens were collected.

UAS Raichur: Activity of spiders and coccinellids coincided with the peak activity of the thrips and hopper populations. Similarly, syrphid predator activity coincided with the activity of aphid population.

IIMR: About 15 – 20 % parasitization by *Cotesia flavipes* was observed in *Chilo partellus* during Kharif, 2019.. In Barnyard, Proso, Little, Kodo millets, the incidence of shoot flies was recorded at seedling, panicle stages causing deadhearts and white ears, respectively. Egg parasitoid *Trichogrammatoidea simmondsi* (20 %); Larval parasitoid, *Neotrichoporoides nyemitawus* (18.0 %) and pupal parasitoid , *Spalangia endius* (10%) were found parasitizing shoot flies across species and millets.

IIRR: Survey and collection of spiders was done and the collected species were *Pardosa pseudoannulata*, *Oxyopes salticus*, *Araeneus inustus*, *Tetragnatha javana*, *Tetragnatha maxillosa*, *Tetragnatha nitens*, *Plexippus* sp., *Bianor* sp., *Argiope catalunata*, *Olios* sp., and *Thomisus* sp. The wolf spider *Pardosa* (1.25/ trap) was the most abundant in pitfall traps while *Tetragnatha* spp., (3.14) were dominant in sweep nets.

MPKV: *Chrysoperla zastrowi sillemi* Esben. was observed in aphid colonies on cotton, maize, bean, jawar, okra and brinjal crops, whereas, *Mallada boninensis* Okam. was observed in aphid, mealy bugs and hopper colonies on cotton, bean, mango, papaya and hibiscus plants from five geographic locations. *Coccinella septempunctata* L. and *Menochilus sexmaculata* F. were recorded in the aphid colonies on leaf surfaces of crops *viz.,* Cotton, sugarcane, sorghum, maize, cowpea, okra, brinjal, soybean, beans, papaya and pomegranate. *Metarhizium rileyi* (Farlow) (*N. rileyi*) diseased cadavers of *S. litura* were collected and isolated from soybean and cabbage crops, while diseased cadavers of *Spodoptera frugiperda (Smith*) infected with *Metarhizium rileyi* (Farlow) (*N. rileyi*) were collected from Maize fields. The cadavers of NPV infected larvae of *S. frugiperda* were also collected from Maize.

NIPHM: A total of eight natural enemies including parasitoids and predators were recorded from maize ecosystem during *Kharif,* 2019. Recorded the predators viz., *Coccinella septempuctata* Linnaeus., *Cheilomenes sexmaculata* Fabricius., *Coccinella transversalis* Fab., *Micraspis discolour* Fab., *Scymnus nobilis* Mulsant, *Podisus maculiventris* Say., *Chrysoperla* sp. The parasitoids reported are *Bracon* sp and *Trichogramma* sp.

OUAT: During survey on the spider fauna of *kharif* paddy (Var. swarna) at Bhubaneswar, ten species of spiders belonging to six genera and four families were recorded. Among the spider species, *Tetragnatha mandibulata* was the most dominant one.

YSPUF&F: Several coccinellids, chrysopids and syrphid flies were observed in different ecosystems. Besides this *Cotesia glomerata* parasitizing *Pieris brassicae* in cauliflower and *Campoletis chloridae* parasitizing *Helicoverpa armigera* in tomato, *Diplazon* sp parasitizing syrphid flies were also collected from Nauni.

SKAUST Srinagar: Different variants of *Harmonia eucharis* (Coleoptera: Coccinellidae) were recorded on fruits. Per cent parasitism by *Aphelinus mali* (Hymenoptera: Aphelinidae) ranged 20 - 80.0 per cent in woolly apple aphid, *Eriosoma lanigerum* in different parts of Kashmir. *Chilocorus infernalis* was found actively associated with San Jose scale on apple and *Parthenolecanium corni* on plum. *Psyllaephagus* sp. was recorded first time parasitizing *P. lecanii* in Kashmir. An average of 60.0 per cent parasitism was recorded by two hymenopterous parasitoids viz. *Psyllaephagus* sp. and *Metaphycus* sp. Total larval parasitism by *Cotesia glomerata*, unidentified ichneumonid and tachinid flies was 34.34 per cent in *Pieris brassicae* whereas in *Plutella xylostella* total parasitism by *Diadegma semiclausum* and *Cotesia vestalis* was 45.75 per cent.

4.2.1.1 SURVEILLANCE FOR ALIEN INVASIVE PESTS

The alien invasive pests, *viz*., *Brontispa longissima, Aleurodicus dugesii, Phenacoccus madeirensis* were not recorded in any of the centres during the year 2019-2020.

4.2.1.2 Surveillance of rugose whitefly & other whiteflies in coconut and assessing the population of natural biocontrol agents

CPCRI, Regional Station, Kayamkulam: Rugose spiraling whitefly (*Aleurodicus rugioperculatus*) was found to be very low (1.5 colonies /leaflet) during July-December 2019 and thereafter shot up as high as 4.5 colonies by February 2020. The population of Bondar's nesting whitefly (*Paraleyrodes bondari*) was found to be higher recording as high as 4.0 colonies per leaflet in the month of September 2019 got reduced subsequently reaching as low as 0.5 colonies on March 2020. The non-native nesting whitefly (*Paraleyrodes minei*) that co-existed with BNW and RSW during 2018 was not observed and was completely displaced by the other exotic whitefly species. Percentage parasitism by *Encarsia guadeloupae* on RSW colonies decreased from 48% in July 2019 to 22% in February 2020 which encouraged the buildup of RSW colonies in 2020 favoured by weather factors.

DRYSRHU Ambajipeta: The RSW population was collected from the variety East coast tall of 10 to 15 years from three different blocks of HRS., Ambajipeta farm. Nil population of parasitoid *E. guadeloupae* and low population of predator's spiders (0.25/ per four leaf lets) and predator *Dichochrysa astur* (0.50/ per four leaf lets) was recorded under natural conditions.

KAU Thrissur: Incidence of rugose whitefly on coconut was widespread in Thrissur and Palghat districts during 2019-20. The buildup of pest started in November, possibly due to the delayed withdrawal of the South West monsoon. The whitefly infestation broadly followed the pattern observed in 2018-19 though the severity of infestation was high well into March, unlike in previous years when it had declined by January. Mean parasitism by *Encarsia guadeloupae* remained throughout the study period, ranging from 28.64 to 80.18 per cent at Palakkad and from 35.72 to 62.10 per cent at Thrissur and never reached 90 per cent at either of the locations.

KAU Vellayani: Observations recorded for a period of 10 months revealed that the pest population is dwindling between low and severe levels. The peak was noted during Dec 19 to February 2020. Three species have been observed *A. rugioperculatus, P. mineyi and P. bondari.* When the population of *A. rugioperculatus* was more, high parasitism (75.72 %) was recorded, while less parasitism (28.74 %) was recorded when the population of nesting whiteflies is more.

RARS Kumarakom: In Kumarakom, whitefly infestation was noticed to be in a medium range from April to June 2019, followed by a slight decline in July with an average of 9.60 live colonies per leaflet. Thereafter, gradual increase was noticed in the colony count with a maximum of 24.85 colonies per leaflet recorded in February. Highest per cent intensity was noticed in March (80.32%) and the least in August (29.41%) which might be subjected to the heavy rain and flood occurred then. Per cent infestation was observed to follow an increasing trend from September 2019 onwards.

4.2.1.3 SURVEY AND SURVEILLANCE OF NATURAL ENEMIES OF PINWORM, *TUTA ABSOLUTA* ON TOMATO

AAU-A: No incidence of *Tuta absoluta* was recorded during the survey period.

TNAU: Survey was conducted to assess the occurrence of tomato pinworm, *Tuta absoluta* in tomato growing areas of Coimbatore district *viz.,* Pichanoor, Patchapalayam, Thekarai and Thudiyalur. In Thekarai, the leaf damage was 12.0 per cent where as no fruit damage was observed. In Patchapalayam, the fruit damage was 3.00 per cent. In Pichanoor, 12.00 and 4.00 per cent leaf and fruit damages were observed respectively.

MPKV: There was no infestation of *Tuta absoluta* on tomato in Pune, Satara, Sangli, Solapur and Kolhapur and Ahmednagar districts of Maharashtra state.

IIVR: Occurrence of pin worm on leaf and fruit was first recorded during the last week of November, 2019 (48^{th} SMW). The maximum fruit damage (5.56%) was observed during the first week of January, 2020 (1^{st} SMW) whereas lowest fruit damage (0.60%) was during third week of March, 2020 (12^{th} SMW). Maximum 3.7 *Nesidiocoris tenuis* per apical twigs were recorded.

MPUAT: The infestation ranged from 6 to 25 per cent. Whenever no control measures were adopted, 55-65 per cent infestation was recorded in tomato crop. Survey reveals that the pest is more severe under protected conditions than in open field conditions and prefers tomato over other host plants.

PJTSAU: Marginal incidence of the pest was observed.

4.2.1.4 SURVEILLANCE FOR PEST OUTBREAK AND ALIEN INVASIVE PESTS INCLUDING FAW

TNAU: In guava orchard (11°07'N ,76°59' E) in Coimbatore, woolly whitefly (*Aleurothrixus floccosus*) (Maskell) (Hemiptera: Aleyrodidae), was observed during October 2019. Predators *viz., Cryptolaemus montrouzieri* and *Mallada desjardinsi* were found feeding on the woolly whitefly. Bondar's Nesting Whitefly *Paraleyrodes bondari* Peracchi (Hemiptera: Aleyrodidae) was observed in coconut gardens in Coimbatore, Erode and Tirupur Districts since October

2019. *Mallada boniensis* was found feeding on Bondar's Nesting Whitefly. Maize fall armyworm damage was observed in all the maize fields except in a field in Edapadi where the farmer has sprayed insecticides on 15th day after sowing.

KAU Thrissur: No report of invasive and pest outbreak.

UAS Raichur: Roving survey conducted in six districts of North Eastern Karnataka indicated that FAW incidence was negligible in rabi Jowar (M 35-1). On Maize the number of egg patches per plant and number of larvae were highest compared to rabi jowar. In Koppal district the natural epizootic of *Metarhizium rileyi* was noticed.

MPKV: Amongst the targeted invasive pests, the mealybug species, *Pseudococcus jackbeardsleyi* and *Paracoccus marginatus* were recorded on custard apple and papaya respectively, in Pune, Nadurbar, Dhule and Jalgaon districts. *Tuta absoluta* was not observed on tomato crop in Western Maharashtra. The Fall Army Worm (FAW), *Spodoptera frugiperda* (Smith) was recorded in all maize growing areas of Maharashtra. The pest extended its host range on sorghum and bajara crop in Pune, Solapur, Satara and Sangli districts. FAW is reported for the first time on Cotton crop at Susare Village of Pathardi Tahasil in Ahmednagar district.

MPUAT: Incidence of fall armyworm was noticed to be moderate to severe in Udaipur, Chittorgarh, Banswara and Dungarpur districts of Southern Rajasthan with an average incidence range of 30-40 per cent. The swarm of Locust was first spotted in month of December, 2019 in Udaipur region, mainly Kotra block. It has damaged many hectares of mustard and wheat crops and eaten up plants in the large forest area. It has so far stationed at Dedhmariya, Phulwariya, Maldar, Mahudi and Khajuria village. Earlier, locust swarm spotted in Jaisalmer, Barmer, Jodhpur, Jalore, Sirohi, Pali, Bikaner and Ganganagar districts of Rajasthan. Among these districts, in Jalore, Barmer, Jaisalmer district, this pest caused significant damage to cumin, castor and isbagol crops.

OUAT: Mild to moderate infestation of fall armyworm was observed.

YSPUH&F: Different Vegetable and fruit ecosystems in district Solan, Sirmour, Mandi, Kullu, Bilaspur, Shimla, Kangra, Kinnaur and Lahaul & Spiti were surveyed for the collection of pests like, *Aleyrodicus digessi, Phenacoccus manihoti, Paracoccus marginatus, Phenacoccus madeirensis* and *Tuta absoluta* but only *T. absoluta* was recorded.

PJTSAU: Fall armyworm (FAW) incidence was noticed from low to moderate during *Kharif* 2019-20, in many maize growing districts of Telangana *viz*., Karimnanagar, Siddipet, Sangareddy & Mahbubnagar. It was found to be medium to high in Nagarkurnool and Khammam districts as compared to other districts of the state.

IIMR: Surveys for incidence of *Spodoptera frugiperda* showed 3 – 10 % foliar damage on Sorghum. During Rabi season 15 – 40 % foliar damage was observed at Hyderabad, Warangal.

4.2.2 BIOLOGICAL SUPPRESSION OF PLANT DISEASES

4.2.2.1 Evaluation of fungal and bacterial isolates for crop health management in rice

GBPUA&T: Glasshouse: In mixed formulation treatments, highest germination percentage was observed in PBAT-3 (87.00 %) followed by, Th17+Psf-173 (84.66%), Carbedazim (81.83%) as compared to control (61.00%). Maximum root length was observed with PBAT-3 (22.08 cm) followed by Th14+Psf-2 (21.83 cm), Psf-173 (21.50 cm), which did not differ significantly with each other but was significantly better than the control (15.08 cm).

Field: Minimum Sheath blight (*Rhizoctonia solani*) disease severity was recorded with PBAT-3 (30.30%) followed by Carbendazim (30.58 %), Th17+Psf-2 (31.00%) and Th17+Psf-173 (31.29%), which did not differ significantly from each other but were significantly better than control (37.30%). Minimum percentage of Brown spot (*Drechslera oryzae*) infected panicle/hill was observed with Carbendazim (42.26%) which was statistically at par with PBAT-3 (42.77%) and followed by Th17+Psf-173 (44.17%). Maximum yield was obtained with PBAT-3 (53.83 q/ha) followed by other treatments.

4.2.2.2 Evaluation of microbial antagonists for the management of foot rot of kinnow caused by *Phytophthora* spp.

PAU: The experiment to evaluate the microbial antagonists against foot rot of citrus showed highest per cent recovery in final lesion size in chemical control (45.5%) over untreated control followed by NBAII- Pf DWD *Pseudomonas fluorescence* and *Trichoderma harzianum* with 24.59 and 21.94 percent recovery, respectively. The mean number of fruits per plant was maximum (504.0) in chemical treatment (Curzate M8) followed by NBAII-PfDWD *Pseudomonas fluorescence* (482.0). However, minimum number (382.0) of fruits was recorded in untreated control. The yield per tree was 99.5 kg and 109.5 kg in *Pseudomonas fluorescence* NBAII-PfDWD and chemical control, respectively.

4.2.3 BIOLOGICAL SUPPRESSION OF SUGARCANE PESTS

4.2.3.1 Efficacy of entomopathogenic nematode and entomofungus for the management of white grub in sugarcane ecosystem UAS Raichur:

Plant damage was lowest (8.50 %) in *Heterorhabditis indica* WP (ICAR- NBAIR) and it was at par with *Metarhizium anisopliae* (ICAR-NBAIR Ma 4) and Chlorantraniliprole 18.5 SC which recorded 9.25 and 6.50 per cent plant damage. Highest plant damage of 61.25 per cent was noticed in untreated control. *Heterorhabditis indica* WP (ICAR- NBAIR) recorded 121.85t/ha cane yield which was at par with *Metarhizium anisopliae* (ICAR-NBAIR Ma 4) and Chlorantraniliprole 18.5 SC which recorded 118.50 and 123.50t/ha. Untreated control recorded 95.25 t/ha cane yield.

4.2.3.2 Field efficacy of dose application of EPN against white grubs in sugarcane

MPKV: Highest white grub reduction (75.85 %) was recorded in chemical treatment with Fipronil. Amongst EPN strains, highest white grub reduction (72.78 %) was recorded in *H. indica* @ 3.0 $x10^5$/ m^2 (NBAIR WP formulation).

4.2.3.3 Field efficacy of EPN strains against white grubs in sugarcane.

MPKV: Amongst EPN *H. indica* @ $1.0x10^5$/ m^2 (NBAIR WP formulation) treatment recorded 54.72 % and become next promising treatment after chemical treatment (Fipronil) for suppressing white grub in sugarcane

4.2.4 BIOLOGICAL SUPPRESSION OF COTTON PESTS

4.2.4.1 Biointensive management of pink bollworm on *Bt* cotton

TNAU: In the field trial, pink boll worm damage was 22.50 per cent in BIPM plots which was 28.57 per cent lesser than the damage in the control plot. There was 36.13 per cent reduction in pink boll worm damage in the insecticide sprayed plots. The yield was maximum in insecticide sprayed plots (1654Kg/ha) followed by 1562Kg/ha and 1344Kg/ha in BIPM and control plots respectively. The CB ratios were 1:2.41 and 1:2.57 for BIPM and insecticide treatments respectively.

UAS-Raichur: The number of PBW larvae in plant protection treatment (T_1) and chemical treatment (T_2) was 5.18 and 2.36 larvae per 10 bolls, respectively while in control (T_3) maximum of 8.94 larvae per 10 bolls were noticed. Rosette flower in T_1 (6.28 %) and T_2 (4.36 %) differed statistically and T_3 recorded highest rosette flower of 10.26 per cent. Similarly, highest seed cotton yield of 31.80 q/ha was noticed in T_2 while T_1 recorded 27.35 q/ha and lowest seed cotton yield of 17.75 q/ha was recorded in T_3.

PJTSAU: Despite low incidence of PBW during *Kharif*, 2019-20, the module with pheromone traps (Funnel type) @ 10/ plot + releases of *Trichogrammatoidea bactrae* 100,000/ha/release, 6-8 releases starting from 55 days after germination + application of 5% Neem Seed Kernel Extract (NSKE) fared better in terms of percent green boll damage (19.20), percent locule damage (6.12) than insecticide treatment (24.67 % green boll and 7.13 percent locule damage).

4.2.4.2 Population dynamics of whitefly, *Bemisia tabaci* (Gen) and its natural enemies in cotton: A study in farmers' field in North Zone

NCIPM: Whitefly population (adults/ 3 leaves) remained below ETL in all locations throughout the season in July. Mean population (average of all locations) of whitefly (adults per three leaves) was maximum in July (9.44±5.12) followed by Aug (5.23±1.39), Sep (4.55±3.29), June (3.63±1.19) and October (1.85±0.66). Among all the locations, maximum population (mean of the season) was observed in Fazilka (8.19±6.37), followed by Sirsa (5.2±2.28), Muktsar (3.81±1.91), Hanumangarh (3.79±2.17) and Sriganganagar (3.71±2.82). Mean (average of the season) parasitization (per cent) of whitefly nymphs by *Encarsia* spp or other parasitoids was recorded maximum in Muktsar (33.85, Range 25.00 – 57.14) followed by Sirsa (29.650 Range 12.50-40.90), Fazilka (29.28 range 18.11-39.42), Sriganganagar (26.57; range 12.33-38.46) and Hanumangarh (25.40 range 14.71-37.93).

4.2.4.3 Management of pink bollworm by using *Trichogrmmatoidea bactrae* on *Bt* cotton

PDKV: Significantly minimum bad open bolls were recorded in treatment T2 (insecticide treated field) (23.50 % bad open bolls) followed by treatment T1 (biocontrol practices) (26.09%), both the treatments were at par with each other and significantly superior over untreated control (36.58 %). Treatment T2 recorded significantly maximum yield of 1316.87 Kg/ha seed cotton,

followed by treatment T1 recording 1221.71 Kg/ha seed cotton. Both these treatments were significantly superior over untreated control (812.76 Kg/ha seed cotton).

4.2.4.4 Biointensive Pest Management in *Bt* cotton ecosystem

UAS Raichur: Sucking pest population *viz*; thrips, leafhoppers, aphids and whiteflies population was more in biointensive practice (7.84, 11.36, 5.36 and 0.76 thrips, leafhoppers, aphids and whiteflies, respectively/leaf) compared to farmer practice (2.92, 4.84, 2.18 and 0.26 thrips, leafhoppers, aphids and whiteflies, respectively/ leaf). Biointensive practice recorded 11.32, 33.68 and 21.86 PBW larvae, GOB and BOB per plant, respectively and in farmers practice it was 7.98, 39.84 and 13.85 PBW larvae, GOB and BOB per plant, respectively. Biointensive practice recorded 27.25 q/ha seed cotton yield while in farmer practice it was 31.75 q/ha.

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

MPKV: Pooled means for two years (2017-18 and 2018-19) indicated that amongst the biopesticides, *Lecanicillum lecanii* (1 x 10^8conidia/g) @ 5 g/litre recorded lowest population of sucking pests *viz.*, aphids (5.74), jassids (2.69), thrips (2.61), and white flies (1.77) on 3 leaves per plant compared to the untreated control which recorded aphids (39.24), jassids (12.73), thrips (31.67), and white flies (10.62) on 3 leaves per plant. The *L. lecanii* treatment recorded seed cotton yield of 18.32 q/ha which is at par with dimethoate 0.05 per cent (19.02 q/ha) with B:C ratio (1.25), and 1.32, respectively.

PJTSAU: Among the biologicals evaluated, *Lecanicillium lecanii* followed by application of azadirachtin 1500 ppm @ 5ml/l at ETL hosted significantly a smaller number of sucking pests such as jassids, aphids & whiteflies as compared to control and equivalent to insecticidal check indicating *L. lecanii* as a viable alternative to insecticidal applications in cotton for the management of sucking pests.

4.2.5 BIOLOGICAL SUPPRESSION OF RICE PESTS

4.2.5.1 Management of plant hoppers through BIPM approach in organic *basmati* rice

PAU: The population of plant hoppers in BIPM and control plots was 1.93 and 3.00 per hill, respectively resulting in a reduction of 35.8 per cent over control. The population of spiders was comparatively higher in BIPM plot. Basmati yield was 32.00 q/ha in BIPM as compared to 30.50 q/ha in untreated control with an increase of 4.92 per cent.

ANGRAU: Hopper population was low in BIPM plot (0.48 hoppers/hill) and farmers practice plot (0.78 hoppers/hill) compared to control plot (3.5 hoppers /hill). Reduction in hopper population after first spray was high in BIPM plot (83.6 %) and farmers practice plot (77.38%) and increase in hopper population was recorded in control plot (20.14 %). Grain yield recorded was high in BIPM practice (3.85 t/ha) compared to farmer's practice and untreated control. Percent yield increase in BIPM practice over control was 52.77% and in farmers practice was 44.05 %.

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

ANGRAU: Percent reduction in leaf folder damage over untreated control was high in Flubendiamide (81.52 %) followed by *Bacillus thuringiensis* (73.62%), *Heterorhabditis indica* (65.72%) and *Steinernema carpocapsae* (63.19 %). Percent reduction in stem borer damage over untreated control was high in flubendiamide (78.28%) and *Bacillus thuringiensis* (56.49 %). Grain yield recorded was high in chemical treatment (3.65t/ha) followed by *Bacillus thuringiensis* (NBAIR strain) (3.4 t/ha) and *Beauveria bassiana* (3.27t/ha), *Steinernema carpocapsae* (3.25 t/ha) and low in control (2.82 t/ha).

KAU Thrissur: Plots treated with *B. thuringiensis*, *H. indica*, and *B. bassiana* had significantly lower number of dead hearts (3.66, 5.00 and 8.33/ m^2 respectively) than remaining treatments 28 days after the third spray. *Metarrhizium anisopliae* and flubendiamide registered mean values of 16.00 and 21.66 dead hearts/m^2 and were on par with untreated control (17.00 dead hearts/ m^2). The lowest mean number of 1.66/m^2 rolled leaves was recorded in plots treated with flubendiamide, which was on par with both *H. indica* as well as *M anisopliae* treatments with mean values of 2.66 and 3.33 rolled leaves /m^2.

4.2.5.3 Improved formulation of *Beauveria bassiana* against Rice leaf roller *Cnaphalocrocis medinalis.*

KAU Vellayani: Pooled analysis of data for two years 2018-19 and 2019-20 revealed that indigenous isloalate of KAU *B. bassiana* was invariably the superior treatment for the management of *C. medinalis*. Furthermore, the chitin enriched oil formulation could enhance the virulence of the pathogen as it could reduce 82.69 per cent pest population compared to its conodial suspension which showed 79.84 % reduction in larval count.

4.2.5.4 Comparative efficacy of entomopathogenic fungi against sucking pests of rice, *Leptocorisa acuta*

KAU Vellayani: Analysis of data revealed that *L. saksenae* @ 10^7 spores ml^{-1}, was the best treatment to manage *L. acuta* population, when sprayed twice at the panicle initiation and milky stage of the crop. NBAIR isolate Bb5 was found to be superior to thiamethoxam. It is notable that the bug population was nil in the *L. saksenae* treated plots after the second spraying. Data on mean count of natural enemies which included the total count of spiders, coccinellids, scarbids and mirid, analysed revealed that the population did not vary among treatments.

4.2.5.5 Testing of BIPM trial on paddy along with farmers practice and control

IGKV: Maximum percent of dead heart (8.50), white ear head (20.51) was recorded in control compared to BIPM trial (dead heart: 12.20; white ear head: 15.58). Maximum percentage leaf folds were observed in control (3.84) compared to BIPM plot (1.51). Significant maximum grain yield/plot (31.56 kg) was obtained in BIPM treatment followed by farmer's practice (28.88kg)/plot and control (25.25 kg) per plot respectively.

4.2.6 BIOLOGICAL SUPPRESSION OF CEREAL PESTS

4.2.6.1 Evaluation of entomopathogenic fungi and *Bt* against stem borer, *Chilo partellus* (Swinhoe) in maize

PAU: Among biopesticides, lowest dead heart incidence was recorded in commercial Bt formulation (6.45%) and it did not differ significantly from NBAIR Bb-5a (8.57%) and NBAIR Bt (8.62%). The dead heart damage in NBAIR Ma-35 was 11.17 per cent and it was not significantly different from NBAIR Bt and Bb-5a. Grain yield was highest in chemical control (49.26 q/ha). It was followed by commercial Bt formulation (46.04 q/ha), Bb-5a (44.11 q/ha), NBAIR Bt (43.44 q/ha) and Ma-35 (42.04 q/ha).

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

MPUAT: The dead heart incidence in fields with the releases of *T. chilonis* (T_1) was 9.89 per cent and in chemical control (T_2), it was 7.37 per cent. The reduction in incidence over control was 45.20 and 59.16 per cent in T_1 and T_2, respectively. The yield in *T. chilonis* (28.65q/ha) and Spinosad 45 SC(T_2) (31.45 q/ha) fields were significantly more than in untreated control (23.48 q/ha).

4.2.6.3 Bio-ecological engineering for the management of major insect pests of maize and benefit of their natural enemies

SKAUST Jammu: Percent plant damage by *C. partellus* on maize was significantly lowest in T_3 – Maize + cowpea + Sorghum. Number of *Spodoptera litura* larvae per five intercropped plants and whiteflies per five leaves of various intercrops were significantly lowest in T_3 - Maize + cowpea + sorghum. The natural enemies present in the ecosystem; Coccinellids and spiders were more active in okra and maize intercrops, where the population of whiteflies and *S. litura* larvae were more.

4.2.6.4 BIOLOGICAL SUPPRESSION OF FALL ARMYWORM *SPODOPTERA FRUGIPERDA* (J. E. SMITH) (LEPIDOPTERA: NOCTUIDAE) IN MAIZE

ANGRAU: During 2019-20, fall armyworm damage at 20 days after sowing was low in *T. pretiosum* released treatments (23.82 – 35.1 %) with egg parasitisation (5.84 - 9.01 parasitised eggs/20 plants). Upto 50 days after sowing, total damaged plants per plot recorded high in untreated control (169.33) followed by pheromones @ 15 traps/acre (155.33). Total number of dead larvae per plot was high in insecticidal check (50.38) followed by *T. pretiosum* release+ *M. anisopliae* sprays (42.9) and *T. pretiosum* release + NBAIR Bt (41.9). Cob yield recorded high in insecticidal check (40.18 q/ha) and was on par with *T. pretiosum* release + NBAIR Bt (39.97q/ha); *T. pretiosum* release + *M. anisopliae* (39.38 q/ha) and low in untreated check (22.63 q/ha).

TNAU: Among the biocontrol agents, 89.24 per cent damaged plants was observed in *Trichogramma pretiosum+ Beauveria bassiana* NBAIR -Bb 45 followed by *Trichogramma pretiosum+ Metarhizium anisopliae* Ma 35 (89.75%), *Trichogramma pretiosum+* NBAIR Bt 2%

(90.58%) and *Trichogramma pretiosum*+Spfr NPV(NBAIR1) (90.67%) on 45 days after sowing while in insecticide treated plots 59.57 per cent damage was observed. Yield was maximum (6300Kg/ha) in *Trichogramma pretiosum*+ *Beauveria bassiana* NBAIR -Bb 45 plots followed by *Trichogramma pretiosum*+ *Metarhizium anisopliae* Ma 35(6067Kg/ha) and these two treatments were on par with the yield (6513 Kg/ha) in the insecticide treated plots.

AAU-A: Among different biocontrol agents tested, significantly lowest number of *S. frugiperda* larvae/ 10 plants was recorded in treatment 1 (*Trichogramma pretiosum* @ 1 card/acre + *Bacillus thuringiensis* - NBAIR BTG1 - 1% WP) which was at par with the treatment T_2 (*T. pretiosum* @ 1 card/acre + *Metarhizium anisopliae* - NBAIR Ma35 - 1% WP) (2.19 larvae/10 plants). The treatment T_1 recorded the highest grain and fodder yield (3736.67 & 7066.67 kg/ha) which was at par with the treatment T_2 (3716.67 & 7066.67 kg/ha). No significant differences were found with regard to number of egg patches/ 10 plants and number of predators/ 10 plants among biocontrol treatments. Significant numbers of dead larvae due to entomopathogens were found in biocontrol treatments.

IIMR: number of egg mass laid were minimum in *Trichogramma pretiosum* 1 Card/ acre +NBAIR *Bb 45* (1.66) and *Trichogramma pretiosum* 1 Card/ acre + NBAIR *H* 38 (2.00) and *Trichogramma pretiosum* 1 Card/ acre + *Pf* DWD 2% (2.67) and were significantly different compared to control (14.67). The treatments *Trichogramma pretiosum* 1 Card/ acre+ NBAIR *MA* 35- 0.5% and NBAIR *Bb* 45- 0.5% recorded maximum number of dead larvae of 5.67 and 4.33, respectively. Maximum grain yield was recorded in *Trichogramma pretiosum* 1 Card/ acre+ NBAIR *H* 38 0.5% (4436.66 kg/ha), *Trichogramma pretiosum* 1 Card/ acre+ NBAIR *Bb*-45 0.5% (4275.55 kg/ha) and *Trichogramma pretiosum* 1 Card/ acre+ Spfr NPV (NBAIR 1) (4048.89 kg/ha). However, standard check emamectin benzoate (4555.56) gave highest yield when compared to all the treatments.

OUAT: Although, the insecticidal check excelled best among all other treatments, but among the bio-modules, trichocard releases (2)+Bt sprays (2) expressed highest green cob yield (/14.12t/ha) and lowest pest damage which is comparable to chemical check and closely followed by trichocard releases (2) + *Metarhizium* sprays (2).

UAS-Raichur: Three days after spray treatment T_3. (*Trichogramma pretiosum* (1 card per acre to be installed after one week of planting) + EPN *H. indica* NBAIR H38 whorl application @ 4kg/acre) recorded lowest of 0.48 larva per plant which was at par with chemical treatment, Emamectin benzoate 5 SG @ 0.4 g/lit which recorded 0.36 larva per plant. Per cent plant damage was also low in T_3 (14.25 per cent) and it was at par with chemical treatment (12.75 per cent) while, untreated control recorded 41.25 per cent plant damage. Yield q/ha was on par between T_3 and chemical treatment.

MPKV Pune: Three sprays of (Emamectin benzoate 0.4g/l) recorded lowest plant damage of FAW (4.44 %) and it was significantly superior over rest of the treatments. Among the biocontrol agents, *T. pretiosum* 1 card (2 Rel.) + EPN *H. indica* NBAIR H38 @ 4kg/acre and *T. pretiosum* 1 card (2 Rel.) + *M. anisopliae* Ma 35, 0.5% @ 2.0 g/l) were the next best treatments in suppressing the FAW in maize with plant damage of 28.89 %.

4.2.6.5 EFFICACY OF BIOCONTROL AGENTS AGAINST FALL ARMYWORM IN RABI SORGHUM DURING 2019-20

UAS-R: Number of egg patches of FAW ranged from 1.58 to 1.84 per plant which was statistically non significant. Minimum of 0.64 larva per plant was noticed in T_3 (*Trichogramma pretiosum* 1 card per acre followed by application of EPN *H. indica*) which was followed by sole release of *Trichogramma pretiosum.* Highest per cent parasitisation was noticed in continuous release of *Trichogramma pretiosum* which recorded 28.75 per cent. The highest grain yield of 13.10 q/ha was noticed in T_3 which was at par with all the treatments including untreated control.

4.2.6.6 Evaluation of entomopathogenic fungi formulations against millet borers in Finger millet, Kharif, 2019

IIMR: The Dead heart caused in Finger millet due to Pink borer were significantly least in Bb-45 @ 10 ml /lt treatment (3.08%) and it was on par with T_4 (Ma-35 @10 ml /lt) (3.31%) and statistically better than Carbofuran soil application (4.13%). White earhead were least in T5 (Carbofuran 3G granules @ 20 kg/ha) soil application) (2.50 %) and it was statistically on par with T_4 (2.68%) and T3 (2.78%). Highest grain yield was obtained in T5 (3.78 kg/plot) which was on par with T4 (3.62 kg/plot) and T3 (3.48 kg/plot).

4.2.7 BIOLOGICAL SUPPRESSION OF PESTS OF PULSES

4.2.7.1 Evaluation of NBAIR Bt formulation on pigeon pea against pod borer complex

PDKV: The data on pod borer damage at harvest revealed significant differences among the treatments, recording significantly minimum damage of 13.13 % in Bt treatment (T1) followed by treatment T2 with insecticidal sprays recording 14.13 % pod damage and both the treatments were significantly superior to untreated control (24.25 % damage). Maximum yield (16.59 q/ha) was observed in T2 followed by T1 (15.74 q/ha) and both treatments were at par with each other and significantly superior over untreated control.

UAS Raichur: The per cent pod damage in NBAIR *Bt* G 4 was 10.16 per cent while in farmers practice it was 7.38 per cent. In NBAIR *Bt* G 4 the grain yield was 10.68q/ha in farmers practice 13.04 q/ha.

4.2.7.2 Biological suppression of pod borer, *Helicoverpa armigera* (Hubner) infesting chickpea

MPUAT: The maximum reduction was recorded in quinalphos 25 EC @ 250g a.i/ha treatment (1.7 larvae per plant) and the minimum reduction was observed in *Bt.* @ 1 Kg/ha (2.2 larvae per plant) at ten days after spray; whereas, the untreated control recorded least reduction in larval population (5.0 larvae per plant). Minimum per cent pod damage was recorded in chemical treated field (8.68%) followed by *B. bassiana* (12.18 %) and Bt (13.56%) and maximum was recorded in control (18.59).

4.2.7.3 Evaluation of entomopathogenic fungi against pod bug *Riptortus pedestris* on cowpea, *Vigna unguiculate*

KAU- Thrissur: *Beauveria bassiana* (NBAIR Strain) and malathion were significantly superior to the untreated control with mean pod damage of 34.05 per cent. The treatments did not differ significantly at either 10 or 12 days after second spray. There was no significant difference among the treatments in terms of yield, though plots treated with *B. bassiana* recorded the highest yield of 822.91 g/plot.

4.2.7.4 Evaluation of bio-agent consortium in glasshouse (pot experiments) and in field for crop health management in chickpea

GBPUA&T: Glasshouse: In mixed formulation treatments maximum germination percentage, root length was observed by PBAT-3 followed by other treatments. Maximum shoot length was observed with Th17+Psf2 (42.90 cm) which was statistically at par with PBAT-3. Maximum fresh weight was observed with Th17+Psf173 (0.28 gm) which was statistically at par with PBAT-3.
Field: Maximum plant stand, 60 DAS and 120 DAS respectively was recorded with consortium Th17+Psf173 followed by PBAT-3 and other treatments. Minimum number of mature plant wilt at 120 DAS was observed with consortium Th17+Psf173 (3.24), while maximum in control (6.10) after 120 days of sowing.

4.2.7.5 BIPM module for management of *Helicoverpa armigera* on chickpea

TNAU: Larval population in both the BIPM modules (BIPM 1: Erection of bird perches Spray of HaNPV strain twice during the early pod formation stage at 15 days interval, Use of pheromone traps @ 1 trap per plot; BIPM module -2: Erection of bird perches Spray of *Bacillus thuriengiensis* at 7 day interval, 2 sprays twice during the early pod formation stage at 15 days intervals, Use of pheromone traps @ 1 trap per plot) were statistically similar with 3.17 and 3.00 larvae/ 10 plants respectively on seventh day after spraying (DAS). The same trend was observed on 14DAS also. Pod damage was significantly less (7.29%) in chemical treatment when compared to BIPM modules. However, there was 35.93 to 37.53 per cent reduction in the pod damage in BIPM modules. The yield was maximum in chemical treatment (644Kg/acre) followed by BIPM module-2 (578Kg/acre) and BIPM module-1 (567Kg/acre).

4.2.8 BIOLOGICAL SUPPRESSION OF PESTS OF TROPICAL FRUIT CROPS

4.2.8.1 Effect of bio pesticides for management of Mango hoppers *Idioscopus* spp in field condition

CISH Lucknow: Entomopathogenic fungi *viz*., *Beauveria bassiana* and *Metarhizium anisopliae* formulations were tested for their bio-efficacy against mango hoppers. Significant difference was found between the treatments at 3, 7 and 14 days after the spray. Among the bio pesticides, low incidence of hopper was recorded in *B. bassiana* (NBAIR formulation) which registered 6.23 hoppers/ panicle at 7 days after spraying. Efficacy of *B. bassiana* (CISH formulation) and *M. anisopliae* (NBAIR formulation) was in parity with each other.

DRYSRHU Ambajipeta: After second spray of imidacloprid and azadirachtin 10000 ppm recorded nil population of hoppers. Among the bio-pesticide treatments, *Metarhizium anisopliae* and *Beauveria bassiana* recorded a low hopper population of 0.25 and 0.75 hoppers / tree after second spray. In untreated control block also a low population of mango hoppers ranging from 3.50 to 4.75 was recorded during the experimental period**.**

4.2.8.2 Bioefficacy of entomopathogenic fungi formulations in suppression of mango leaf webber

CISH: Significant difference was found between *Beauveria bassiana* and *Metarhizium anisopliae* at 7, 15 and 21 days after the spray. All the entomopathogenic fungi reduced the incidence of leaf webber significantly.

4.2.8.3 Management studies for inflorescence thrips on mango with bio-pesticides in field conditions

DRYSRHU Ambajipeta: After second spray, fipronil treated trees had nil thrips population followed by *Metarhizium anisopliae* (NBAIR strain), azadirachtin 10000 ppm and *Beauveria bassiana* (NBAIR strain) with 0.75, 0.25 and 1.00 thrips per tree, respectively. In untreated control block a high population of mango thrips ranging from 7.50 to 11.25 was recorded consistently.

4.2.8.4 Biological control of guava mealy bug and scales using entomopathogens

SKAUST Jammu: Entomopathogenic fungi *B. bassiana*, *M. anisopliae* and *L. lecanii* formulations (NBAIR isolates), along with azadirachtin 10000 ppm were assessed against guava mealy bug and scale. Significantly highest percent reduction in mealy bug as well as scale population was recorded in *B. bassiana* (NBAIR isolates) spray (45.88 and 44.56% reduction in mealy bug and scale population respectively) that was at par with that of azadirachtin spray (44.86 and 41.83% reduction in mealy bug and scale population respectively) at 7 DAS**.**

4.2.8.5 Biological control of anola mealy bug and scales using entomopathogens

SKAUST Jammu: Entomopathogenic fungi *B. bassiana*, *M. anisopliae* and *L. lecanii* formulations (NBAIR isolates), along with azadirachtin 10000 ppm were assessed against aonla mealy bug. Significantly highest percent reduction in scale population was recorded in azadirachtin spray (46.01% reduction) followed by *B. bassiana* spray (34.43% reduction) at 7 DAS.

4.2.9 BIOLOGICAL SUPPRESSION OF PESTS OF TEMPERATE FRUIT CROPS

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

SKAUST Srinagar: Overall fruit damage in treated orchards during 2019 varied from 22.59 to 60.47 per cent as compared to untreated control (83.7). Per cent reduction in damage over control was found highest in T_2 (Light trap + Pheromone trapping + four releases of *T.*

cacoeciae+ trunk banding + use of *H. pakistanensis*+ field sanitation) (61.28) followed by T_1 (Two sprays of Chlorpyriphos 20 EC @ 1.0 ml./ lit. of water + Pheromone + Trunk banding+ field sanitation) (44.61) and (Farmer's practice) (33.68) which was statistically different for treatments. Maximum profit of 300830.0/ 10 tree was earned out of treatment T2 followed by T1.

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

SKAUST Srinagar: Two releases of *B. pallescens* @ 400 /plant caused 34.11 and 68.51 per cent reduction in population of ERM and TSSM, respectively over control as compared to *B. pallescens* @ 200/plant which caused 25.25 and 43.71 per cent reduction. Application of Fenazaquin 10EC @ 0.4 ml/ litre of water caused 90.06 and 89.85 per cent reduction in population of ERM and TSSM respectively. Anthocorid bugs showed more preference to two spotted spider mites than European red mite.

4.2.9.3 Management of apple root borer using *Metarhizium anisopliae*

YSPUH&F: A large scale demonstration on the management of apple root borer covering an area of 5h was conducted. *Metarhizium anisopliae* (10^8conidia/g) was applied @ 30g/ tree basin mixed in well rotten farm yard manure (FYM) during July- August i.e. at the time of egg hatching and emergence of new/young grubs. Chemical treatment comprising of chlorpyriphos (0.06%) was also applied. *Metarhizium anisopliae* treatment resulted in 62.1 to 73.4 per cent mortality of the apple root borer grubs in different orchards, while in chlorpyriphos (0.06%) treated plants the grub mortality was 77.3 to 84.5%.

4.2.9.4 Evaluation of some biocontrol agents against leopard moth, *Zeuzera multistrigata* in apple

YSPUH&F: Results showed that chlorpyriphos (0.04%) was the most effective treatment resulting in 100 per cent mortality of the pest. Among different biocontrol agents evaluated, *Heterorhabditis bacteriophora* (5000IJs/gallery) (local culture) was the most effective resulting in 77.8 per cent mortality followed by *Steinernemma feltiae* (5000IJs/gallery)(local culture) and azadirachtin (2ml/L of 1500ppm; 10ml/gallery) (66.7% each). Other treatments were not very effective and resulted in 33.3 to 44.4 per cent pest mortality; in control no pest mortality was recorded.

4.2.10 BIOLOGICAL SUPPRESSION OF PESTS IN PLANTATION CROPS

4.2.10.1 Efficacy of biorationals on the bio-suppression of rugose spiraling whitefly

CPCRI, regional station, Kayamkulam: Results exhibited that palms treated with neem oil (5%) and water spray could reduce the RSW population significantly and closely followed by *Isaria fumosorosea*-treated palms (56.7%). The least reduction was observed on palms exposed to conservation biological control. Under natural suppression about 36.3% reduction could be obtained in a period of two months.

ANGRAU: Per cent reduction in whitefly intensity was observed high (71.01 % & 75.51%) after two sprays of *Isaria fumosorosea (*NBAIR- Pfu 5) than one spray (36.74% & 58.22 %).

DRYSRHU Ambajipeta: 15 days after second spray lowest number of egg spirals were recorded in neem oil and *I. fumosorosea* treated palm (8.63 and 9.65 egg spirals/leaflet). A high number of egg spirals were observed in natural conservation of *E. guadeloupae* and water spray treatment. However, the nymphal and adult population was observed to be low in Neem oil treatment as compared to other treatments. The numbers of parasitized nymphs (live & blackened) & nymphs with parasitoid emergence holes/leaflet and aborted nymph/pupae were found to be very low in all treatments including natural conservation of *E. guadeloupae* treatment without any significant difference.

TNAU: In a field trial, on 60^{th} day after 2^{nd} spraying, RSW nymphal population was drastically reduced in *Encarsia guadeloupae* (natural conservation) (20.0Nos.) when compared with foliar application of *Isaria fumosorosea* (pfu-5) @ $1x10^8$ cfu/ml (36.0Nos), foliar water spray (39.0Nos.) and foliar application of neem oil 0.5% (44.0 Nos.). Parasitised nymphs in *E.guadeloupae* (natural conservation) and foliar application of neem oil were same (14.00 Nos.) and higher than in *I. fumosorosea* (10.0 Nos.) and foliar water spray (13.0Nos.).

KAU Thrissur: There was no significant difference among the treatments at different intervals even after two rounds of sprays, except in case of nesting whitefly, where 15 days after second spray, the sprayed palms had significantly lower number of parasitized nesting whiteflies than in unsprayed trees.

KAU Vellayani: After 60 days of treatment, percentage reduction in number of RSW spirals was maximum in water spray (37.01%) followed by natural conservation (27.18%). Palms treated with *Isaria fumosorosea* (pfu-5) had 27.18 % reduction in live spirals. Neem oil 0.5 % was least effective (20%). *Isaria fumosorosea* (pfu-5) treatment was effective in reducing the number of pupae (42.18%) followed by neem 0.5% (34.21 %). However, parasitisation was found to be greatly reduced when treated with *I. fumosorosea* treatment (68.8 %). Water spray and neem oil 0.5% did not affect the parasitisation efficacy of *Encarsia*.

4.2.10.2 Biological suppression of Bondar's nesting whitefly in coconut

KAU Kumarakom: Per cent reduction of 17.73 and 8.38 over control were noted in the intensity of whitefly attack in treatments with *Isaria fumosorosea* (Pfu-5) and neem oil respectively at 20 days after spraying. However, significant reduction in per cent intensity could not be obtained at 60 days after spraying in any of the treatments.

4.2.10.3 *In vivo* evaluation of effective bio control agents against *Phytophthora* Pod rot management in cocoa

DRYSRHU Ambajipeta:

Pod rot: Soil application of 50 g of *Trichoderma reesei* along with 5kg Neem cake (once before onset of monsoon) resulted in reduction in pod rot from 45.5 to 53.3 per cent followed by spraying of *T. reesei* spore suspension (2×10^6 cfu/ml) @ 2 sprays at 15 days interval which led to reduction in pod rot from 32.5 percent to 81.8 %, whereas in control, pod rot percent increased from 30.8% to 35.2%.

Stem canker: Chiselling of canker area on the stem and application of *T. reesei* coir pith cake led to reduction in lesion size by 40.6 cm followed by chiselling of canker area on the stem and application of *T. reesei* paste formulation (2×10^6 cfu/ml) on the chiselled area with 32.4 cm reduction.

4.2.10.4 Field evaluation of bio-pesticides against tea red spider mite, *Oligonychus coffeae*.

UBKV: Among the tested fungal bio-pesticides, *Lecanicilium lecani* (NBAIR strain) reduced the mite population better which is statistically at par with azadirachtin 10000 ppm and *Beauveria bassiana* (NBAIR strain). However, best red mite management was noticed in the plots treated with Spiromesifen 240 SC in all spraying. Significantly highest yield of tea leaves was obtained in chemical treatment (6.56 qt/ha) followed by azadirachtin 10000 ppm (4.49 qt/ha), *Lecanicilium lecani* (4.25 qt/ha) and *Beauveria bassiana* (3.84 qt/ha).

4.2.11 BIOLOGICAL SUPPRESSION OF PESTS IN VEGETABLES

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

PAU: The pooled per cent fruit damage in BIPM (13.24%) was significantly lower than untreated control (17.93%). However, chemical control recorded minimum per cent fruit damage (10.86%). The per cent reduction in fruit damage over control was 49.47 and 26.15 per cent in chemical control and BIPM plot, respectively. The fruit yield in BIPM (27.16 q/ha) was at par with chemical control (30.94 q/ha).

AAU-A: No significant difference was observed between BIPM package and chemical control with regard to number of *H. armigera* larvae/plant and fruit damage. Chemical control module recorded the highest yield (16.87 t/ha) which was at par with the yield recorded in BIPM package (16.05 t/ha). However, lowest yield was recorded in untreated control (10.64 t/ha). It can be concluded that BIPM package is promising in minimizing the pest damage with higher yield.

YSPUH&F: Both the BIPM module and the chemical insecticides were statistically equally effective in managing the pest. The average fruit infestation was statistically same in all the plots and varied from 0.47 per cent in chemical control to 0.51 per cent in BIPM plots. Both the BIPM and chemical insecticides were statistically equally effective in reducing the fruit infestation by *T. absoluta* in tomato. The yield was maximum (26.1t/ha) in BIPM plots, but, statistically on par (24.9t/ha) with that recorded in chemical treated plots.

MPKV: Pooled means for two years (2017-18 and 2018-19) indicated that BIPM treatment recorded minimum larval population of *H. armigera* (1.43 larvae/10 plants) which was at par

with chemical treatment. In BIPM treatment, fruit damage on number basis (15.75%) and on weight basis (14.05 %) was at par with chemical treatment (20.58 %) and (17.15 %), respectively. Regarding sucking pest population, the BIPM treatment recorded minimum number of thrips (3.42 thrips/plant) and whiteflies (2.04 flies/plant). The highest marketable fruit yield (21.72 t/ha) was recorded in BIPM treated plots with B:C ratio (1.60) as against yield in chemical treatment (20.24 t/ha) with B:C ratio (1.53).

4.2.11.2 Bio-intensive insect management in brinjal

TNAU: The fruit damage in brinjal due to *Leucinodes orbonalis* was significantly low (17.82%) in plots sprayed with pesticides followed by 21.80 per cent fruit damage in BIPM plots (Azadirachtin 1500 ppm @2ml/lit (one round of spray) + *Lecanium lecanii* (one round of spray) + *Trichogramma pretiosum* (8 releases) + Pheromone traps @20/ha + Cowpea as bund crop). In the control plot fruit damage was 32.55 per cent. The marketable fruit yield was 12140Kg/ha in BIPM plots while in control plots the yield was 8495Kg/ha. The cost benefit ratio realized in BIPM was 1:3.90 as against 1:4.83 in insecticides treated plots.

AAU-J: BIPM module (Spray of Azadirachtin 1500 ppm @ 2ml/lt, Spray of *Lecanicillium lecanii* (NBAIR strain) 1x 10^8 spores/ml @ 5g/lt, Ten releases of *Trichogramma chilonis* multiple insecticide tolerant strain @100,000/ha, at weekly interval from initiation of flowering, Use of pheromone traps @ 20 nos/ha, Mechanical collection and destruction of infested shoot and fruits) was the next best treatment with 10.94 % shoot and 12.11% fruit infestation and contributed next higher yield of 205 q/ha after chemical treatment (six sprays).

4.2.11.3 Bio-efficacy of microbial agents against *Myllocerous subfasciatus* on brinjal

IIHR: The mean number of ash weevils per plant were significantly lower in *Heterorhabditis indica* @ 2.5 10^9 IJs ha^{-1} (4.22/plant) and *M. anisopliae* NBAIR (4.44/plant) followed by *B. bassiana* NBAIR (5.33/plant) and *B. bassiana* AAU strains (5.44/plant). The *B. bassiana* NBAIR and *M. anispoliae* AAU strains were showing significantly lower leaf damage scoring compared to other treatments.

4.2.11.4 Bio-intensive pest management (including RKN) in brinjal

CAU Pasighat: The BIPM module (*P. lilacinus* @ 20 g/m^2 (Root Knot Nematode management), Azadirachtin 1500ppm @2ml/L, *Lecanicillium lecanii* (NBAIR Strain) 1x10^8 spores/ml @ 5g/L (For Sucking Pests) and Mass trapping, Release of *Trichogramma chilonis* @ 100,000/ha. 8-10 release at weekly interval from initiation of flowering, *Bacillus thuringiensis* NBAIR BtG4 2% Spray (Brinjal Fruit and Shoot Borer)) was the next best treatment showing 14.33% shoot and 12.22% fruit infestation and gave 210.83 q/ha yield after chemical treatment (yield: 235.65 q/ha).

MPKV: The treatments with chlorpyriphos 0.04 per cent and BIPM were found at par with each other by recording shoot infestation (7.14 % and 8.64%), fruit damage on number basis (7.45% and 8.93 %) and on weight basis (4.33% and 5.14 %), respectively. The highest marketable fruit yield (228.45 q/ha) with B:C ratio 5.89 was recorded in chlorpyriphos 0.04 per cent treated plots which was at par with BIPM treated plot (212.93 q/ha) with B:C ratio 4.93.

4.2.11.5 To evaluate the efficacy of different biocontrol agents on fruit borer *Earias vittella* infesting okra

AAU-A: Application of *Bacillus thuringiensis* (1% WP - $2x10^8$ cfu/g) (NBAIR strain) @ 50g/10 liter water at fortnightly interval for three times or six releases of *Trichogramma chilonis* @ 50000/ha at weekly interval found effective for the management of fruit borer (*Earias vittella*) on okra. Highest fruit yield (111.02 q/ha) was recorded in *Bacillus thuringiensis* @ 5 g/ litre which was at par with *Trichogramma chilonis* @ 50,000 parasitoids/ ha (105.10 q/ha) and NSKE 5% (104.64 q/ha).

4.2.11.6 Field evaluation of ICAR-NBAIR entomopathogenic strains against cabbage aphid (*Myzus persicae*) and *Plutella xylostella* (DBM)

IIVR: Among the NBAIR biopesticide isolates tested, *Metarhizium anisopliae* (Ma-4 strain) was most promising with 57.13 per cent reduction over control against diamond back moth (*Plutella xylostella*) followed by *Lecanicillium lecanii* (Vl-8 strain). In case of aphid (*Myzus persicae*), maximum reduction (36.99) was recorded with *Lecanicillium lecanii* (Vl-8 strain) which is statistically superior over the other biopesticides followed by *Beauveria bassiana* (Bb-45 strain) with 24.43 percent reduction. However, amongst the all treatments, indoxacarb 14.5 SC @ 0.75ml/lit was the best both in reducing DBM and Aphids in cabbage.

AAU-J: Among the different EPF, V1-8 isolate of *L. Lecanii* @ 5 ml/litre was the best treatment in reducing the mean population of aphid (3.15/plant) and DBM (5.09/plant), with a higher yield of 196.0q/ha after chemical treatment. The rest of the EPF strains (Bb-5a, Bb-45, Ma-4) in reducing the cabbage aphids and DBM was equally effective, and found to be statistically different only from untreated control plots.

CAU Pasighat: Biocontrol based IPM significantly reduced the aphid population 3.5, 2.14, 1.8 colony/ per plant after 1^{st}, 2^{nd}, 3^{rd} spray respectively. Farmers sprayed dimethoate 0.05%, and recorded the aphid population of 4.5, 2.85, 2.5 colony per plant after 1^{st}, 2^{nd}, 3^{rd} spray respectively. Highest yield was recorded in biocontrol based IPM compared to chemical control. In case of DBM biocontrol based IPM recorded significantly lower incidence 1.6,0.9,0.4,0.22 DBM larvae/ leaf at 45, 60, 75 and 90 DAT, respectively. Highest yield 42370kg/ha was recorded in biocontrol based IPM.

4.2.11.7 Evaluation of Fungal pathogens against chilli yellow mite, *Polyphagotarsonemus latus*

UBKV: Among the tested fungal biopesticides, *Lecanicilium lecani* (NBAIR strain) significantly reduced the mite population as compared to the other two biopesticides. Significantly highest yield of green chilli was registered in chemical treatment (Spiromesifen 240 SC) (138 qt/ha) followed by *Lecanicilium lecani* (90.75 qt/ha), *Beauveria bassiana* (78.25 qt/ha) and *Metarhizium anisopliae* (72.50 qt/ha).

4.2.11.8 Screening of promising isolates of entomopathogenic fungi for management of mites in chilli

KAU Kumaralom: None of the bioagents could cause significant reduction in mite population after first and third sprays. However, Vl-8 isolate of *L. lecanii* showed significant reduction in mite infestation at 1st, 3rd, 5th and 9th days after fourth spray, where it was on par with the chemical check at 5thday after spray. *Lecanicillium lecanii* produced notable reduction of 79.91 per cent over control at 3rd day after fourth spray, which was followed by Bb-5a and Ma – 6.

4.2.11.9 Bio-efficacy of some bio-pesticides against white fly (*Bemisia tabaci*) and jassids (*Empoasca flavescens*) in cucumber

UBKV: Among the tested fungal biopesticides, *Lecanicillium lecani* (NBAIR strain) significantly reduced the whitefly population as compared to the other biopesticides. However, the chemical treatment (buprofezin 25SC) was superior in controlling the whitefly followed by azadirachtin 10000 ppm and *Lecanicillium lecani* (NBAIR strain). Significantly highest yield was obtained in chemical treatment (194.75 qt/ha) followed by azadirachtin 10000 ppm (106.75 qt/ha) and *Lecanicillium lecani* (103 qt/ha).

4.2.11.10 Evaluation of *Steinernema carpocapsae, Heterorhabditis indica* (NBAIR strain) and *H. pakistanensis* against lepidopteran pest complex

SKAUST Srinagar: *H. pakistanensis* treatment exhibited maximum larval mortality, both of *P. brassicae* (60.8) and *Plutella xylostella* (64.0) as compared to *H. indica* (42.4 and 53.6) and *S. carpocapsae* (24.8 and 36.8). *Heterorhabditis pakistanensis* was found superior over *H. indica* and *S. carpocapsae* in terms of larval mortality of *Plutella xylostella*. Active Juvenile stage (IJS/ plant) after 24 hrs. on kale was found maximum in case of *H. pakistanensis* (7900.00) followed by *H. indica* (5100.00) and *S. carpocapsae* (3800.00).

4.2.11.11 Efficacy of fungal and bacterial isolates on anthracnose disease of yard long bean

KAU Kumarakom: The fungal isolate *Trichoderma harzianum* (Th-3), *T. viride* (KAU strain) and *Pseudomonas fluorescens* (KAU strain) were effective in controlling yardlong bean anthracnose to about 67 per cent. The next effective treatment was *Hanseniaspora uvarum* (Y-73). Higher yields were obtained in biocontrol agent treated plots but were not significant when compared to control.

4.2.12 BIOLOGICAL SUPPRESSION OF OILSEED CROP PESTS

4.2.12.1 Bio-efficacy of entomopathogenic fungus against mustard aphid

AAU-J: Three rounds of sprays of dimethoate 30 EC @ 2ml/lit at 10 days interval significantly reduced the mean population of aphids (5.91 per 10 cm apical twig) in comparison to other treatments with highest yield of 7.60q/ha. However, it was at par with *Lecanicillium lecanii* (NBAIR strain) @ 5g/litre and *Beauveria bassiana* (AAU-J culture) in reducing the mustard aphids (10.0 and 11.19 /10 cm twig) with next higher yield of 7.35 q/ha and 7.10 q/ha, respectively.

4.2.13. BIOLOGICAL SUPPRESSION OF POLYHOUSE AND FLOWER CROP PESTS

4.2.13.1 Management of spider mite in cucumber using anthocorid predator, *Blaptostethus pallescens* under polyhouse condition

KAU Thrissur: Among all the treatments, spiromesifen at the rate of 100 g a.i ha^{-1} was the most effective treatment, with reduction in mean mite population from 3.89/ cm^2 to 0.08/cm^2. The mite population in plots where *B. pallescens* were released at 20/m row was comparable to that of acaricide treated plots. While 93.6 per cent of plants survived infestation in plots treated with spiromesifen, the corresponding figures were 66.4 per cent and 31.8 per cent for release rates of 20 and 10 bugs/m row respectively. None of the plants survived mite infestation beyond 20 days after release of mites in control plots.

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

IIHR: Among all the treatment *Beauveria bassiana* (NBAIR Bb5a) @ 5g/L followed by *Lecanicilium lecanii* (NBAIR Vl8) @ 5g/L was significantly effective against aphids on capsicum under polyhouse conditions. Thrips infestation was negligible during this period.

YSPUH&F: Among biocontrol agents, *Chrysoperla zastrowi sillemi* (4 larvae / plant) resulted in the highest (80.6%) reduction in the aphid population which was on par with imidacloprid (0.5ml/L) (90.3%) at 10 days of second spray. *Lecanicillium lecanii* (5g/l of 10^8 conidia/ g) (73%) and azadirachtin (2ml/L of 1500ppm) (68%) were also on par with *Chrysoperla zastrowi sillemi* (4 larvae / plant), but could not match with imidacloprid (0.5ml/L) treatment in their efficacy against the pest. Other biocontrol agents namely *Metarhizium anisopliae and Beauveria bassiana* (5g/L of 10^8 conidia/ g each) resulted in 54.3 to 58 per cent reduction in the aphid population over control 10 days after the second spray/ release.

4.2.14 LARGE SCALE ADOPTION OF PROVEN BIOCONTROL TECHNOLOGIES

4.2.14.1 Rice

PAU: Large scale demonstrations of biocontrol based IPM (5 releases of *T. chilonis* and *T. japonicum* each @ 1,00,000/ha) over an area of 248 acres rendered lower incidence of dead hearts in biocontrol field (1.60%) as against untreated control (3.60%) resulting in a reduction of 55.2 per cent. Similarly, leaf folder damage in release field was significantly lower in biocontrol fields (1.90%) as compared to untreated control (4.40%) with a mean reduction of 56.8 per cent. The mean incidence of white ears was significantly lower in biocontrol field (2.24%) as against untreated control (4.47%) resulting in a reduction of 49.9 per cent. The additional benefit in biocontrol practices was Rs 7760/- per ha over untreated control.

ANGRAU: Demonstration conducted in 14 acres area. Paddy stem borer damage was low in BIPM package (1.78 % dead heart) compared to farmers practice (6.25 % dead heart). Leaf folder was low (1.44%) in BIPM plot compared to farmers practice (7.48%). Grain yield recorded high in BIPM plot (5.38 t/ha) compared to farmers practice plot (4.9 t/ha). Adoption of BIPM package in three locations resulted in 9.65 % increased yields with high incremental ratio of 12.04 compared to farmers practice with low incremental ratio of 4.62.

AAU-A: Demonstration was carried out in 2 ha area. In BIPM package the number of damaged leaves/10 hill was 7.62, 9.37 and 12.12 at 30, 45 and 60 DAT, respectively. Whereas in farmers practice the number of damaged leaves/10 hill was 7.37, 11.75 and 14.50 at 30, 45 and 60 DAT, respectively. Significantly lower damaged leaves were recorded at 45 and 60 DAT in BIPM package as compared to farmers' practice. With regard to the yield, the two treatments found at par with each other. It can be concluded that use of BIPM strategies resulted in lower incidence of rice leaf folder and higher grain yield.

KAU Thrissur: Large scale validation of BIPM in rice was carried out over an area of 150 ha. The dead heart as well as white ear head symptoms in BIPM plots was approximately 75 per cent lower than in non BIPM plots. Similarly, leaf folder damage was only 30 per cent of what was reported from conventionally managed plots, while the rice bug population was less than 50 per cent of that in farmer's field. The yield obtained from BIPM plots was approximately 58 per cent more than that obtained from non BIPM plots. The increased yield as well as reduced cost resulted in an increase in profit by Rs 82,910/ha. The cost benefit ratio, at 2.90 for BIPM fields compared quite favorably with 1.66 for non BIPM fields.

GBPUA&T: Large scale demonstration was carried out on 12 ha area. An average yield of 65.0 q/ha was recorded by the farmers adopting bio-control technologies along with need- based organic practices as compared to an average yield of 50.0 q/ha by the farmers adopting conventional practices for the management of insect pests and diseases.

IIRR: Research Farm: Results indicated that organic cultivation with *Trichoderma* or *Pseudomonas* and without application of fertilizers and insecticides significantly reduced incidence of stem borer damage at both dead heart and white ear stage. The white ear damage was significantly higher in farmers practice with insecticidal treatment. However, the yield in organic practices with seed treatments (5980 and 5900 kg/ ha respectively) was also on par with farmers' practice (6340 kg/ha). The reduction in white ears in organic cultivation could be attributed to higher parasitisation of egg masses of stem borer observed (75.26 and 64.68%) as compared to 35.46 per cent in plots with insecticide application.

IIRR: Telangana (2 ha): The leaffolder incidence was lowest in the BIPMmodule with *Bacillus subtilis* seed treatment (4.37 %). The number of spiders observed per five hills were significantly higher in BIPM treatments with the highest number being recorded in the *Bacillus subtilis* based module.

IIRR: Odisha (1.6ha): Stemborer incidence was under ETL in the IPM fields (5.88 and 10.2% respectively) as compared to the significantly high incidence of 17.37 and 22.35 % in non IPM fields. There was an outbreak of brown planthopper in these districts and reached high numbers due to intermittent rains. But the population in IPM fields was significantly lower than that of non IPM fields.

4.2.14.2 Groundnut

AAU-A: Large scale demonstration covering 200 ha area exhibited significantly lower incidence of whitegrub in IPM module (0.39 larva/meter length row) as compared to farmers' practice (1.42 larva/meter length row). Higher yield was also recorded in IPM module.

4.2.14.3 Sugarcane

PAU: Large-scale demonstrations on the effectiveness of *Trichogramma chilonis* @ 50,000 per ha at 10 days interval over an area of **8208 acres** showed 57.14 percent incidence reduction of stalk borer, *Chilo auricilius* over untreated control. Similarly, *T. chilonis* @ 50,000 per ha at 10 days interval (eight releases) over an area of 2688 resulted in 53.9 and 80.4 per cent reduction over control in release fields and chemical control (chlorantraniliprole 18.5 SC @ 375 ml/ ha), respectively. However, the cost: benefit ratio (1: 18.16) was higher in biocontrol as compared to chemical control (1: 10.03). Release of *T. japonicum* against top borer, *Scirpophaga excerptalis* over an area of **510 acres** reduced its incidence over control by 53.4 and 79.7 per cent in release fields and chemical control (chlorantraniliprole 0.4 GR @ 25 kg/ha), respectively. The cost benefit ratio was higher in biocontrol (1: 17.60) as against chemical control (1: 11.08).

ANGRAU: Large scale demonstration using temperature tolerant strain *T. chilonis* was conducted in **13 acres** area against early shoot borer and internode borer. Cane yield and incremental benefit cost ratio recorded was high in temperature tolerant strain of *T. chilonis* released plot (63.93 t/ha and IBCR: 50.19) compared to farmers practice (53.54 t/ ha and IBCR: 6.74). Early shoot borer incidence upto 120 days was low in temperature tolerant strain *T. chilonis* release field with significantly low internode borer incidence (23.6%) and resulted in higher cane yield (83.82 t/ha) with high incremental benefit cost ratio (81.6) compared to farmer's practice.

UAS Raichur: (area: 10 ha) The per cent dead hearts was low in *T. chilonis* (temperature tolerant strain) release plot (1.25 per cent dead hearts per 10 mrl) which was significantly superior over farmers practice and untreated control which recorded 2.85 and 5.25 per cent dead hearts per 10 mrl, respectively. The highest cane yield of 123.50 t/ha was recorded in *T. chilonis* (temperature tolerant strain) release plot which was superior over the farmers practice and untreated control which recorded as 118.50 t/ha and 108.25 t/ha respectively.

MPKV: The pooled means of three years trial conducted during 2017-18, 2028-19 and 2019-20 revealed that eight releases of *T. chilonis* temperature tolerant strain @ 50,000 parasitoids/ha at weekly interval starting from 40 days after emergence of shoots was significantly superior to untreated control in reducing the ESB infestation (from 22.16 to 6.41 % dead hearts) and recorded maximum cane yield (139.64 Mt/ha) with B:C ratio 2.31.

PJTSAU: The module with six releases of *T. chilonis* @ 50,000/ha at weekly intervals fared better than farmers' practice in terms of infestation levels (9.23 percent incidence of early shoot borer compared to 10.57 percent in farmer's practice) as well as cane yield (79.89 t/ha in BIPM module and 71.45 t/ha in farmer's practice).

4.2.14.4 Pigeon pea

PAU: Large scale evaluation of NBAIR Bt formulation against pod borer complex in pigeonpea at farmer's field revealed that per cent pod damage and grain yield in NBAIR Bt G4 @ 2% (9.84%; 11.15q/ha) and chlorantraniliprole18.5 SC @ 150 ml/ha (5.97%; 12.05 q/ha) treatments were significantly superior to untreated control (20.59%; 9.75 q/ha).

4.2.14.5 Large scale field trials for the management *Helicoverpa armigera* (Hubner) on tomato

MPUAT: Demonstration experiment was conducted covering 2 ha area. BIPM package was equally effective as chemical control against *H. armigera*. Chemical control module recorded the highest yield (15.10 t/ha) which was at par with the yield recorded in BIPM package (14.35 t/ha). Significantly, low yield was recorded in untreated control (9.05 t/ha).

4.2.14.6 Maize

PAU: Large-scale demonstrations using *T. chilonis* against maize stem borer, *Chilo partellus* on an area of 448 acres showed that two releases of *T. chilonis* @ 1,00,000/ ha at 10 and 17 days old crop resulted in 53.2 per cent reduction in dead heart incidence over control as compared to 82.9 in chemical control. The additional benefit over untreated control in biocontrol package was Rs 5483/- per ha as compared to Rs 9764/- per ha in chemical control.

ANGRAU: Demonstration conducted in 15 acres during rabi, 2019-20. Damage by maize stem borer, *Chilo partellus* was nil in *Trichogramma chilonis* and *T. pretiosum* release plots and low in chemical sprayed plot (2.67% DH) and *Sesamia inferens* damage as shot holes was low in *T. pretiosum* release plot (6.39 %) followed by *Trichogramma chilonis* release plot (6.7 %) and high in chemical sprayed plot (11.84 %) .

Fall army worm, *Spodoptera frugiperda* damage recorded low in *Trichogramma pretiosum* release plot (15.72 %) followed by *Trichogramma chilonis* release plot (21.2 %) and high in chemical sprayed plot(41.45%).

4.2.14.7 Soybean

MPKV: The pooled result of trials conducted during 2017 and 2018 *Kharif* seasons indicated that two sprays of *Metarhizium rileyi* (Farlow) (N. rileyi*)* 2.0 x 10^8 cfu/g were significantly superior in suppressing the larval population of *S. litura* (2.46 larvae/m row) due to fungal infection with maximum soybean yield of 16.43 q/ha with BC ratio 1.62:1.

4.2.14.8 Pea

GBPUA&T: Large scale field demonstrations of bio-control technologies on pea were conducted covering an area of 25 ha during rabi season. Seed treatment with bio-agents resulted in considerably higher germination upto 30 per cent more than the conventional practices. There was no disease incidence in the crop. An average green pod yield of 80 q/ha was recorded with bio-control technologies as compared to 62 q/ha with conventional farmers practices.

4.2.15 Tribal Sub plan programme (TSP)

ANGRAU: Front line Demonstrations and trainings were conducted on organic farming of paddy, ginger, turmeric and vegetables at eleven villages in 165 acres benefitting 280 tribal farmers of Arakuvalley and Chinthapalli divisions,Visakhapatnam district, Andhra Pradesh. TSP

farmers benefited with organic farming technology in obtaining good yields in rice, ginger and turmeric and expressed willingness to adopt organic farming for achieving higher yields.

KAU Thrissur: A total of 184 farmers in Kottathara, Padinjarethara, Kuppadithara and Vengappalli Panchayats in Mananathavadi Taluk and Edavaka and Nallurnad Panchayats in Vythiri Taluk were provided with biopesticides. The major agriculture crops include black pepper, ginger, rice, turmeric, banana, coconut, arecanut, vegetables, cardamom, coffee and tea. The bioinputs distributed included trichocards, *Trichoderma viride*, *Pseudomonas flourescens*, *Lecanicillium lecanii*, *Paecilomyces lilacinus* and arbuscular mycorhizal fungi (AMF).

AAU-A: Biological interventions to enhance the crop production and productivity of tribal farmers of Narmada district in Gujarat

Tribal farmers (100 No.) from Dediyapada, Sagbara and Tilakwada tehsils of Narmada district covering ~1 acre area/farmer. Biopesticides and pheromone traps were distributed among farmers. Field visits were conducted to record the use of bio-inputs by the farmers and bio-efficacy of inputs. Significant reduction (35-40%) in use of chemical pesticides was recorded.

UBKV Pundibari: 195 farmers were trained and inputs were supplied to them for management of insect pests of vegetables, rice, and pulses.

AAU-J: A total of 200 farmers were selected from Baksa district dominated by tribal community. Four villages (Amarabati, Barama, Tamulpur and Baganpara) were selected under the programme. Biopesticides and neem pesticides were supplied to the farmers.

IGKV: About 150 farmers were selected all belonging to ST category. Three trainings were organised. Application method of Trichocards was demonstrated on a model plant. Low cost candle based light traps were also displayed. These were also distributed to the tribal farmers.

SKAUST: Under Tribal Sub Plan, inputs were given to seventy seven farmers, in a total of forty villages of subdivision Kargil and Leh. Interacted with the farmers and provided know- hows in each village for the use of distributed inputs. Beneficiaries from different villages of Kargil reported 20- 90.0 per cent increase in marketable yield.

YSPHU&F Solan: To manage the insect-pests and diseases of important cash crops through eco-friendly methods to minimize the use of chemical pesticides on these crops:
Two hundred farmers of Powari, Kangosh, Rangrik and Hurling villages of districts Kinnaur and Lauhal and Spiti of Himachal Pradesh covering 35 ha area of apple, almond, apricot, cabbage and pea were benefited from the trainings/demonstrations. These farmers were exposed to the use of bio-pesticides for pest management for the first time. In pea, cauliflower and cabbage there was a reduction of 2 sprays of chemical pesticides. In case of apple, farmers saved about Rs 15000/- per hectare by avoiding chemical treatment for the control of apple root borer.

5. Project Coordinator's and monitoring team visits to AICRP-BC centres during 2019-20

Sl. No.	Dates	Visit of Director/ NBAIR Scientist	Place of visit	Highlights of visit
1	06.-6.2019 to 07.06.019	Dr Chandish R. Ballal Director and Project Coordinator, NBAIR, Bengaluru	AAU Anand	To organize the 28th AICRP-BC workshop and monitor the progress of the centre.
2	22.08.2019	Dr Chandish R. Ballal Director and Project Coordinator, NBAIR, Bengaluru	AAU Anand	Reviewed the progress of the committed AICRP-BC programme
3	13.05.2019	Dr N. Bakthavatsalam Principal Scientist & HOD	IGKV, Raipur	Reviewed the progress of the committed AICRP-BC programme
4	29.05.19 09.11.19 27.01.20	Dr.G.Sivakumar, Principal Scientist, NBAIR, Bengaluru	TNAU, Coimbatore	Reviewed the progress of the committed AICRP-BC programme
5	13.09.19	Dr.N.Bakthavatsalam, Principal Scientist, & HOD NBAIR, Bengaluru	TNAU, Coimbatore	Reviewed the progress of the committed AICRP-BC programme
6	26.09.19	Dr.R.Chandish Ballal, Director and Project Coordinator, NBAIR, Bengaluru	TNAU, Coimbatore	Reviewed the progress of the committed AICRP-BC programme
7	13.12.2019	Dr. Sreeramkumar, Principal Scientist and Dr. Sampath, Scientist, NBAIR, Bengaluru	KAU Thrissur	Reviewed the progress of the committed AICRP-BC programme
8	23.12.2019	Dr Chandish R. Ballal Director and Project Coordinator, NBAIR, Bengaluru	NCIPM, New Delhi	Reviewed the progress of the committed AICRP-BC programme
9	02.02.2020	Dr Chandish R. Ballal Director and Project Coordinator, NBAIR, Bengaluru	MPKV Pune	Reviewed the progress of the committed AICRP-BC programme
10	05.02.2020	Dr Chandish R. Ballal Director and Project Coordinator, NBAIR, Bengaluru	IIHR, Bengaluru	Reviewed the progress of the committed AICRP-BC programme
11	14.02.2020	Dr Chandish R. Ballal Director and Project	UAS Raichur	Reviewed the progress of the committed AICRP-

		Coordinator, NBAIR, Bengaluru		BC programme
12	25.02.2020	Dr Chandish R. Ballal Director and Project Coordinator, NBAIR, Bengaluru	CAU Imphal	Reviewed the progress of the committed AICRP-BC programme

6. Publications: During the year 2019-20, a total of 431 Research papers/symposium papers/reviews/technical bulletins, etc. were published by the different centers.

Centre	**Research papers in journals**	**Papers in Symposia/Seminars**	**Books/ Book Chapters /Tech. Bulletins/ Popular articles/ Newsletters/Proceedings articles**	**Total**
NBAIR,Bangalore	66	58	93	217
AAU, Anand	3	2	5	10
AAU, Jorhat	8	-	13	21
ANGRAU	4	2	2	8
GBPUAT,Pantnagar	5	4	12	21
KAU, Thrissur	-	-	-	-
KAU, Vellayani	2	4	-	6
MPKV, Pune	4	-	2	6
MPUAT, Udaipur	1	3	3	7
PAU, Ludhiana	6	6	7	19
UAS Raichur	5	19	1	25
TNAU, Coimbatore	13	-	2	15
SKUAST, Srinagar	6	1	-	7
SKAUST Jammu	4	3	7	14
DRYSRUH	-	-	-	-
YSPUHF, Solan	10	3	-	13
IGKV	4	-	7	11
UBKV	5	8	1	14
CISH	-	-	-	-
CPCRI	2	7	6	15
IIVR	1	1	-	2
Total	**149**	**121**	**161**	**431**

7. Profile of experiments and demonstrations carried out during 2019-20

Crop/Insect	Experiments	Large Scale Demonstrations
Biodiversity of biocontrol agents	5	-
Antagonists of crop disease management	2	-
Sugarcane	3	5
Cotton	5	-
Rice	5	7
Cereals	6	2
Plantation crops	3	-
Pulses	5	1
Oilseeds	1	2
Tropical and temperate fruits	9	1
Vegetables	11	2
Polyhouse crops	3	-
Tea	1	-
TSP	8	-
Total	**67**	**20**

8. Budget of AICRP on Bio control for 2019-20

Item of Expenditure	Sanctioned and allotted grants (Rs. in lakh)	Grants released during 2019-20 from ICAR (Rs. in lakh)	Total expenditure (Rs.)
Pay and allowances	225.38	225.38	225.38
Rec. Contingencies	387.40	387.40	387.40
T.A	66.40	66.40	66.40
TOTAL	**679.18**	**679.18**	**679.18**

PROCEEDINGS OF THE TECHNCIAL SESSIONS

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

SESSION I: BASIC RESEARCH ON BIODIVERSITY AND NATURAL ENEMIES OF INSECT PESTS AND BIOLOGICAL CONTROL OF PLANT DISEASES

Chairmen : Dr. T.R. Sharma, DDG (CS), ICAR, New Delhi
: Dr. S.K. Jalali, Former Head (Genomic Resources), ICAR- NBAIR, Bengaluru

Repporteurs : Dr. Jagadeesh Patil, ICAR-NBAIR, Bengaluru
Dr. Neelam Joshi, PAU, Ludhiana

Achievements

- There are many first report of parasitoid parasitizing faa armyworm eggs. For Ex. *Cotesia ruficrus* parasitizing *S. frugiperda* , *Coccygidium transcaspicum* as a parasitoid of *S. frugiperda* across the globe.
- An egg-larval parasitoid, *Chelonus formosanus* Sonan (Hymenoptera: Braconidae) parasitizing *S. frugiperda* in India (in natural field conditions) was also recorded and this is amenable to mass production (in laboratory conditions).
- Parasitism of *Trichogramma chilonis* Ishii was recorded on *Spodoptera frugiperda* (J.E. Smith) for the first time on eggs of fall armyworm infesting maize.
- *Neoseiulus indicus* could reduce red spider mite population in rose by 88% followed by *Blaptostethus pallescens* where 46% reduction in mite population was observed
- ICAR-NBAIR Ma-35 and ICAR-NBAIR-Bb-45 showed 62-86% of pest reduction in FAW population in maize, respectively.
- NBAIR Bt-25 showed 85%,88% and 76% decrease in FAWincidence over control, respectively at three different places.
- In glass house studies, the endophytic isolates of *B. bassiana* (ICAR-NBAIR Bb-5a & Bb-45) and *M. anisopliae* (ICAR-NBAIR-Ma-4 & Ma-35) caused 8.4-76% mortality on second instar larvae of *Plutella xylostella* when applied through different inoculation methods. Among the isolates tested, Ma-35 isolate caused highest mortality on *P. xylostella* in all the application methods.
- Minimum Sheath blight (*Rhizoctonia solani*) disease severity was recorded with PBAT-3 (30.30%) followed by Carbendazim (30.58 %), Th17+Psf-2 (31.00%) and Th17+Psf-173 (31.29%)
- In mixed formulation treatments, highest germination percentage in rice was observed in PBAT-3 (87.00 %) followed by, Th17+Psf-173 (84.66%), Carbedazim (81.83%)

Biodiversity, biosystematics, molecular characterization and Biocontrol potential of new natural enemies (ICAR-NBAIR)

Speaker: Dr. Richa Varshney, ICAR-NBAIR, Bengaluru.

Recommendations:

- Biodiversity data should be reported on season wise, crop wise and region wise. (NBAIR and **All AICRP-BC Centres)**

Biodiversity and pest outbreak reports

Speaker: Dr. M. Sampath Kumar, ICAR-NBAIR, Bengaluru

Recommendations:

- Pest incidence level above threshold level should be reported in pest outbreak report.

Biological control of plant diseases using antagonists:

Speaker: Dr. Rupali Sharma, GBPUA&T, Pantnagar

Recommendations:

- While reporting local strain to be potent its genotyping characterization must be done to know how it is different from other strains**.(GBPUA&T Pantnagar)**
- Economics of experiment should be considered for farmers to take up the technology. **(GBPUA&T Pantnagar)**
- More concentration on biological control of plant diseases should be given and centers for this may be identified. In future data on percent disease and yield should be provided instead of agronomical data. **(All AICRP-BC Centres)**

SESSION II: BIOLOGICAL SUPPRESSION OF PESTS OF FRUIT, VEGETABLE

CROPS AND POLYHOUSE CROP PESTS

Chairmen : Dr. P.K. Chakrabarty, Member, ASRB & former ADG (PP&BS), ICAR, NewDelhi
Dr. Rajan, ADG (PP&BS), ICAR, New Delhi

Rapporteurs : Dr. Amala Udayakumar, ICAR-NBAIR Bengaluru
Dr. N. Chalapathi Rao, DRYSRHU, Ambajipeta

Achievements

- In mango, among the bio pesticides, low incidence of hopper was recorded in *B. bassiana* (NBAIR formulation) which registered 6.23 hoppers/ panicle at 7 days after spraying.
- Significant difference in mango leaf webber population was found between *Beauveria bassiana* and *Metarhizium anisopliae* at 7, 15 and 21 days after the spray.
- Per cent reduction in damage over control was found highest in Treatment 2 (Light trap + Pheromone trapping + four releases of *T. cacoeciae*+ trunk banding + use of *H. pakistanensis*+ field sanitation) (61.28) followed by treatment 1 (Two sprays of Chlorpyriphos 20 EC @ 1.0 ml./ lit. of water + Pheromone + Trunk banding+ field sanitation) (44.61) and (Farmer's practice) (33.68) which was statistically different for treatments.

- *Metarhizium anisopliae* treatment resulted in 62.1 to 73.4 per cent mortality of the apple root borer grubs in different orchards.
- Pooled means for two years (2017-18 and 2018-19) indicated that BIPM treatment recorded minimum larval population of *H. armigera* (1.43 larvae/10 plants) in tomato which was at par with chemical treatment.
- Application of *Bacillus thuringiensis* (1% WP - $2x10^8$ cfu/g) (NBAIR strain) @ 50g/10 liter water at fortnightly interval for three times or six releases of *Trichogramma chilonis* @ 50000/ha at weekly interval found effective for the management of fruit borer (*Earias vittella*) on okra.
- Among the different EPF, V1-8 isolate of *L. Lecanii* @ 5 ml/litre was the best treatment in reducing the mean population of aphid (3.15/plant) and DBM (5.09/plant), with a higher yield of 196.0q/ha after chemical treatment in cabbage
- Among all the treatment *Beauveria bassiana* (NBAIR Bb5a) @ 5g/L followed by *Lecanicilium lecanii* (NBAIR Vl8) @ 5g/L was significantly effective against aphids on capsicum under polyhouse conditions..

Tropical &Temperate fruits
Speaker: Dr. B. R. Jayanthi Mala, ICAR-IIHR Bengaluru

Vegetables, Polyhouse crop pests & Flowers
Speaker: Dr. Jaydeep Halder, ICAR-IIVR Varanasi

Recommendations:

- Biological control agents are a component of IPM and needs integration in BIPM module. Thus in all experiments approved insecticides and their compatibility with biocontrol agents may be studied for microbial agents to the extent possible. **(All AICRP-BC Centres)**
- Nematicides *viz*., Fluensulfone and fluopyram may be used as control in the trial on management of guava root knot nematode. **(CISH, Lucknow)**
- Cost benefit ratio to be worked out in experiments of mealybug, mango leaf webber and apple codling moth management trials with the help of an economist**(All fruit centres)**
- A treatment comprising of combination of entomofungal bioagent and insecticide application can be used in the trials on mango webber and apple borer management. **(CISH, Lucknow and YSPUHF, Solan)**
- For protected cultivation, mass production in commercial scale for sucking pests need perfection and generation in regular norms. In greenhouse mites, aphids, jassids, thrips, whiteflies etc. are common pests. Mass production protocols for predatory mites/wasps like *Amblyseius, Phytoseiulus, Neoseiulus, Eretmocerus, Encarsia*for whiteflies, *Diglyphus*and *Orius* for leafminers etc., needs to be standardized and developed in commercial scale **(NBAIR and All AICRP-BC Centres)**
- Government may exempt or simplify registration/toxicological data requirement wherever the pheromone is used at low active ingredient (eg. Less than 50 active ingredient or while using nano matrix-based dispensers at active ingredient less than 10g/acre). Such devices should GST free /incentivized.
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SESSION III: BIOLOGICAL SUPPRESSION OF PESTS OF SUGARCANE AND COTTON

Chairmen : Dr. H.C. Sharma, Former Vice-Chancellor, YSPUHF, Nauni, HP
Dr. B. Ramanujam, Principal Scientist, ICAR-NBAIR, Bangalore

Rapporteurs : Dr. S.M. Galande, MPKV, Pune
Dr. Raghunandan, B.L. AAU, Anand

Achievements:

- In sugarcane, plant damage was lowest (8.50 %) in *Heterorhabditis indica* WP (ICAR-NBAIR) and it was at par with *Metarhizium anisopliae* (ICAR-NBAIR Ma 4) and Chlorantraniliprole 18.5 SC which recorded 9.25 and 6.50 per cent plant damage.
- Amongst EPN *H. indica* @ $1.0x10^5$/ m^2 (NBAIR WP formulation) treatment recorded 54.72 % and become next promising treatment after chemical treatment (Fipronil) for suppressing white grub in sugarcane.

- In the cotton field trial, pink boll worm damage was 22.50 per cent in BIPM plots which was 28.57 per cent lesser than the damage in the control plot.

- Amongst the biopesticides, *Lecanicillum lecanii* (1 x 10^8conidia/g) @ 5 g/litre recorded lowest population of sucking pests *viz.,* aphids (5.74), jassids (2.69), thrips (2.61), and white flies (1.77) on 3 leaves per plant compared to the untreated control.

Sugarcane
Speaker: Dr. M. Visalakshi, ANGRAU, Anakapalle

Cotton
Speakers: Dr. Jeyarajan Nelson, TNAU, Coimbatore

Recommendations:

- In case of large scale demonstration trials, centres may increase the area under coverage so as to stimulate the supply chain of biocontrol agents for eco-friendly management of insect pests. **(All AICRP-BC Centres)**
- Centres must ensure the inclusion of biocontrol agents (at least predators and parasitiods)which does not require CIB registration in university package of practice after the successful evaluation of biocontrol agent against particular pest in a particular crop. **(All AICRP-BC Centres)**
- While recording CB ratio or increase in yield due to biocontrol intervention, the yield. advantage in terms on monetary benefits must be mentioned **(All AICRP-BC Centres)**
- Large scale demonstration trials with *Trichogramma* against borer pests of sugarcane maybe taken up by SBI, Coimbatore.**(SBI, Coimbatore)**
- ANGRAU centre may explore taking up of demonstration trials with EPF/ EPN against sugarcane white grub in other parts of Andhra Pradesh when pest incidence is reported.**(ANGRAU, Anakapalle)**

SESSION IV: BIOLOGICAL SUPPRESSION OF PESTS OF RICE AND MAIZE

Chairmen : Dr. R.J. Rabindra, Former Director, ICAR-NBAIR Bengaluru
Dr. A. Krishnamurthy, Principal Scientist (Rtd.), ICAR – IIHR Bengaluru
Rapporteurs : Dr. M. Sampat Kumar, ICAR- NBAIR, Bengaluru
Dr. P. S. Shera, PAU, Ludhiana

Achievements:

- The population of plant hoppers in BIPM and control plots was 1.93 and 3.00 per hill, respectively resulting in a reduction of 35.8 per cent over control.
- Plots treated with *B. thuringiensis*, *H. indica*, and *B. bassiana* had significantly lower number of dead hearts (3.66, 5.00 and 8.33/ m^2 respectively) than remaining treatments 28 days after the third spray.
- *Lecanicillium saksenae* @ 10^7 spores ml^{-1}, was the best treatment to manage *L. acuta* population, when sprayed twice at the panicle initiation and milky stage of the crop.
- Significant maximum grain yield/plot (31.56 kg) was obtained in BIPM treatment followed by farmer's practice (28.88kg)/plot and control (25.25 kg) per plot respectively.
- Large scale demonstrations of biocontrol based IPM (5 releases of *T. chilonis* and *T. japonicum* each @ 1,00,000/ha) over an area of 248 acres rendered lower incidence of dead hearts in biocontrol field (1.60%) as against untreated control (3.60%) resulting in a reduction of 55.2 per cent in Punjab.
- In Kerala, the yield obtained from BIPM plots was approximately 58 per cent more than that obtained from non BIPM plots. The increased yield as well as reduced cost resulted in an increase in profit by Rs 82,910/ha. The cost benefit ratio, at 2.90 for BIPM fields compared quite favorably with 1.66 for non BIPM fields.
- In Maize among the biocontrol agents, 89.24 per cent damaged plants was observed in *Trichogramma pretiosum*+ *Beauveria bassiana* NBAIR -Bb 45 followed by *Trichogramma pretiosum*+ *Metarhizium anisopliae* Ma 35 (89.75%), *Trichogramma pretiosum*+ NBAIR Bt 2% (90.58%) and *Trichogramma pretiosum*+Spfr NPV(NBAIR1) (90.67%) on 45 days after sowing.
- Number of FAW egg mass laid in maize were minimum in *Trichogramma pretiosum* 1 Card/ acre +NBAIR *Bb 45* (1.66) and *Trichogramma pretiosum* 1 Card/ acre + NBAIR *H* 38 (2.00) and *Trichogramma pretiosum* 1 Card/ acre + *Pf* DWD 2% (2.67) and were significantly different compared to control.

Rice
Speaker: Dr. Chitra Shanker, ICAR-IIRR, Hyderabad

Maize
Speaker: Dr. Arunkumar Hosamani, UAS, Raichur
Recommendations

- As encouraging results have been obtained with *Lecanicillium saksenae* in controlling rice bug with no obvious impact on natural enemies, *L. saksenae* may be evaluated for efficacy against all the important sucking pests of rice in multilocation trials at a few

centres. Cultures/ Formulation of the fungus should be sent to NBAIR for further action **(KAU, Vellayani& NBAIR)**

- Instead of schedule-based application / release of natural enemies, need-based application based on pest occurrence may be made. Release of *Trichogramma* for the management of stem borer and leaf folder should be made based on occurrence eggs scouted by monitoring. Earlier studies have shown that *T. japonicum* can parasitize both the stem borer and the leaf folder eggs **(All AICRP-BC centres).**
- The proven model of IPM involving the release of *T. japonicum* and *Pseudomonas fluorescens* demonstrated in the entire Adat and nearby panchayats may be compared with any new models that are evaluated and the cost benefit ratio may be worked out **(KAU, Thrissur).**
- Data on dead hearts, white ears and leaf folder damage may be recorded as a percentage in addition to number per m^2**(All AICRP-BC Centres)**.
- Potential bioagents (macrobials & microbials) may also be supplied to All India Coordinated Rice Improvement Project for evaluation under biopesticide/IPM trials in rice from different Network centres across India **(NBAIR, AICRP- RICE, IIRR, Hyderabad).**
- Keeping in view of the natural parasitisation by *T.chilonis* on FAW, it is suggested to have a midterm change in the technical programme to include the parasitoids, *T. chilonis* and *Telenomus remus* as treatments to compare with *T. pretiosum*. The NBAIR may provide nucleus cultures of *Telenomus* **(NBAIR and All AICRP-BC Centres).**
- It was quite evident from the Adhoc trials undertaken by various centres that bioagents both macrobials and microbials including EPN are effective in suppressing the Fall armyworm and increased yield on par with the chemical control. Centres should ensure that a supply chain for biocontrol agents is established in model of the State Biocontrol laboratory, Mannuthi, Thrissur Kerala **(All AICRP-BC Centres)**.

SESSION V: BIOLOGICAL SUPPRESSION OF PESTS OF PULSES

Chairmen : Dr. H. B. Singh, Professor (Rtd.), BHU, Varanasi
: Dr. T. Venkatesan, Principal Scientist, ICAR-NBAIR, Bengaluru

Rapporteurs : Dr. A. Kandan, ICAR-NBAIR, Bengaluru
Dr. Omprakash Navik, ICAR-NBAIR, Bengaluru

Achievements

- Significantly minimum damage of pod borer in pigeon pea (13.13 %) was observed in Bt treatment (T1) followed by treatment T2 with insecticidal sprays recording 14.13 % pod damage and both the treatments were significantly superior to untreated control
- *Beauveria bassiana* (NBAIR Strain) and malathion were significantly superior to the untreated control with mean pod damage of 34.05 per cent by pod bug in cowpea.
- **In chickpea** Maximum plant stand at 60 DAS and 120 DAS respectively was recorded with consortium Th17+Psf173 followed by PBAT-3 and other treatments.
- Larval population in both the BIPM modules (BIPM 1: Erection of bird perches Spray of HaNPV strain twice during the early pod formation stage at 15 days interval, Use of pheromone traps @ 1 trap per plot; BIPM module -2: Erection of bird perches Spray of

Bacillus thuriengiensis at 7 day interval, 2 sprays twice during the early pod formation stage at 15 days intervals, Use of pheromone traps @ 1 trap per plot) were statistically similar with 3.17 and 3.00 larvae/ 10 plants respectively on seventh day after spraying (DAS).

Speaker: Dr. B. L. Raghunandan, AAU, Anand

Recommendations / Suggestions

- The management options should be addressed for the pod borer complex of pigeon pea such as *Maruca vitrata*, pod wasp, pod fly along with *Helicoverpa armigera* under field conditions. **(All pulses Centres).**
- Formulation of *B. thuringiensis* strain BtG4 should be used as component of IPM in pigeon pea and two sprays may be taken in pigeon pea **(All pulses Centres).**
- BIPM adopted for pod borer management in pigeon pea should follow uniform observation *viz*., No. of larvae, per cent pod damage, grain yield and also record the occurrence of natural enemies on the pod borer complex by all the centres **(All AICRP-BC Centres).**

SESSION VI: BIOLOGICAL SUPPRESSION OF PESTS OF OILSEEDS AND PLANTATION CROPS

Chairmen : Dr. Abraham Verghese, Former Director, ICAR-NBAIR, Bengaluru
Dr. N. Bakthavatsalam, Head, GC&U, ICAR-NBAIR, Bengaluru

Rapporteurs : Dr. K. Selvaraj, Scientist (Entomology), ICAR-NBAIR
Dr R.N.Borkakati, AAU, Jorhat

Achievements

- Palms treated with neem oil (5%) and water spray could reduce the RSW population significantly and closely followed by *Isaria fumosorosea*-treated palms (56.7%).
- Lowest number of egg spirals were recorded in neem oil and *I. fumosorosea* treated palm (8.63 and 9.65 egg spirals/leaflet) 15 days after second spray.
- Per cent reduction of 17.73 and 8.38 over control were noted in the intensity of **Bondar's nesting whitefly** attack in treatments with *Isaria fumosorosea* (Pfu-5) and neem oil respectively at 20 days after spraying.
- Chiselling of canker area on the stem and application of *Trichoderma reesei* coir pith cake led to reduction in lesion size by 40.6 cm followed by chiselling of canker area on the stem and application of *T. reesei* paste formulation (2×10^6 cfu/ml) on the chiselled area with 32.4 cm reduction.
- *Lecanicilium lecani* (NBAIR strain) reduced the spider mite population in tea better which is statistically at par with azadirachtin 10000 ppm and *Beauveria bassiana* (NBAIR strain).
- *Lecanicillium lecanii* (NBAIR strain) @ 5g/litre and *Beauveria bassiana* (AAU-J culture) were found to be at par with chemical treatment in reducing the mustard aphids (10.0 and 11.19 /10 cm twig) population with yield of 7.35 q/ha and 7.10 q/ha, respectively.

Oilseed crops
Speaker: Dr. S. J. Rahman, PJTSAU, Hyderabad

Coconut and Tea
Speaker: Dr. A. Joseph Rajkumar, ICAR-CPCRI, Kayamkulam

Recommendations:

- Dr H.C. Sharma appreciated the intensive study on invasive whiteflies on coconut and opined that similar kind of studies may be extended to other crops with minimum of 5 AICRP on BC centers. He also advised to explore other tree oil available in the market to compare neem oil against whiteflies associated with coconut (**Action: All centres).**
- Concepts of ecological engineering in pest management of coconut may be refined and popularized (**Action: All AICRP-BC centres).**
- A detailed study on the competitive regulation and coexistence of different invasive whiteflies on coconut is envisaged (**Action: NBAIR and All centres).**
- Impact of *Isaria fumosorosea*on natural parasitism of *Encarsia guadeloupae* need to be studied in detail for the synergistic utilization of these bioagents on coconut.(**Action: NBAIR and All centres).**
- Cost benefit ratio may be worked for the area-wide demonstration of bio-suppression of white grub in groundnut. **(Action: AAU, Anand).**
- *Metarhizium anisopliae* (MA4) was found as a promising bio-control agent and therefore all centres may procure the technology from ICAR-NBAIR for localized production and distribution to farmers **(Action: All centres).**
- Conservation technologies for parasitoids of mustard aphid may be worked out (**Action: AAU, Jorhat).**
- The components of BIPM package may be discussed with AINP on soil arthropods to avoid conflict in recommendations **(Action: AAU, Anand).**

SESSION VII: TRIBAL SUB PLAN PROGRAM

Chairmen	:	Dr. M.J. Chandre Gowda, Director, ICAR-ATARI,Bengaluru
	:	Dr. A.N. Shylesha, Principal Scientist, ICAR-NBAIR, Bengluru
Rapporteurs	:	Dr. Roopali Sharma, GBPUAT, Pantnagar
		Dr. P. L. Sharma, YSPUHF, Solan
Speaker	:	Dr. Chalapati Rao, HRS, Ambajipeta

Achievements:

- In Andhra Pradesh, front line demonstrations and trainings were conducted on organic farming of paddy, ginger, turmeric and vegetables at eleven villages in 165 acres benefitting 280 tribal farmers of Arakuvalley and Chinthapalli divisions,Visakhapatnam district, Andhra Pradesh.

- **In Kerala, a** total of 184 farmers in Kottathara, Padinjarethara, Kuppadithara and Vengappalli Panchayats in Mananathavadi Taluk and Edavaka and Nallurnad Panchayats in Vythiri Taluk were provided with biopesticides. The bioinputs distributed included trichocards, *Trichoderma viride*, *Pseudomonas flourescens*, *Lecanicillium lecanii*, *Paecilomyces lilacinus* and arbuscular mycorhizal fungi (AMF).
- In Gujarat, Tribal farmers (100 No.) from Dediyapada, Sagbara and Tilakwada tehsils of Narmada district covering ~1 acre area/farmer were pselected and biopesticides and pheromone traps were distributed among the farmers. Significant reduction (35-40%) in use of chemical pesticides was recorded.
- In west Bengal a total of 195 farmers were trained and inputs were supplied to them for management of insect pests of vegetables, rice, and pulses.
- In Aasam a total of 200 farmers were selected from Baksa district dominated by tribal community. Four villages (Amarabati, Barama, Tamulpur and Baganpara) were selected under the programme. Biopesticides and neem pesticides were supplied to the farmers.
- In Chattisgarh a **total of** 150 farmers were selected all belonging to ST category. Three trainings were organised. Application method of Trichocards was demonstrated on a model plant. Low cost candle based light traps were also displayed. These were also distributed to the tribal farmers.
- In Kashmir, inputs were given to seventy seven farmers, in a total of forty villages of subdivision Kargil and Leh. Interacted with the farmers and provided know- hows in each village for the use of distributed inputs. Beneficiaries from different villages of Kargil reported 20- 90.0 per cent increase in marketable yield.
- In Himachal Pradesh, two hundred farmers covering 35 ha area of apple, almond, apricot, cabbage and pea were benefited from the trainings/demonstrations. In pea, cauliflower and cabbage there was a reduction of 2 sprays of chemical pesticides. In case of apple, farmers saved about Rs 15000/- per hectare by avoiding chemical treatment for the control of apple root borer.

Recommendations / Suggestions (Action: All concerned centres)

- Centres are providing consumables to the tribals, and in addition some support for establishments need to be given.
- Local KVKs need to be involved for better dissemination of technology and supply of inputs.
- Centres should start impact analysis and increase in income, number of technologies adopted, beneficiaries and benefits can be the immediate impact to be measured and documented.
- Availability of quality inputs at the ground level at a right time should be ensured.
- Centres should also supply basic inputs like quality seed in addition to biocontrol inputs.
- Previous beneficiaries may be utilised in future trainings to share their experiences with the new beneficiaries.
- Budget utilisation should be planned from the beginning to avoid the last movement hurry to purchase anything not relevant or less relevant.
- Standard format for TSP should be shared to all centres.

SESSION VIII: TECHNICAL PROGRAMME

Panel of experts: Dr. Chandish R. Ballal, Director, ICAR- NBAIR, Bengaluru
Dr. S. K. Jalali, Former HOD (Genomic Resources), ICAR- NBAIR, Bengaluru
Dr. B. Ramanujam, Principal Scientist,ICAR-NBAIR, Bengaluru
Dr. G. Sivakumar, ICAR-NBAIR, Principal Scientist, Bengaluru

Repporteurs : Dr. M. Sampath Kumar, ICAR-NBAIR, Bengaluru
Dr. Richa Varshney, ICAR-NBAIR, Bengaluru
Dr. K. Selvaraj, ICAR-NBAIR, Bengaluru
Dr. Amala Udayakumar, ICAR-NBAIR, Bengaluru

Speaker: Dr.Jagadeesh Patil, ICAR –NBAIR,Bengaluru

Recommendations:

- Keeping in view of the natural parasitisation by *T. chilonis* on FAW, it is suggested to have a midterm change in the technical programme to include the parasitoids, *T. chilonis* and *Telenomus remus* as treatments to compare with *T. pretiosum*. The NBAIR may provide nucleus cultures of *Telenomus* **(NBAIR and All AICRP-BC Centres).**

- All the centres should also focus on plant disease management and to develop integrated disease management strategies using the native local isolates for the management of serious crop diseases (**All AICRP BC Centres**).

SESSION IX: INSTITUTE-INDUSTRY- DEPARTMENT PARTNERSHIPS

Chaired by : Dr. T. M. Manjunath, Former Director, M/s. Monsanto, Bengaluru
Dr. M. S. Rao, Principal Scientist (Rtd.), ICAR-IIHR, Bengaluru
Dr. M. Nagesh, HOD (Genomic Resources), ICARNBAIR, Bengaluru

Rapporteur: Dr. Jaydeep Halder, IIVR, Varanasi,
Dr. Richa Varshney, NBAIR, Bengaluru

Presenter : Speakers from various industries

Recommendations / Suggestions

- While it is encouraging that, there are about 200 registered biopesticide manufacturers in India who are involved in commercial production of microbials, but, at the same time, it is disappointing that none is engaged in the commercial production and supply of macrobials (parasitoids and predators). This area calls for special attention for proper collaboration for PPP **(All AICRP-BC Centres)**

- The industry may continue to take the basic technologies and products developed by NBAIR and make further progress to scale up the production etc. to suit the commercial needs **(NBAIR ITMU).**
- The biopesticide industry has become vibrant and responsive to the technologies evolved from the ICAR-NARES (NBAIR, AICRP BC, SAUs, KVKs etc.) for the benefit of the farming community. The complimentarily and synergy among researchers, industry and other stakeholders can be strengthened by consultancy/contract /industrial funding for research relating to specific industrial requirements.

General recommendation

- Strain name and source of entomopathogenic organisms should be mentioned in the experiment results. **(All AICRP-BC Centres)**

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Experts & Special External Invitees

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Dr. Chandish R.Ballal, Director Dr. N. Bakthavatsalam, Principal Scientist & HOD(GC&U.) Dr. Sunil Joshi, Principal Scientist & HOD (GC& C) Dr.M. Nagesh, Principal Scientist& HOD(GR) Dr. B. Ramanujam, Principal Scientist (Pl. Path) Dr. T. Venkatesan, Principal Scientist (Ento.) Dr. A.N. Shylesha, Principal Scientist (Ento.) Dr.R. Rangeswaran, Principal Scientist (Micro.)	Dr. K. Subaharan, Principal Scientist(Ento.) Dr. G.Sivakumar, Principal Scientist (Micro.) Dr. M.Mohan, Principal Scientist (Ento.) Dr.A.Kandan, Principal Scientist (Pl.Path.) Dr.K.Sreedevi, Principal Scientist (Ento.) Dr. Jagadeesh Patil, Scientist (Nematology) Dr. Sampath Kumar, Scientist (Ento.) Dr. K. Selvaraj, Scientist (Ento.) Dr. Amala Udaikumar, Scientist (Ento.) Dr. Richa Varshney, Scientist (Ento) Dr. Omprakash Navik, Scientist (Ento.)
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Assam Agriculture University (AAU-J), Jorhat	**G. B. Pant University of Agriculture & Technology (GBPUAT), Pantnagar**

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Others and AINPs, AICRPs& Plant Protection Institutes	
ICAR-National Institute of Biotic Stress Management, Raipur(Chhattisgarh) Dr MuraliBhaskar, Pr.Scientist (Ento.)	**ICAR-National Bureau of Agriculturally Important Microorganisms, Mau (UP)** Dr. H.V. Singh, Principal Scientist
AINP on Agricultural Acarology, Bangalore Dr. N. Srinivasa, Network Coordinator	
Manufacturers of Biocontrol Agents/ Biopesticides	1.Dr. Sithanantham, Sun Agro, Chennai 2. Dr. Dinesh Shetty, Ponalab, Bengaluru 3. Mr. Narayanan, UPL, Chennai

	4. Dr. S. K. Ghosh, Multiplex Biotech Pvt ltd Bengaluru 5. Mr. S. Kumar, Multiplex Biotech Pvt ltd Bengaluru 6.Mr.Khandelwal, KhandelwalBiofertilizers, Belgaum 7.Mr. Lakshman Dole, Godavari biofertilizers, Nashik 8. Mr. GopikrishnaVeppala, Nalanda Agro Naturals, Kerala and 9. Mrs. Mini, State Biocontrol Laboratories, Thrissur, Kerala

ACRONYMS

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

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NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES
BENGALURU 560024
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ALL INDIA COORDINATED RESEARCH PROJECT ON BIOLOGICAL CONTROL OF CROP PESTS AND DISEASES
(AICRP-BC)

Technical Programme
(2020-21 & 2021-22)

Compiled and Edited by

Jagadeesh Patil, G Sivakumar, B Ramanujam, U Amala, K Selvaraj, M Sampath Kumar, Richa Varshney, Chandish R Ballal and N Bakthavatsalam

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

TECHNICAL PROGRAMME FOR 2020-21 & 2021-22

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

Objectives: To study the diversity of natural enemies of insect pests infesting crops in different agro-ecological zones catered by the all the AICRP centers.

II. SURVEILLANCE FOR PEST OUTBREAK AND ALIEN INVASIVE PESTS

Name of the study/trial	:	**Surveillance for pest outbreak and alien invasive pests - Crop Pest Outbreak Report (CPOR)**
Objectives	:	To monitor and report incidence, buildup and outbreaks of insects and diseases of different crops in the region catered by the AICRP center.
Trial allotted centers	**:**	**All Centres**
Method	:	Visit, survey and surveillance and interaction with state/line department officials and local farmers.
Periodicity	:	Once in a month.
Target area	:	Covering the district where centre is located and 2-3 adjoining districts. In case of pest outbreaks, affected area may be specifically visited.
Desirable important information	:	1. Specific site & date visited-District, Mandal (Taluk), village (Give specific GPS coordinates, if available). 2. Area covered in ha 3. No. of crops specifically examined and Variety grown 4. Major insects and disease (s) noticed and natural enemy occurrence 5. Severity of damage (low, moderate, severe) 6. Age of crop in severely damaged field(s) (in DAT/DAS and years for field and tree/ horticultural crops, respectively) 7. Previous crop grown in the area 8. Occurrence of the pest in weeds in surrounding area of the crop 9. Plant protection measures adopted by the farmer prior to the visit 10. Advice given to the farmer and follow up report if any

Crop Pest Outbreak Report Proforma

Name of Centre: Date visited:

1.	Site details	Village(s) with GPS Co-ordinates, Mandal/Taluk/ District

2.	Crop details	Crop*: Variety : Age of Crop (DAS/DAT/: Years in case of perennial crop: Area cultivated (ha) :
3.	Pest Scenario: Insects Natural enemy occurrence	Name of Insect : Level of infestation: Low/Moderate/Severe Predators: (Coccinellids/Chrysopids/Spiders/Others) Parasitoids:
4.	Disease Scenario	Name of Disease: Per cent disease incidence:
5	Previous crop grown in the area	
6	Occurrence of the pest in weeds (identification where possible) in surrounding area of the crop	
7	Plant Protection measures followed by the farmer	
8	Advice given to the farmer	
9	Sender's name	

*for each crop separate proforma to be used

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

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

Submission of report

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

III. BASIC WORK

(i) Evaluation of NIPHM white media for production of *Nomuraea rileyi (Metarhizium rileyi)* NIPHM MRF-1 strain for management of Maize Fall Army worm (*Spodoptera frugiperda*) (NIPHM, Hyderabad)

a. Mass production studies (Lab Studies)
Treatments: 2 and Replications: 13

T1. NIPHM-White Medium

T2. Broken Rice grains

Observations:

- Spore production & cfu /g estimated at 10, 15, 20 and 25 days after inoculation.
- Shelf life of the product (cfu/g) at room temperature (Hyderabad conditions) at monthly intervals

b. Laboratory Bioassay studies

Methodology: As per standard protocol of Lab. Bioassay of EPF
Observations:

- Percentage mortality and mycosis
- LC_{50} and LT_{50}

(ii) Isolation, molecular characterisation and mass production of *Metarhizium rileyi* collected from North Eastern Karnataka on fall armyworm, *Spodoptera frugiperda* (J.E.Smith) (UAS-Raichur).

Objectives	:	During 2019-20 intensive survey were made in North Eastern Karnataka and collected the fall armyworm cadavers infected by *M. rileyi* from six districts (Bidar, Kalaburgi, Yadgir, Raichur, Ballari and Koppal)
Location	:	Biocontrol Field, MARS, Raichur
Methodology	:	The collected cadavers have been stored as per the standard procedure and all the pathological parameters will be recorded to ascertain the proper identity of the entomopathogen through morphological, molecular characterisation and mass production protocols will be standrized.

(iii) Bioassay of *Metarhizium rileyi* collected from North Eastern Karnataka against fall armyworm, *Spodoptera frugiperda* (J.E.Smith) in laboratory condition (UAS-Raichur).

Objectives	:	The potential strain will be subjected for bioassay studies for mass multiplication of the potential isolate
Location	:	Biocontrol Lab, MARS, Raichur
Methodology	:	The IRAC method will be employed for bioassay (Diet incorporation technique). The stock culture of the FAW will be maintained at laboratory and third instar larvae will be

		selected for the bioassay studies.

(iv) Efficacy of *Aschersonia placenta* for the management of whitefly in sugarcane ecosystem (ICAR-SBI)

Basic studies on the potential of *A. placenta* on whitefly will be made. Experiments to characterize the pathogen in the laboratory and mass produce the entomopathogen for the management will be taken up. Pot culture and field experiments will be carried out on evaluation of the pathogen.

Mass production of entomopathogenic fungi

Suitable economic media will be developed for mass production and formulation of entomopathogenic fungi at cottage level. Spore harvest and virulence will be assessed.

(v) Isolation of the Biocontrol agents like *Trichoderma* and *Pseudomonas fluorescence* in Cooch Behar district during 2020-21 (UBKV-Pundibari)

Methodology	:	The information to be collected 1. Place of collection 2. Name of the plant/crop from where the agent is collected. **Note**: **In next year (2021-22**) the laboratory programme shall cover the following aspect c) Screening of efficient antagonist against any soil borne fungi *in vitro* d) Estimation of efficacy of the good performing isolates against any soil borne pathogen *in vitro* and *in vivo* in comparison with the other isolates (From UBKV and other parts of India).

CROP WISE PROGRAMME

CEREALS

1. RICE

1.1 Evaluation of identified bacterial and fungal isolates against stem borer (*Scirpophaga incertulas*), leaf folder (*Cnaphalocrocis medinalis*) and BPH (*Nilaparvata lugens*) in ICAR-NRRI, Cuttack in collaboration with ICAR-NBAIR, Bengaluru.

Laboratory pathogenicity studies

Methodology:

- Leaf dip assay for leaf folder (*Cnaphalacrocis medinals)*

Treatments (6) and Replications (3):

1. NBAIR-PEOWN isolate of *Pseudomonas entomophila*
2. NBAIR-BATP isolate of *Bacillus albus*
3. NBAIR-BtoyPS isolate of *Lysinibacillus sphaericus*
4. NBAIR-PFDWD isolate of *Pseudomonas fluorescens*
5. NBAIR-TATP isolate of *Trichoderma asperellum*
6. Control (Untreated)

Observations:

- Percentage mortality, Probit analysis calculation

Net house bio-efficacy studies

Methodology:

- Potted plant spray method for Yellow Stem Borer (YSB) and Brown Planthopper (BPH)

Treatments (7) and Replications (3):

1. NBAIR-PEOWN isolate of *Pseudomonas entomophila*
2. NBAIR-BATP isolate of *Bacillus albus*
3. NBAIR-BtoyPS isolate of *Lysinibacillus sphaericus*
4. NBAIR-PFDWD isolate of *Pseudomonas fluorescens*
5. NBAIR-TATP isolate of *Trichoderma asperellum*
6. Recommended Insecticide application
7. Control (Untreated)

Observations:

- Yellow stem borer - Neonate larvae will be released and assessed the dead heart per cent (Dead heart % = Dead tillers/Total tillers * 100)
- Brown planthopper - Nymphs will be released and assed the mortality, days to wilt of plants.

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

Variety	:	Jyothi
Layout	:	Randomized Block Design.
Plot size		1 x 4 cents for each treatment, 1 cent = 8x5 m
Treatments	:	Five T1: *Heterorhabditis indica* (NBAIR strain) @ $1.2x10^9$ IJs ha^{-1} T2: *Bt* (NBAIR strain) 2g/l T3: *Beauveria bassiana* (NBAIR strain) @$1x10^8$ spores/g-5g/l T4: Flubendiamide 25g.a.i.ha^{-1} T5: Untreated control
Replications		Four
Observations		• Mean No. of dead heart/white ear/sq. m. • Mean No. of rolled leaves per sq. m.

		• Yield kg/plot
The treatments will be applied twice based on ETL.		

1.3 Large scale bio-intensive pest management on rice [PAU (25 ha); KAU- Vellayani (100 ha; KAU- Thrissur (150 ha), AAU-J (50 ha); OUAT (5 ha); IGKV (1 ha)]

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

Note: **centers using isolates from other centres may indicate**

1.4 Large scale bio-intensive pest management on rice (ICAR-IIRR, Hyderabad)

Location : Two locations in Nalgonda, Hyderabad (2 ha) and one location in Odisha (1 ha)

Area : 3 ha

Module	**Details of treatments**	**Practices**
BIPM 1	Seed	Seed treatment with *Psuedomonas flourescens* (@ 10 g / kg seed at the time of sowing or Wet seed treatment @ 10 g / litre of water / kg seed
	Nursery	FYM @ 1 kg / m^2 and 100g of rice husk ash / m^2 of the nursery bed and mix well with the soil at the time of preparation of the field
	Fertilization	5 tonnes of FYM/ compost/ green leaf manure or 2.5 tonnes of vermicompost as basal + 300-500 kg neem cake / ha half as basal and half as top dressing at active tillering stage
	Pest Management	1. Clipping of rice seedlings before Transplanting 2. Mass trapping of stem borer by installing pheromone traps @ 20 numbers/ ha. 3. *Trichogramma japonicum* 5 cc egg cards/ha, six times weekly from first week after transplanting 4. Need based application of neem formulations/ biopesticides for other defoliating pests 5. Foliar spray of *P. fluorescens* on the foliage @ 20 g / litre of water. Spraying can be repeated depending on the disease severity.
BIPM 2		Same as above in all respects except application of *Trichoderma* IIRR strain instead of *Psuedomonas*
Farmers Practice		General POP with RFD and need based application of insecticides

Observations to be recorded:

- Observations on pest and disease incidence will be recorded on 50 randomly selected hills in each treatment at fortnightly interval.
- Observations on natural enemies like predators and parasitoids by visual or sweep net count and by collection of egg masses for stem borer
- At harvest record yield in each treatment
- Benefit cost ratio will be calculated

1.5 Biointensive pest management in rice (KAU-Vellayani)

Major Pest	:	Leaf folder *Cnaphalocrocis medinalis*
Treatments	:	**T1 -Biological control** • Seed priming with *B. bassiana?* @ 10g/Kg of seeds • Seedling dip with *Pseudomonas flourescens?* @ planting @ 10g/L

		• Foliar spray with *B. bassiana?* @ 20 g/L at fortnightly intervals during vegetative phase (normal or chitin enriched?) • Foliar spray of chitin enriched oil formulation of *L. saksenae* at fortnightly intervals twice during reproductive phase • Placement of *Trichogramma japonicum* + *T. chilonis* from 30 DAP at 10 days interval till panicle formation **T2 - Farmers practice**
No. of Replications	:	7
Unit plot size	:	10×10 m^2
Observations to be recorded	:	1. Pre count of Major pest 2. Post count of Major pest 3. Precount of Predators 4. Post count of Predators 5. Yield per plot

1.6 Validation of BIPM practices against pest complex of organic Black rice (AAU-J)

Location: Dungdhora, Jorhat

Season: *kharif*, 2020

Area: 1 ha

Variety: Locally recommended variety

Treatments: 2 (organic and farmer's practice)

A) Organic package

- Use of *Pseudomonas fluorescens* (8g / kg of seed as seed treatment)
- Application of organic manure MUKTA 2t/ha
- Application of *Beauveria bassiana* 10^{13}spores/ha against sucking pests.
- Use of bird perch (10/ha)
- Release of *Trichogramma japonicum* @ 1 lakh/ha/week depending upon stem borer and leaf folder activity.
- Spray *Pseudomonas fluorescens* (as per university recommendation)
- Need based application of botanicals NSKE5%

Observation to be recorded

- Area (1ha) will be divided into 15 sub plots to serve as 15 replication.

- Population of leaf folder, stem borer, case worm and natural enemies will be recorded in 20 randomly selected hills/plot before and after the release of bioagents and botanicals.
- In case of sucking pest population will be counted before and after each spray of *B. bassiana* from 20 randomly selected hills per plots.
- Grain yield of crop at harvest (kg/ha)
- CB ratio will be determined

1.7 Comparative efficacy of entomopathogenic fungi against sucking pests of rice, *Leptocorisa acuta* IIRR, Hyderabad

Objective

To assess the comparative efficacy of KAU isolate of *Lecanicillium saksenae* (ITCC Ls Vs 1 7714) with NBAIR isolates of *L. lecanii*, *M. anisopliae* and *B. bassiana* in the management of major sucking pest of rice *Leptocorisa acuta*

Crop : Rice
Major pest : Rice bug, *Leptocorisa acuta*
Treatments :

T1- *L. saksenae* @ $1x10^7$ cfu ml^{-1} KAU 7714 (20g talc formulation /L)
T2- *B. bassiana* @ $1x10^8$ cfu ml^{-1} NBAIR Bb 5 (20g talc formulation /L)
T3- *M. anisopliae* @ $1x10^8$ cfu ml^{-1} NBAIR Ma 4 (20g talc formulation /L)
T4- Thiamethoxam 0.2 g/L
T5- Untreated

Locations: 2
No. of Replications : 4
Unit plot size : 5 x 5 m^2
No. of sprayings: 2

Observations to be recorded

1. Pre count of rice bug
2. Post count of rice bug
3. Pre count of beneficial insects
4. Post count of beneficial insects
5. Yield per plot

1.8 Field evaluation of ICAR-NBAIR entomopathogenic strains against Rice stem borer (*Scirpophaga incertulas*), leaf folder (*Cnaphalocrocis medinalis*), Brown planthopper (*Nilaparvata lugens*) (ICAR-NRRI, Cuttack).

Variety	:	Susceptible variety
Replications	:	03
Design	:	RBD
Date of sowing	:	As per the package of practice
Treatments	:	1. NBAIR-PEOWN isolate of *Pseudomonas entomophila* 2. NBAIR-BATP isolate of *Bacillus albus* 3. NBAIR-BtoyPS isolate of *Lysinibacillus sphaericus* 4. NBAIR-PFDWD isolate of *Pseudomonas fluorescens* 5. NBAIR-TATP isolate of *Trichoderma asperellum* 6. Recommended Insecticide application 7. Control (Untreated)
Observations	:	• Mean No. of dead heart/white ear/sq. m. (weekly intervals) • Mean No. of damaged leaves per sq. m. (weekly intervals) • The population of plant hoppers will be recorded from 25 hills selected at random at weekly interval starting from 30 days after transplanting (DAT) from each plot. • The population of predators will be also recorded at weekly intervals. • Growth promotion character viz., plant height (cm), biomass (gm) • Yield (kg/plot)

Note: Four rounds of foliar sprays of talc and liquid formulations of entomopathogenic fungi and bacteria at **dosage of 10^8 cfu/ml** has to be given at 14 days interval.

2. MAIZE

2.1. Laboratory bioassay of *Metarhizium rileyi* (Anakapalle strain AKP-Nr-1) against Fall armyworm, *Spodoptera frugiperda* (ANGRAU- Anakapalle)

Treatments	**:**	Six concentrations of *Metarhizium rileyi* isolate from $1x10^4$ to $1x10^9$ cfu / ml prepared by 1-10 fold dilution from main stock culture and tested under controlled conditions (26 ± 2° C and 65 ± 5 % RH) against third instar and fourth instar larva. 1. Fresh maize leaves sprayed with desired fungus concentration as larval feed with untreated leaves as control. 2. Topical application of *M .rileyi* spore suspension of seven concentrations from 1×10^2 to 1×10^8 cfu / ml prepared by 1-10 fold dilution from main stock culture Ten third instar larvae of *S. frugiperda* per each concentration Replications : Five
Field study :		
Treatments	**:**	Efficacy of *M. rileyi* isolate against FAW in maize at different dates of sowing T1: *M. .rileyi* (Anakapalle strain AKP-Nr-1) concentration 1×10^8 cfu / ml

		T2: Untreated control Three sprays at weekly interval
Plot size	**:**	8 × 5m
Observations	:	**Laboratory study :** Number of Dead larvae recorded from 5th day of spore inoculation Percent larval mortality **Field study :** • Number of larvae per plot • Number of damaged plants per plot • Number of dead larvae due to fungus per plot 20 plants randomly selected for FAW incidence and larval mortality

2.2 Field efficacy of *Metarhizium rileyi* (Anakapalle strain AKP-Nr-1 different dates of sowing (ANGRAU Anakapalle; UAS Raichur))

Treatments	**:**	T1: *Metarhizium rileyi* (Anakapalle strain AKP-Nr-1) concentration 1×10^{8} spores/ml (5g/L) T2: *Metarhizium rileyi* (Anakapalle strain AKP-Nr-1) concentration 1×10^{10} spores/ml (5g/L) T3: *Metarhizium rileyi* (Anakapalle strain AKP-Nr-1) concentration 1×10^{12} spores/ml (5g/L) T4 : *Metarhizium rileyi* (UASR strain KK-Nr-1) concentration 1×10^{8} spores/ml (5g/L) T5 : *Metarhizium rileyi* (UASR strain KK-Nr-1) concentration 1×10^{10} spores/ml (5g/L) T6 : *Metarhizium rileyi* (UASR strain KK-Nr-1) concentration 1×10^{12} spores/ml (5g/L) T7: Untreated control Three sprays at weekly interval Three sprays at weekly interval
Replications	**:**	Three
Plot size	**:**	8 × 5m
Observations	:	• Number of larvae per plot • Number of damaged plants per plot • Number of dead larvae due to fungus per plot 20 plants randomly selected for FAW incidence and larval mortality

2.3 Evaluation of entomopathogenic fungi and *Bt* against maize stem borer (PAU)

Variety	:	Any susceptible high yielding variety
Layout	:	Randomized Block Design.
Plot size		1 × 5 cents for each treatment, 1 cent = 8x5 m
Variety	:	Recommended variety at each place
Treatments	:	Seven T1: *Beauveria bassiana* (NBAIR Bb45) 1x 10^8 spores /ml)-5 ml/lt. T2: *Metarhizium anisopliae* (NBAIR Ma4) 1x 10^8 spores /ml)-5 ml/lt. T3: Two sprays of *Bt* formulation (commercial)@ 1250 ml/ha on 10 and 17 days old crop T4: Two sprays of *Bt* formulation (NBAIR formulation) @ 2% on 10 and 17 days old crop T5: Chemical control (region specific for maize crop as per university recommended / as per label claim) T6: Release of *T. chilonis* 1 lakhs/ha, 2 releases at weekly interval on 10 and 17 days after germination T7: Control
Replications		Three
Observations		• Dead heart count at weekly interval starting from from 20 randomly selected plants at 30 and 45 DAS. • Leaf damage at weekly interval starting from initial incidence of stem borer. • Number of exit holes/plant. • Grain Yield at harvest

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

Variety	:	Location specific recommended variety
Treatments	:	Three T1: Three releases of *Trichogramma chilonis* @ 100,000/ha/release at 15, 22 and 29 days after crop germination. **(For PAU only two releases of *Trichogramma chilonis* @ 100,000/ha/release at 10 and 17 days after crop germination)** T2: Farmers' practice (to be recorded at each location) T3: Untreated control
Replications	:	Divide each block into 8 equal sized units, each unit to be considered as replication (each unit = one replication)
Observations		• Dead hearts from 20 randomly selected plants at 30 DAS • Yield (t/ha) and incremental benefit cost ratio

2.5 Bio-ecological engineering for the management of major insect pests of maize and benefit of their natural enemies (SKSUAT-Jammu)

Number of treatments: 12 Number of replications: 3, Design: RBD and Plot size: 4.5 × 4.5 m^2

Treatments	Treatment detail
T1	Maize + okra (intercrop) + sorghum (border crop)
T2	Maize + mash (intercrop) + sorghum (border crop)
T3	Maize + cowpea (intercrop) + sorghum (border crop)
T4	Maize + sesamum (intercrop) + sorghum (border crop)
T5	Maize + okra (intercrop) + naiper (border crop)
T6	Maize + mash (intercrop) + naiper (border crop)
T7	Maize + cowpea (intercrop) + naiper (border crop)
T8	Maize + sesamum (intercrop) + naiper (border crop)
T9	Sole maize
T10	Sole maize + sorghum (border crop)
T11	Sole maize + naiper (border crop)
T12	Sole maize with cartap hydrochloride (Recommended check)

A buffer distance of 15 m shall be maintained in between the treatments with napier and sorghum as border crop, so as to nullify their effect on each other.

Observations to be recorded

- Insect pest succession on maize, intercrops and border crops in correlation with its phenophases
- Percent infestation of major insect pests on maize, intercrops and border crops with special reference to stem borer
- Natural Enemy abundance on maize, intercrops and border crops
- Grain Yield
- Equivalent maize grain yield

2.6 Demonstration of BIPM module against fall army worm, *Spodoptera furgiperda* on *rabi* maize (AAU-J).

Target pests: *Spodoptera furgiperda*

Location: RARS (AAU, Jorhat), Diphu, Dist. Karbi Anglong

Season: *Rabi*, 2020

Variety: Vijoy/ Kisan (locally recommended variety)

Plot size: 20m × 20m

Treatments: 2

T_1 = BIPM package

T_2 = Farmer's field.

(Two blocks, each 20m x 20m, one for farmers practice and one for IPM module. Each block will be divided into 8 sub plots to serve as 8 replications. A distance of atleast 200m will be maintained in between IPM and farmer's practice plots. Analysis will be done using't' test.)

BIPM module

1) Rogue out of infested plants as early as possible.
2) Collection and destruction of egg masses.
3) Erection of bird perches @ 10 nos./ha
4) Installation of pheromone trap (Faw lure) @ 15traps/ha
5) Application of NSKE 5% starting from 25 days after germination, 3 sprays will be made.
6) Three release of *Trichogramma pretiosum* @ 100,000/ha at 10 days interval, starting from 30 days after germination (4-5 releases will be made).

Farmers practice

Alternate spray of Lamda cyhalothrin 2.0% @ 1.5 ml/lit and emamectin benzoate 5% SG @ 0.4gm/lit

Observation:

- Larval counts of *S. furgiperda* to be taken before and 7 and 10 days after release of bio agents and application of insecticides from 5 randomly selected plants in each sub plots.
- Percent egg and larval parasitization will be calculated out.
- Number of predators/plant will be observed.
- Yield data from each sub plot at harvest.

2.7 Field trial against Fall Armyworm in maize at AICRP-BC centres (NBAIR, IIMR, Maize Hyderabad, PAU, PJTSAU, AAU-Anand, OUAT, MPKV, CAU and TNAU).

Treatments= 10

T1. *Trichogramma chilonis* 1 card per acre (2 releases, first release after one week of planting & second one after one week of first release) + NBAIR Bt 2% (2-3 sprays depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)

T2. *Trichogramma chilonis* 1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release) + *Metarhizium anisopliae* NBAIR -Ma 35, 0.5% (2-3 sprays depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)

T3. *Trichogramma chilonis* 1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release) + *Beauveria bassiana* NBAIR -Bb 45, 0.5% (2-3 sprays depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)

T4. *Trichogramma chilonis* 1 card per acre (2 releases, first release after one week of planting & the second one after one week of first release) + EPN *H. indica* NBAIIH38 (1-2 whorl sprays @ 4kg/acre, first spray after 30 days of planting & if required next spray should be at 10 days interval)

T5. *Trichogramma chilonis* 1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release) + *Pseudomonas fluorescens* (Pf DWD 2%) (2-3 sprays @ 20 gm/litre depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)

T6. *Trichogramma chilonis* 1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release) + SpfrNPV (NBAIR1) (2-3 sprays @ 2ml/liter depending on pest incidence, first spray after 20-25 days of planting & then the next sprays at 10 days intervals)

T7. *Trichogramma chilonis* alone (1 card per acre (2 releases, first release after one week of planting & then second one after one week of first release)

T8. Pheromones @15 traps/acre (install one week after planting and the lures to be replaced once in 25-30 days)

T9. Insecticidal check (Emamectin benzoate 0.4gm/lt)

T10. Untreated check (control)

Plot size 8 × 5m, three replications; Separate blocks should be used for each treatment giving sufficient isolation distance between the treatment blocks

Observations:

Select 10 plants randomly per plot and take observations on following parameters,

1. Number of egg patches per plot
2. Number of larvae per plant/plot
3. Number of damaged plants/plot
4. Number of dead larvae (due to bacteria/virus/fungus) per plot
5. Percent egg parasitization and larval parasitization
6. Number of predators per plant
7. Final yield

Nucleus culture of *T. chilonis*, formulations of microbials, pheromone traps and lures will be supplied by NBAIR.

2.8 Evaluation of BIPM module for fall armyworm, *Spodoptera frugiperda* in maize ecosystem (UAS-Raichur)

Variety/ Hybrid	:	Syngenta NK-6240
Area	:	1acre

Treatments	:	5
Replication	:	3
Treatment Details		**T1: BIPM** • *Trichogramma preteosum* @ 1.0 lakh/ha at 10 and 20 DAS • *Metarhizium rileyi* 1×10^8 spores/g @ 2.0 gm/l at 30 DAS • *Heterorhabditis indica* NBAIIH-138 @ 4 kg/acre at 40 and 50 DAS **T2: Farmers' practice** • Application of Emamectin benzoate 5 SG @ 0.2 G/lit at 20, 30 and 40 DAS **T3: Control**
Methodology	:	Number of egg patches per plot The percent egg parasitisation Number of larvae per plant/plot Number of damaged plants/plot Number of dead larvae (bacteria/virus/fungus) per plot Final yield

2.9 Large scale demonstration of Management of fall armyworm using biological control agents and Biopesticides (ANGRAU, Anakapalle)

Location	:	Farmers fields (3 ha)
Treatments	:	T1: *Trichogramma chilonis* 3 cards (50,000 eggs) (2 releases, first release after one week of sowing & second one after one week of first release)+ NBAIR Bt @ 2g/lt (2-3 sprays depending on pest incidence, first spray after 20-25 days of sowing & then the next sprays at 10 days intervals) T2: *Trichogramma chilonis* 3 cards (50,000 eggs) per acre releases, first release after one week of sowing & then second one after one week of first release) + *Metarhizium anisopliae* NBAIR -Ma 35 @ 5g/lt (2-3 sprays depending on pest incidence, first spray after 20-25 days of sowing & then the next sprays at 10 days intervals) T3: *Trichogramma chilonis* 3 cards (50,000 eggs) per acre releases, first release after one week of sowing & then second one after one week of first

		release) + *Beauveria bassiana* NBAIR -Bb 45 @ 5g/lt (2-3 sprays depending on pest incidence, first spray after 20-25 days of sowing & then the next sprays at 10 days intervals) T4: Insecticidal check : Spraying Azadirachtin 10000 ppm @ 2 ml/lt at 15 days after sowing + Chlorantraniliprole 18.5 SC@ 0.4 ml/lt at 25 days after sowing + Emamectin benzoate 5SD@ 0.4gm/lt at 35 days after sowing
Observations	:	• Number of egg patches per plot • Number of larvae per plot • Number of damaged plants per plot • Number of dead larvae(due to bacteria/virus/fungus) per plot • Percent egg parasitization and larval parasitization • Number of predators per plant • Final yield 20 plants randomly selected for FAW incidence and larval mortality

3. SORGHUM, FINGER, BARNYARD, FOXTAIL MILLETS

3.1 Evaluation of entomopathogenic fungi formulations against millet borers in Finger millet (IIMR, Hyderabad, Kharif, 2020, Kharif 2021) (ICAR-IIMR- Hyderabad)

No of Treatments : 6
Replications : 4
Plot size : 20 sqm
Finger millet Variety : 5614
Dose: 5 ml/liter (1×10^8 spores/ml)

Treatments:

T1 : Bb 23 spray at 20, 45 DAE
T2 : Bb 45 spray at 20, 45 DAE
T3 : Ma 35 spray at 20, 45 DAE

T4 : Strains of Bb
T5: Strains of Ma
T6: Strains of Ma
T7 : Basal application of Carbofuran 3G @ 20 kg /ha) at sowing + soil application of Carbofuran 3G at 30 DAE.
T8 : Untreated Control

Note: Strains of White and greem muscardine fungus for treatments T4, T5 and T6 to be suggested by NBAII

Observations:

- Lab studies on egg, larval mortalities after EPF spray at 2, 4th day after exposure
- Deadhearts (%) at 30, 60 DAE
- White earheads (%) at Harvest
- Yield/plot (kg)
- Cost benefit ratio

All sprayable formulations of Bioagents to be supplied by NBAIR, Bengaluru

3.2 Management of FAW in Sorghum using biocontrol agents (2 locations) (ICAR-IIMR-Hyderabad)

Plot size: 0.5 acre and Variety: CSH 16

T1 : Release of *Trichogramma chilonis* 1 card/acre (2 releases, first release one week of planting & second one after one week of release + spray of *Metarhizium anisopliae* Ma 35 0.5 % at 20, 30 DAE (need based when > 5% foliar damage is noticed)
T2: Control (Farmers practice)

Observations:

Egg patches/10 plants/ plot (nos)
Larvae/10 plants/plot (nos)
Per cent damaged plants/ plot (%)
Grain yield (kg/plot)

Oil based formulation of Ma 35 to be supplied by **NBAIR, Bengaluru**

PULSES

4. PIGEON PEA

4.1 Evaluation of NBAIR Bt formulation on pigeon pea against pod borer complex (PDKV, Akola)

Variety	:	PKV Tara
Treatments	:	Three **T1: Biocontrol** 3 sprays - NBAII BtG4 2% @ 2.0 ml/lt - at pre flowering, post Flowering and pod formation stage.

		T2: Chemical control 1st Spray – Thiodicarb 75 WP @ 625 ml/ha 2nd Spray – Chlorantraniliprole 18.5 SC @ 150 ml 3rd spray – Monocrotophos 36 SL @ 625 ml **T3: Control**
Replications	:	8 replications Divide each block into 8 equal sized units, each unit to be considered as replication (each unit = one replication)
Area	:	T1 – 1814 m^2 T2 – 1814 m^2 T3 – 1814 m^2
Observations	:	• No. of gram and legume/pod borer complex (spotted pod borer, plume moth, slug caterpillar*, etc) / plant • Pod borer complex (*Helicoverpa*, Plume moth, podfly) – commonly observed at this location • Per cent pod damage • Grain yield (kg/ha)
Product required		Bt – 0.7 to 1 Lt

5. COWPEA

5.1 Field evaluation of ICAR-NBAIR entomopathogenic strains against cowpea aphid (*Aphis craccivora*) (KAU-Thrissur and MPKV-Pune)

Variety	:	Phule vithai
Plot size	:	8 × 5m
Replications	:	04
Design	:	RBD
Treatments	:	1. Bb-5a isolate of *Beauveria bassiana* 1×10^8 cfu/ml @ 5ml/litre 2. Ma-6 isolate of *Metarhizium anisopliae* 1×10^8 cfu/ml @ 5ml/litre 3 Vl-8 isolate of *Lecanicillium lecanii* 1×10^8 cfu/ml @ 5ml/litre 4. Recommended Insecticide application 5. Control (Untreated)
Observations	:	Pre and post count of aphids (nymphs and adults) Grain yield/ha

5.2 Evaluation of oil formulation of *Lecanicillium* spp against sucking pests (aphids and pod bugs) of cowpea (KAU-Vellayani)

Treatments	:	T1 - Chitin enriched oil formulation of *L. lecanii* Vl 8 (NBAIR isolate) T2 - Chitin enriched oil formulation of *L. saksenae* (KAU isolate) T3 - Spore suspension of *L. lecanii* Vl 8 (NBAIR isolate) T4 - Spore suspension of *L. saksenae* (KAU isolate) T5 - Thiamethoxam 25 WDG 2g/10L T6 - Untreated check
No. of Replications	:	4
Unit plot size	:	10×10 m^2
Area	:	2400 m^2 (0.24 ha)

No. of sprayings: 3

Observations to be recorded:

1. Pre count of sucking pests
2. Post count of sucking pests
3. Precount of Predators
4. Post count of Predators
5. Yield per plot

5.3 Evaluation of entomopathogenic fungi aga**inst pod bug, *Riptortus pedestris* on cowpea *Vigna unguiculata* (KAU, Thrissur)**

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

5.4 Evaluation of entomopathogenic biopesticide against *Aphis craccivora* in cowpea (*Vigna unguiculata*) (AAU-Jorhat).

Target pests: *Aphis craccivora*

Location: Experimental farm, Dept. of Horticulture

Season: *Kharif*, 2020
Variety: Location specific recommended variety
Plot size: 3m × 3.5m
Experiment design: 4RBD
Treatments: 6

Treatments include:

1) *Beauveria bassiana* 1×10^8 cfu/ml @ 5gm/lit
2) *Metarhizium anisopliae* 1×10^8 cfu @ 5gm/lit
3) *Verticilium lecanii* 1×10^8 cfu/ml @5gm/lit.
4) Spinosad 45SC @ 0.3ml/lit.
5) Malathion 50EC @ 2ml/lit (standard check)
6) Untreated control

(Three rounds of spray will be made. The first spray to be given on initial occurance of aphid and rest will be based on abundance of pests.)

Observation to be recorded:

1. Aphid population in five randomly selected plants (terminal shoots) for each plot will be recorded before as well as 3, 7 day and 10 days after each treatment.
2. Yield at each harvest.

6. CHICKPEA

6.1 Evaluation of microbial biopesticides against wilt disease of chickpea in Bundelkhand region (ICAR-NCIPM)

Field Layout

Treatments: 8; Replications-3 Plot size: 5×4 m

1. Seed treatment with *Trichoderma harzianum*
2. Seed treatment with *Bacillus subtilis*
3. Seed treatment with *Pseudomonas fluorescens*
4. Combined seed treatment with *T. harzianum + B. subtilis + P. fluorescens*
5. Soil application of *T. harzianum* with FYM
6. Soil application + Seed treatment with *T. harzianum*
7. Seed treatment with Thiram + Carbendazim
8. Control

Observations to be recorded: Per cent disease incidence will be recorded at weekly interval

6.2 Evaluation of Biointensive Integrated Pest Management against pod borer in chickpea in Bundelkhand region (ICAR-NCIPM)

BIPM module: Area 1 acre

1. Deep summer ploughing and field sanitation
2. Timely sowing in the first fortnight of October
3. Selection of tolerant/resistant variety
4. Seed Treatment with *T. harzianum*
5. Intercropping with mustard
6. Installation of pheromone trap for monitoring 5/ha
7. Erection of bird perches 20/ha
8. Need based application of botanical neem and biopesticides Bt, *Ha*NPV

Observations to be recorded: on pest and disease incidence will be recorded at weekly interval, yield and economics will be workout. BIPM fields will be compared with Farmers practices field.

6.3 BIPM module for management of *Helicoverpa armigera* on chickpea (PAU, Ludhiana and TNAU)

Variety	:	Locally recommended variety
Treatments	:	**T1 = BIPM Package** 1. Seed bio-priming *T. harzianum* @ 10g/kg of seeds 2. Erection of bird perches @ 8/acre 3. Spray of *HaNPV* strain (1.5×10^{12} POBS/ha) @ 500 ml/ha twice at 15 days interval, first spray starting from pod initiation stage 4. Raising marigold as trap crop. 5. Use of pheromone traps @ 1 trap per plot. **T2 = BIPM Package** 1. Seed bio-priming *T. harzianum* @ 10g/kg of seeds 2. Erection of bird perches @ 8/acre 3. Sprays of *Bacillus thuriengiensis* @ 2 kg/ha twice at 15 days interval, first spray starting from pod initiation stage 4. Raising marigold as trap crop 5. Use of pheromone traps @ 1 trap per plot.

		T3 = Chemical insecticide (recommended) **T4** = Untreated control
Replications	:	Divide each block into 6 equal sized units, each unit to be considered as replication (each unit = one replication)
Observations	:	• Number of larvae/ m row length before spray and 3, 7, 10 and 15 days after spray • Total and damaged pods at harvest. • Record natural enemies from 5 plants in each plot. • Pod yield will be recorded on whole plot basis.

6.4 Biological suppression of pod borer, *Helicoverpa armigera* infesting chickpea on-farm and farmers field (MPUAT-Udaipur and MPKV-Pune)

Variety	:	Location specific recommended variety
Layout	:	Randomized Block Design.
Plot size		8 ×5 m
Treatments		T1: *Beauveria bassiana* @ 1×10^8 conidia /gm @ 5 gm/l at 7 day interval, at pod initiation stage, 2 sprays T2: *Bacillus thuriengiensis* @ 1 Kg/ha at 7 day interval, at pod initiation stage, 2 sprays T3: • Spinosad 45SC @ 150ml/ha - 2 sprays/Azadirachtin 1500 ppm @ 500 ml/ha - 2 Sprays (MPKV) • Quinalphos 25EC @250g a.i/ha at pod initiation stage 2 sprays (MPUAT) T4: Spray of HaNPV (1.5×10^{12} POBs/ha) twice during the peak flowering and at pod initiation stage at 15 days interval T5: Untreated control
Replications	:	Five
Observations		• Number of larvae/ m row length before spray and 3, 7, 10 and 15 days after spray • Total and damaged pods at harvest. • Record natural enemies from 5 plants in each plot. • Pod yield will be recorded on whole plot basis.

6.5 Habitat manipulation / Bio-ecological engineering for the management of *Helicoverpa armigera* in chickpea (SKSUAT-Jammu)

Number of treatments : 12	**Number of replications : 3**
Design : RBD	**Plot size: 4.5 x 4.5 m^2**

Treatment details:

T1	Chickpea + Linseed (intercrop) + napier (border crop)
T2	Chickpea + Coriander (intercrop) + napier (border crop)
T3	Chickpea + Fenugreek (intercrop) + napier (border crop)
T4	Chickpea + Fennel (intercrop) + napier (border crop)
T5	Chickpea + Linseed (intercrop) + mustard (border crop)
T6	Chickpea + Corainder(intercrop) + mustard (border crop)
T7	Chickpea + Fenugreek (intercrop) + mustard (border crop)
T8	Chickpea + Fennel (intercrop) + mustard (border crop)
T9	Sole chickpea
T10	Sole chickpea + napier (border crop)
T11	Sole chickpea + mustard (border crop)
T12	Novaluron @ 25kg/ha (recommended check)

- A buffer distance of 15 m shall be maintained in between the treatments with Napier as trap crop and sorghum as border crop, so as to nullify their effect on each other.
- Twelve treatments will be imposed, taking mustard and Napier as border crops.
- Four intercrops (Linseed, Coriander, Fenugreek and Fennel) in additive series (1:1)
- Sole chickpea with and without insecticidal spray Novaluron @ 25 kg/ha recommended check.

Observations to be recorded

- No. of larvae / 5 plants
- Percent pod damage by *Helicoverpa* on chickpea, intercrops and border crops
- Natural Enemy abundance on chickpea, intercrops and border crops
- Grain yield
- Equivalent chickpea grain yield

6.6 Evaluation of bio-agent consortium in glasshouse (pot experiments) and in field for crop health management in chickpea (GBPUAT, Pantnagar)

Variety	:	PG-186
Plot size	:	3 × 2
Treatment	:	11
Replication	:	03
Glasshouse experiment	:	In pots (2 kg capacity) with same treatments and replications
Treatments	:	1. Th-17 + Psf-173 2. Th-17+ Psf-2 3. Th-17 + Th-14 4. Th-14+ Psf-2 5. Th-17 (positive control)

		6. Th-14 (positive control) 7. Psf-2 (positive control) 8. Psf-173 (positive control) 9. Th-14 + Psf-173 (Standard check) 10. Carbendazim 11. Control (Negative control)
Methodology		• Seed bio-priming @ 10g/kg seed • In filed application of bioagents along with vermicompost (50g/500g) per plot. • In glasshouse soil will be pre inoculated with *Fusarium* (5g inoculum/pot) one week before sowing followed by bioagents along with vermicompost (10g/100g) per pot ❖ Three foliar sprays cum drench with bioagents (at 15 days interval) **Observations** **In glasshouse:** • Per cent seed germination 15 DAS • Plant stand at 30 and 45 DAS • Plant Growth at 45 DAS **In field** • Per cent seed germination 30 days after sowing • Plant stand at 60 and 90 days after sowing • Number of mature plant wilt at 90 DAS • Yield / plot and q/ha

6.7 Large Scale Demonstration of *Ha*NPV Kalaburgi strain against chickpea pod borer (UAS, Raichur)

Location	:	ARS, Kalaburgi (10 ha), ICAR-KVK, Kalaburgi (20 ha), ICAR-KVK, Raddewadagi (10 ha), ICAR- AICRP on Biocontrol, Raichur (10 ha)
Total Area	:	50 ha
Crop	:	Chick pea
Treatment Details		T_1: Application of ***Ha*NPV** @ 100 LE/acre, Installation of traps 10/acre T_2: Farmers' practice (as per sprays recommended insecticide at each place as per university recommendation or label claim). T_3: Untreated control
Replications	:	Divide each block into 8 equal sized units (each unit = one replication)
Methodology	:	Record the following observations • Number of larvae per meter row length • Per cent pod damage • Grain yield

7. GREEN GRAM

7.1 Integration of botanicals/microbials and insecticide spray schedule for the management of pod borer complex in Greengram (ANGRAU, Anakapalle)

Plot size	:	4 × 5 m^2
Replications	:	03
Design	:	RBD
Date of sowing	:	Rabi season
Treatments	:	T1: *Bacillus thuringiensis* @ 1.25 l/ha + Azadirachtin 1 % @ 1.25 l/ha T2: *Bacillus thuringiensis* @ 1.25 l/ha + *Bacillus thuringiensis* @ 1.25 l/ha T3: *Bacillus thuringiensis* @ 1.25 l/ha + Spinosad 45 SC@ 150 ml/ha T4: Azadirachtin 1% @ 1.25 l/ha +*Bacillus thuringiensis* @ 1.25 l/ha T5: Azadirachtin 1% @ 1.25 l/ha + Azadirachtin 1 % @ 1.25 l/ha T6: Azadirachtin 1% @ 1.25 l/ha + Spinosad 45 SC@ 150 ml/ha T7: Spinosad 45 SC@ 150 ml/ha + Azadirachtin 1 % @ 1.25 l/ha T8: Spinosad 45 SC@ 150 ml/ha + *Bacillus thuringiensis* @ 1.25 l/ha T9: Spinosad 45 SC@ 150 ml/ha + Spinosad 45 SC@ 150 ml/ha T10: Untreated Control First and second sprays at pod formation stage.
Observations	:	• Pod damage (%) recorded at 15 days after spraying • Yield (Q/ha)

COMMERCIAL CROPS

8. COTTON

8.1 Evaluation of entompthogenic fungi, *Beauveria bassiana* (NBAIR-Bb-5a) against sucking insect pests of cotton (UAS- Raichur)

Variety/ Hybrid	:	KCH-14K59 BG II (Jadoo)
Design	:	RBD
Treatments	:	8
Replication	:	3
Plot Size	:	54sqm
Treatment Details		T_1: *B.bassiana* @ 1×10^8 @ 5 gm/l (NBAIR-Bb-5a) @ 5.0 g/l T_2: *L. leccani* @ 1×10^8 @ 5 gm/l (NBAIR-VL-8) @ 5.0 g/l T_3: *L. leccani* @ 1×10^8 @ 5 gm/l (NBAIR-VL-15) @ 5.0 g/l T_4: *M. anisopliae* @ 1×10^8 @ 5 gm/l (NBAIR-Ma 4) @ 5.0 g/l T_5: *Isaria fumosorosea* (NBAIR strain) @ 1×10^8 @ 5.0 g/l

		$T_{6:}$ Azadirachtin 1500ppm @ 2 ml/lit T_7 : Fipronil 5 SC @ 1 ml/lit T_8: Untreated control
Methodology	:	• Average number of sucking pest population / 3 leaves, *viz.*, Aphids, Jassids, whiteflies and thrips will be counted and recorded. • Number of whitefly adults from 3 leaves (top, middle and lower canopy) of 5 randomly selected plants in each plot will be recorded before spray, 3 and 7 days after spray. • Cadavers without apparent sporulation along with leaves will be brought in the laboratory and incubated under optimal condition. After 5 days cadavers were observed for signs of fungal infection and sporulation. • The population of other sucking pests will also be recorded. • Yield (q/ha) to be recorded.

8.2 Biointensive management of pink bollworm on *Bt* cotton (PJTSAU; PDKV, Akola, TNAU)

Variety		Grow early maturing varieties recommended for each centre so that the cotton bolls mature before the heavy population of pink bollworm builds up.
Plot size		Three Each treatment consisting of 0.5 ha, except untreated control which can be of 5 cent size (1 cent = 8×5 m).
Layout	:	Randomised Block design
Treatments	:	Three Each treatment consisting of 0.5 ha, however, untreated control to be of 5 cent size (1 cent = 8×5 m). T1: Standard practice of plant protection till 55th day or appearance of PBW. The following inputs to be provided for PBW. I. Erection of pheromone traps (Funnel type) @ 10/ plot/PB Robe II. Releases of *Trichogrammatoidea bactrae* 100,000/ha/release, 6-8 releases starting from 55 days after germination. III. Application of azadirachtin 1500 ppm at ETL IV. Need based chemical insecticide based on label claim/university recommendation. T2: Spraying of insecticides as per label claim for PBW / SAUs at each centre during PBW infestation. Only for PDKV Akola 1st spray – Triazophos 40 EC @ 20 ml/10 Lt 2nd spray – Spinosad 45 SC @ 2.2 ml/10 Lt 3rd spray – B-cyfluthrin 2.5 %@10 ml/10 Lt

		4th spray – Indoxacarb 14.5 SC @ 5 ml/10 Lt 5th spray – Fenvalerate 20 EC@ 6 ml/10 Lt T3: Control
Replications	:	Totally 8 quadrants will be made in 0.5 ha of land. Further each quadrant will serve as replications.
Methodology and observations:	:	• No. of good open bolls and bad open bolls (at least 100 balls to be observed & five observation/plot) and number of pink bollworm larvae. • No. of rosette flowers • No. of green bolls • No. of eggs recorded & no. of parasitized eggs (at least 20-50 eggs will collected in each observation) and yield at harvest.

PDKV-Akola: For sucking pest management – Spraying of Flonicamid 50 WG @ 2 g/ 10 Lt and Acetamiprid 20 % @ 15 g/10 Lt will be done.

8.6 Evaluation of entomofungal agents and botanicals for the management of sucking pests in cotton [PJTSAU & MPKV (for all sucking pests)]

Variety	:	Any recommended *Bt* cotton hybrid at each centre
Plot size	:	40 sq m x 4 for each treatment
Layout	:	Randomized Block Design
Treatments	:	Six T_1: *Metarhizium anisopliae* ($1x10^8$ spores/g) @ 5 g /lit. T_2: *Lecanicillium lecanii* ($1x10^8$ spores/g) @ 5g/lit. T_3: *Beauveria bassiana* ($1 x 10^8$ spores/g) @ 5g/lit. T_4: Azadirachtin 1500ppm @ 2 ml/lit. T_5: As per label claim or as recommended by respective SAU T_6: Untreated control
Replications	:	Four
observations:	:	• Average number of sucking pest population / 3 leaves, *viz.*, Aphids, Jassids, whiteflies and thrips will be counted and recorded. • Number of whitefly adults from 3 leaves (top, middle and lower canopy) of 5 randomly selected plants in each plot will be recorded before spray, 3 and 7 days after spray. • Cadavers without apparent sporulation along with leaves will be brought in the laboratory and incubated under optimal condition. After 5 days cadavers were observed for signs of fungal infection and sporulation. • The population of other sucking pests will also be recorded.

		• Yield (q/ha) to be recorded.

9. SUGARCANE

9.1 Field evaluation of ICAR-NBAIR endophytic entomopathogenic strains against shoot borers (*Chilo infuscatellus* and *Chilo sacchariphagus indicus*) in sugarcane (ANGRAU, Anakapalle)

Plot size	:	1 × 5 cents for each treatment, 1 cent = 8×5 m^2
Replications	:	03
Design	:	RBD
Date of sowing	:	Kharif season
Treatments	:	T1: NBAIR - *Beauveria bassiana* Bb-11 @ 5 ml/lt T2 : NBAIR - *Beauveria bassiana* Bb-23@ 5 ml/lt T3: NBAIR - *Beauveria bassiana* Bb-45@ 5 ml/lt T4: NBAIR - *Beauveria bassiana* Bb-47 @ 5 ml/lt T5: NBAIR - *Beauveria bassiana* Bb-58 @ 5 ml/lt T6: NBAIR - *Beauveria bassiana* Bb-61@ 5 ml/lt T7: NBAIR - *Metarhizium anisopliae* Ma-35@ 5 ml/lt T8: Recommended Insecticide application (Chlorantraniliprole @ 0.3 ml/lt) T7: Untreated Control Sett treatment at planting and spraying of endophytic entomopathogenic fungi 3 times at 14 days interval from 25 days after germination.
Observations	:	• Cumulative incidence of early shoot borer upto 120 days after planting • Internode borer incidence (%) in 50 canes • Internode borer intensity (%) i.e., number of bore holes per cane in 10 m row length • Cane yield data (t/ha) and single cane weight (kg/cane) • Sucrose (%) and incremental benefit cost ratio at harvest.

9.2 Field efficacy of EPN strains against white grubs in sugarcane (MPKV-Pune)

Experimental details:

Treatments: 6

T1: *Heterorhabditis indica* WP

T2: *H. bacteriophora* WP

T3: *Steinernema carpocapsae* WP

T4: *S. abbasi* WP

T5: Chemical (Chlorpyriphos/fipronil)

T6: Control

Replications: 4 and Design: RBD.

Plot size: 8 × 5 m^2 Spacing: 90 x 60 cm

Methodology:

The experiment will be conducted on the farmer's field, Sugarcane variety will be selected as per the university recommendation. The first application of entomo pathogenic nematode will be given after notice of white grub infestation

Observations:

1. No healthy tillers and dead tillers / 1 m row length before application of EPN Per cent reduction of white grub population;
2. Yield of sugarcane will be recorded at the time of harvesting (comparison with insecticides and control),
3. Cost benefit ratio.

9.3 Field efficacy of dose application of EPN against white grubs in sugarcane (MPKV-Pune)

Methodology:

The experiment will be conducted on the farmer's field, Sugarcane variety will be selected as per the university recommendation. Plot size: 8x5 m^2 (Spacing: 90 x 60 cm); No. of Replications: 4; Design: RBD.

The treatment details are as follows:

T1: *H. indica* @ 1.0 $\times 10^5$/ m^2 (NBAIR WP formulation)

T2: *H. indica* @ 2.0 $\times$ 10^5/ m^2 (NBAIR WP formulation)

T3: *H. indica* @ 3.0 $\times 10^5$/ m^2 (NBAIR WP formulation)

T4: *H. indica* @ 1.0 $\times 10^5$/ m^2 (Commercial WP formulation)

T5: *H. indica* @ 2.0 $\times$ 10^5/ m^2 (Commercial WP formulation)

T6: *H. indica* @ 3.0 $\times$ 10^5/ m^2 (Commercial WP formulation)

T7: Chemical (Chlorpyriphos/fipronil)

T8: Control

Observations :

1. No healthy tillers and dead tillers / 1 m row length before application of EPN,
2. Per cent reduction of white grub population;
3. Yield of sugarcane will be recorded at the time of harvesting (comparison with insecticides and control),

4. Cost benefit ratio.

9.4 Efficacy of entomopathogenic fungi for the management of white grub in sugarcane ecosystem (ICAR-SBI)

Treatments:

T1: *B. brongniartii*
T2: *B. brongniartii* + Lasenta
T3: *M. anisopliae*
T4: *M. anisopliae* + Lasenta
T5: *M. anisopliae* + *B. brongniartii*
T6. *M. anisopliae*+ *B. brongniartii*
T7. *M. anisopliae* + *B. brongniartii* + Lasenta and
T8: untreated control.

Observations:

Pretreatment and post treatment observations after a month will be taken as grubs/ m^2. In addition, pot culture experiments to assess the persistence of the fungi and efficacy will be carried out.

9.5 Large Scale Demonstration of *Trichogramma chilonis* against sugarcane borers [PAU (4000 ha); OUAT (5 ha); MPKV (5 ha); UAS-R (50 ha); PJTSAU (5 ha); Sun Agro (5 ha), IISR, Lucknow]

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

		interval from initiation of parasitoid release up to 4 months • Per cent cane attacked at harvest • Cane yield data • Number of millable canes, juice quality and incremental benefit cost ratio estimated post harvest.

OILSEEDS

10. MUSTARD

10.1 Bio-efficacy of entomopathogenic fungus and neem against mustard aphid (UBKV-Pundibari)

Location	:	Instructional Farm, UBKV
Season	:	Rabi
Layout	:	Randomized Block Design
Plot Size		5 × 4m
Treatments	:	T1: *Beauveria bassiana* (NBAIR Culture) @1×10^8 spore/g-5g/lit T2: *Metarhizium anisopliae* (NBAIR Culture) @1×10^8 spore /g-5g/lit ***T3:*** *Lecanicillium lecanii* (AAU-J Culture) @1×10^8 spore/g -5g/lit T4*: Lecanicillium lecanii* (NBAIR) @1×10^8spore/g-5g/lit T5: Azadirachtin 3000ppm @ 2.5ml/lit T6: Standard check (Any systemic insecticide)
Replications	:	Four
Observations	:	Counts of aphids to be made before treatment and 7 days after each treatment. 1. Aphid population at weekly interval on randomly selected 10 plants (terminal shoot) per plot up to maturity will be recorded from each plot. 2. Yield per plot

11. Ground nut

11.1 Evaluation of locally isolated potential entomopathogenic fungi, *Metarhizium rileyi* and *Beauveria bassiana* (NBAIR-Bb-5a) against groundnut leaf miner and tobacco caterpillar in ground nut ecosystem (UAS Raichur)

Crop	:	Ground nut
Variety/ Hybrid	:	R- 8808
Design	:	RBD
Treatments	:	7
Replication	:	3

Plot Size	:	54sqm
Treatment Details		T_1: *M. rileyi* 1×10^8 spores/g @ 5.0 g/l T_2: *M. rileyi* 1×10^8 spores/g @ Dharwad strain 5.0 g/l T_3: *B. bassiana*1×10^8 spores/g (NBAIR-Bb-5a) @ 5.0 g/l T_4: *M. anisopliae* 1×10^8 spores/g (NBAIR-Ma 4) @ 5.0 g/l T_5: NBAII BtG4 2% @ 2.0 ml/lt T_6: Emamectin benzoate 5 SG @ .02gm/lit T_7: Untreated control
Methodology	:	Number of active miner per 20 leaflet – Leaf miner Number of larvae per mrl - Spodoptera Number of dead larvae (bacteria/virus/fungus) per plot Pod and Halum yield

12. SOYBEAN

12.1 Large scale demonstration of entomopathogenic fungi, *Metarhizium rileyi* against soybean defoliators in Bidar district (UAS Raichur)

Crop	:	Soybean
Variety/ Hybrid	:	Dsb21
Area	:	50 ha
Treatment Details	:	T_1: *M. rileyi* 1×10^8 spores/g @ 2.0 g/l T_2: Farmers' practice (as per sprays recommended insecticide at each place as per university recommendation or label claim). T_3: Untreated control
Methodology	:	• Standard procedure will be followed to record the incidence of defoliators. • Cadavers without apparent sporulation along with leaves will be brought in the laboratory and incubated under optimal condition. After 5 days cadavers were observed for signs of fungal infection and sporulation. • Yield (q/ha) to be recorded.

FRUIT CROPS

13. BANANA

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

Variety	:	Cavendish (CV Jahaji)
Layout	:	Randomized Block Design.
Treatments	:	T1: Four spray of Neem product (Azadiractin 1500) @

		2ml/lt at 15 days interval. T2: Four time filling of Leaf axil with *Beauveria bassiana* (AAU J Culture) @1×10^8 spore / g at 15 days interval. T3: Four spray of *Beauveria bassiana* (AAU J Culture) @1× 10^8 spore / g at 15 days interval. T4: Bunch covering with plastic bags. T5:Sprays of insecticides as per label claim or recommended by the University at 15 days interval T6: Untreated control (Spray will be imposed after bunch formation)
Replications	:	Five trees per treatment
Observations	:	• Number of *N. **subcostatum*** per plant will be recorded at 3 days after the treatment by counting on leaves including those hidden inside the crown leaves. • Number of leaf scares on leaf surface will be recorded from 5 sq. cm. on 3 different areas of the youngest leaves. • Observations on the number of healthy and infested fingers per bunch will be recorded and used for computing the mean finger infestation after harvesting the crop. • Influence of various treatments on finger weight of banana will be calculated after harvesting the crop. • Yield data from each treatment will be recorded

14. PAPAYA

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

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

		incidence based on random selection of 25 plants from each orchards visited. • Pest intensity rating (1-5 scale) will be recorded from 5 plants/ orchard. • Record natural enemies species-wise from two leaves/ plant and 5 plants/ orchard.

15. APPLE

15.1 Validation and large scale field demonstration of IPM Technology of Codling moth, *Cydia pomonella* infesting apple in Ladakh (SKSUAT-Srinagar)

Crop	:	Apple
Variety	:	Red delicious and others
District	:	Kargil (Ladakh)
Specific villages	:	Trespone, Mingy, Slikchay and Bagh-e-Khomini
Area		2.0 ha.
Treatment	:	One chemical spray+ Light trap + Pheromone trapping + four releases of *T. cacoeciae*+ trunk banding + field sanitation
Observations	:	• Per cent fruit damage • Per cent reduction in damage over control • Yield

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

Variety	:	Red delicious
Plot size / No. of plants to be treated		10 per treatment
Layout	:	Randomized Block Design.
Treatments	:	T1: 200 nymphs/ tree @ two release /week T2: 400 nymphs/ tree @ two release /week T3: Chemical control with recommended insecticide as per university recommendation or label claim. T4: Control
Replications	:	Each tree to serve as replication
Methodology and	:	• Two field releases of anthocorid bugs @ 200 (T1) and

observations		400 (T2) / plant when number of ERM crosses 10/leaf • *In situ* observations on population density of motile ERM/ leaf on 3rd and 7th day after the treatments • Comparison of the treatments for the efficacy of the bugs against Control(T4) • % Decline in mites' population • Effect of dosage on per cent reduction in motile stages of mites • Comparison of data with untreated check

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

Variety	:	Apple variety in different orchards to be noted
Treatments	:	T1: *Metarhizium anisopliae* (NBAIR) 1×10^8 spores/g @ 30g per tree mixed with enriched FYM 1.5 kg /tree, as soil application during July- August i.e at the time of emergence of new grubs) T2: Farmers' practice (as per university recommendation or as per label claim).
Replications	:	Each orchard to serve as replication.
Observations	:	• Number of live and dead larvae will be counted at the time of basin preparation and percent mortality will be calculated

15.4 Evaluation of some biocontrol agents against leopard moth, *Zeuzera multistrigata* in apple (YSPUHF, Solan)

Treatments	T1: *Beauveria bassiana* (5g/L of 10^8 conidia/g; 10ml/gallery) T2: *Metarhizium anisopliae* (5g/L of 10^8 conidia/g; 10ml/gallery) T3: *Steinernemma feltiae* (2500IJs/gallery) T4: *Steinernemma feltiae* (5000IJs/gallery) T5: *Heterorhabditis bacteriophora* (2500IJs/gallery) T6: *Heterorhabditis bacteriophora* (5000IJs/gallery) T6: Azadiraditin (2ml/L of 1500ppm; 10ml/gallery) T7: Chlorpyriphos (0.04%; 10ml/gallery) T8: Control (water, 10ml/Gallery)
Replications	Three; 3 trees per replication The above treatment solutions will be injected in to the live insect galleries with the help of a syringe (without needle) during August-September. After treatment the galleries will be sealed with clay.

Observations	After 7-10 days the trees will be inspected and the opened galleries will be closed again. The data on live and dead galleries will be recorded after one month. The galleries reopened by the pest will be treated as live, while those not opened by the pest as dead. The data thus obtained will be used to calculate the per cent mortality and will be analysed as per RBD.

16. MANGO

16.1 Habitat manipulation for conservation of bioagents for management of mango insect pests (CISH-Lucknow)

Variety	:	Dashehari
No. of trees		10 trees per treatment
Layout	:	Randomized Block Design.
Treatments	:	T1: Mango intercropped with maize. T2: Mango intercropped with mustard T3: Mango intercropped with Coriander T4: Mango as sole.
Replications	:	Three
Methodology for imposing treatments		Crops will be sown during December or January, so that these crops comes flowering during the second fortnight of February and it will be synchronised with panicle emergence and flowering of mango
Methodology and observations	:	Observation will be taken at different intervals after application; Status of major pest of mango and Natural enemies, if any

16.2 Field evaluation of microbial biocontrol agents for the management of mango thrips (CISH-Lucknow)

Variety	:	Dashehari
No. of trees		3 trees per treatment
Layout	:	Randomized Block Design.
Treatments	:	T1: ICAR-NBAIR *Pseudomonas fluorescens* NBAIR PFDWD5 @20g/lit T2: *L. lecanii* NBAIR (VL8) @5g/lit T3: Chemical control with recommended insecticide as per CISH recommendation or label claim. T4: Control
Replications	:	Three
Methodology for imposing treatments		Soil application and Spray
Methodology and observations	:	Observation will be taken at different intervals after application; No of thrips/ tree; percent damage of fruits; Natural enemies, if any

16.3 Bioefficacy of entomopathogenic fungi formulations in suppression of mango tortricid borers (CISH-Lucknow).

Variety	:	Dashehari
No. of trees		5 trees per treatment
Layout	:	Randomized Block Design.
Treatments	:	T1: *Beauveria bassiana* (CISH culture) @1x10^8 spores/g @ 5g/lit T2: *Metarhizium anisopliae* (NBAIR culture) @1x10^8 spores/g @ 5g/lit T3: *Beauveria bassiana* (NBAIR culture) @1x10^8 spores/g @ 5g/lit T4: Dimethoate 30% EC 2 ml/lit (CISH POP) T5: Untreated control
Replications	:	Each tree to serve as replication
Methodology and observations	:	Observation will be taken at different intervals after application; percent damage by fruit borer, Natural enemies, if any

16.4 Management studies for inflorescence thrips on mango with bio-pesticides in field conditions. (DRYSRHU)

Experimental Details

Treatment details

Treatment	Dose	Source/ Strain name
T1- *Beauveria bassiana*	5 ml/l	Anand Agril. University (Source of Strain NBAIR Bb5a)
T2- *Metarhizium anisopliae*	5 ml/l	Anand Agril. University (Source of Strain NBAIR Ma4)
T3- *Verticillium lecanii*	5 ml/l	Anand Agril. University (Source of Strain NBAIR NBAIR VL15)
T4- Azadirachtin 10000 ppm	5 ml/l	Commercial
T5- Fipronil 5SC	2 ml/l	Commercial
T6- Untreated Control	-	-

Replications: 4

Location: Bavajipeta village, Gokavaram Mandal, East Godavari district

Frequency of spray: Weekly (a total of three/ four sprays) (with the incidence of thrips first generation)

Data to be recorded in the spraying experiment: Observations were taken on different intervals on thrips population (nymphs and adults) by counting single tap of shoot or panicle on whitepaper on 10 panicles per tree at standing height of tree on a day before spray and 7^{th}, 14^{th}, 21^{st} and 28^{th} day after spray.

16.5 Bio-intensive management of mango hopper (AAU-Anand)

	Year of commencement	:	2020-21
	Location	:	Farmers' fields, District –Valsad/Navsari
	Crop/variety	:	Mango
	Area	:	2 ha
	Treatments	:	02
	Repetition	:	10
	Design	:	Large plot sampling CRD
	Spacing	:	10 x 10 m
	Plot size	:	1 ha for each treatment
	Treatments		
T_1	BIPM module		• One spray of *Metarhizium anisopliae* 1% WP (2×10^8 cfu/ g) @ 50 g/ 10 litre of water on tree trunk during the month of November • Three sprays of *Metarhizium anisopliae* 1% WP (2×10^8 cfu/ g) @ 50 g/ 10 litre of water on foliage during flowering at fifteen days interval with the initiation of pest
T_2	Chemical module/ Farmers' practice		-
	Methodology & Observations		• Total ten trees will be selected randomly in each treatment. Each tree will serve as one replication • **Number of hoppers/twig** • Five twigs-panicles (approx. 15 cm length) from each tree will be observed and number of hoppers per twig will be recorded • **Fruit yield - q/ha** • **C:B ratio**

17. GUAVA

17. 1 Evaluation of bio-agents against root-knot nematode and Fusarium wilt complex in guava under controlled conditions (CISH Lucknow)

Treatments:

1. *Purpureocillium lilacinum* @ 10^6 spores/cfu per kg of soil
2. *Pochonia chlamydosporia* @ 10^6 spores/cfu per kg of soil
3. *Trichoderma asperellum* @ 10^6 spores/cfu per kg of soil
4. *Bacillus* spp. @ 10^6 spores/cfu per kg of soil
5. ICAR-FUSICONT @ 20 g formulation per kg of soil
6. Vermi compost @ 100 g per kg of soil
7. T1 + T4
8. T2 + T4
9. T3 + T4
10. T1 + T6
11. T2 + T6
12. T3 + T6
13. T4 + T6
14. T5 + T6
15. Inoculated (nematode only) control
16. Inoculated (*Fusarium oxysporum* only) control
17. Inoculated (nematode + fungus) control
18. Uninoculated control

Nematode inoculums dose: 2000 J2 per kg soil mixture (8: 2 Soil: FYM)
Replicates: 5 per treatment

Methodology:

- Bio-agent inoculation : All the treatments (1-14) will be applied 7 days prior to transplantation of seedlings and treatment number 1-9 will be repeated 60 days after transplanting by scrapping top 2-3 mm soil followed by treatment application and replacement of same soil.
- Age of seedlings at transplanting : 45 days (after seed sowing)
- Nematode inoculation : Just after transplantation
- Termination of Experiment: 180 days after inoculation

Data to be recorded:

- Root-knot index (0-4 scale)
- Number of J2 in soil
- Colonization of roots by fungus
- Shoot height (cm)
- Shoot and root weight (g)

GD Comment: Occurrence of *Meloidogyne enterolobii* has to be confirmed. (CISH Lucknow)

The *Meloidogyne* females have been excised from infected roots taken from culture plants and from guava roots collected during survey and have been given for molecular characterization. This work will be continued at least for a year and results will be presented time to time.

17.2 Development of biocontrol based ipm module for the management of guava fruit borers (CISH-Lucknow)

Variety	:	Allahabad safeda
No. of trees		5 trees per treatment

Layout	:	Randomized Block Design.
Treatments	:	T1: *Beauveria bassiana* (CISH culture) @1x10^8 spores/g-5g/lit T2: *Metarhizium anisopliae* (NBAIR culture) @1x10^8 spores/g-5g/lit T3: *Beauveria bassiana* (NBAIR culture) @1x10^8 spores/g-5g/lit T4: Azadirachtin 1500 ppm @ 2ml/lt T5: Dimethoate 30% EC 2 ml/lit (CISH POP) T6: Untreated control
Replications	:	Each tree to serve as replication
Methodology for imposing treatments		Spray
Methodology and observations	:	Observation will be taken at different intervals after application; percent damage by fruit borer, Natural enemies, if any

17.3 Biological control of root knot nematode in guava (UAHS-Shivamogga)

Variety	Lucknow 49
No of trees	10 trees per treatment
Lay out	Randomized block design
Treatments	T_1 : *Purpureocillium lilacinum* (UAHS-15) @ 1 × 10^8 Cfu/ g @ - 30g/ plant multiplied in 3kg of FYM
	T_2 : *Trichoderma harzianum* (UAHS-3) @ 1 × 10^8 Cfu/ g - 30g/ plant multiplied in 3kg of FYM
	T_3 : *Pseudomonas fluorescens* (UAHS-56) @ 1 × 10^8 Cfu/ g - 30g/ plant multiplied in 3kg of FYM
	T_4 : *P. lilacinum* (UAHS-15) + *P. fluorescens* (UAHS-56) + *T. harzianum* (UAHS-3) @ 1 × 10^8 Cfu/ g - 10g each/ plant multiplied in 3kg of FYM
	T_5 : Carbofuran 10 G @ 25g per plant
	T_6 : Non-treated trees (check)
Replications	Each trees to serve as replication
Methodology and observations	Observations regarding plant growth parameters and galling on roots will be taken at different intervals after application

17.4 Biological control of guava mealy bug and scales using entomopathogens (SKUAST-Jammu)

Number of treatments: 5

Number of replications: 5

Design: RBD

Five trees per replication in Guava

Treatment details

T1	*B. Bassiana* (NBAIR-Bb-5a) @ 5 g/L
T2	*Metarhizium anisopliae* (NBAIR-Ma-4) @ 5 g/L
T3	*Lecanicillium lecanii* (NBAIR-VI-22) @ 5 g/L
T4	Azadirachtin 10000 ppm @ 1 ml/L
T5	Untreated Control

Observations to be recorded- Pre and post spray mealy bug and scales counts

17.5 Evaluation of entompthogenic fungi, *Beauveria bassiana* (NBAIR-Bb-5a) against mealy bug in guava ecosystem (UAS-Raichur)

Crop	:	Gauva
Variety/ Hybrid	:	Lucknow 49
Design	:	RBD
Treatments	:	8
Replication	:	3
No. of plants per treatment	:	05
Treatment Details		T_1: *B.bassiana* @ 1×10^8 @ 5 gm/l (NBAIR-Bb-5a) @ 5.0 g/l T_2: *L. leccani* @ 1×10^8 @ 5 gm/l (NBAIR-VL-8) @ 5.0 g/l T_3: *L. leccani* @ 1×10^8 @ 5 gm/l (NBAIR-VL-15) @ 5.0 g/l T_4: *M. anisopliae* @ 1×10^8 @ 5 gm/l (NBAIR-Ma 4) @ 5.0 g/l T_5: *Isaria fumosorosea* (NBAIR strain) @ 1×10^8 @ 5.0 g/l T_6 : Azadirachtin 1500ppm @ 2 ml/lit T_7 : Buprofeizn 25 SC @ 1 ml/lit T_8: Untreated control
Methodology	:	• Standard procedure will be followed to record the mealy bugs Number of whitefly adults from 3 leaves (top, middle and lower canopy) of 5 randomly selected plants in each plot will be recorded before spray, 3 and 7 days after spray. • Cadavers without apparent sporulation along with leaves will be brought in the laboratory and incubated under optimal condition. After 5 days cadavers were observed for signs of fungal infection and sporulation. • Yield (q/ha) to be recorded.

18. ANOLA

18.1 Biological control of anola mealy bug and scales using entomopathogens (SKAUST-Jammu)

Number of treatments: 5
Number of replications: 5
Design: RBD
Five trees per replication in Guava

Treatment details

T1	*B. Bassiana* (NBAIR-Bb-5a) @ 5 g/L
T2	*Metarhizium anisopliae* (NBAIR-Ma-4) @ 5 g/L
T3	*Lecanicillium lecanii* (NBAIR-VI-22) @ 5 g/L
T4	Azadirachtin 10000 ppm @ 1 ml/L
T5	Untreated Control

Observations to be recorded- Pre and post spray mealy bug and scales counts

19. CITRUS

19.1 Field evaluation of bio pesticides for the management of sucking pests of citrus (PDKV Akola)

Experimental Details:

Variety		**Nagpur mandarin/Acid lime**
Plot size		Each treatment consisting of two trees
Layout	:	Randomised Block design
Area	:	Citrus orchard of 12 years old having about 100 trees
Treatments	:	**T1:** *Beauveria bassiana* @ 5 g/lit (NBAIR-Bb-5 a) T2: *Metarhizium anisopliae* @ 5g/lit (NBAIR-Ma-4) T3: *Lecanicillium lecanii* @ 5 g/lit (NBAIR VI-8) T4: *Aschersonia aleyrodis* @ 5 ml/lit (source of strain Dr.PDKV, Akola) T5: Azadirachtin 10000 ppm @ 5 ml/lit T6: Imidacloprid 17.8 SL @ 0.25 ml/10 lit T7: Untreated control
Replications	:	3
Methodology and	:	• Four shoot of 10 cm length will be selected in four

observations & frequency of spray		directions at eye sight level on randomly selected observational trees to record the build of sucking pests population in citrus orchard • As soon as sucking pests incidence will be noticed treatment sprays will be initiated and subsequent sprays will be applied at 15 days interval. • Observations will be recorded on a day before spray and 3, 7 and 14 days after each spray.

19.2 Evaluation of potential isolates of microbials against citrus thrips (YSRHU, Tirupati)

Methodology:

Experimental material: Existing orchard with 6 x 6m spacing.

Age of plants: 8 years (Tirupati)

Treatment details:

T_1	*Beauveria bassiana* (NBAIR Bb-5a Strain) @ 5g/ Litre
T_2	*Metarhizium anisopliae* (NBAIR Ma-4 Strain) @ 5g/ Litre
T_3	*Lecanicium lecanii* (NBAIR Vl-8 Strain) @ 5g/ Litre
T4	*Pseudomonas fluorescens* (NBAIR-PFWD)20g/litre
T5	Chemical check (Acephate 75SP @ 0.1%)
T6	Control

Design: RBD; **Replications**: 5; **Plants/replication**: 3; **Variety**: Sathgudi

Observations: The per cent leaf infestation due to thrips on foliage at 0 days (pre count) and 3, 7 and 14 days after second spray and for fruits, the percent infested fruits will be counted. The observed data for per cent thrips infestation on leaf and fruits infestation will be analysed statistically and the values will be converted into arc sine transformed values. The yield data will be recorded and expressed into tonnes/ha.

Parameter	**SI unit**
Infestation of thrips on foliage/fruits,	%

Time of spray**:** First spray at the peak activity of the pest and second at 14 days after first spray for thrips damaging leaf and in case of thrips, treatments should be initiated immediately after fruit set (10 days after flowering)

19.3 Evaluation of potential isolates of microbials against citrus Rust and Green mites (YSRHU, Tirupati)

Methodology:

Experimental material: Existing orchard with 6 x 6m spacing

Treatment details:

T_1	:	*Beauveria bassiana* (NBAIR Bb-5a Strain) @ 5g/ Litre
T_2	:	*Metarhizium anisopliae* (NBAIR Ma-4 Strain) @ 5g/ Litre

T_3	:	*Lecanicium lecanii* (NBAIR Vl-8 Strain) @ 5g/ Litre
T4		*Pseudomonas fluorescens* (NBAIR-PFWD)20g/litre
T5	:	Local check (Propargite 57EC @0.0.057%)
T6	:	Control
Treatments should be given during active period of the pest twice at 15 days interval		

Design: RBD; **Replications**: 4; **Plant/replication**: 2; **Variety**: Sathgudi

Observations: The population counts of mites before and 3, 7 and 14 days after treatment will be recorded. In case of rust mites, observation on infested fruits (%) before harvest will be noted and the yield data will be recorded and expressed into tonnes/ha. The observed data for population counts on leaf and fruits infestation will be analysed statistically and the values will be converted into square root and arc sine transformed values, respectively.

20. Litchi

20.1 Bio-intensive management of litchi fruit borer, *Conopomorpha sinensis* (Bradley) in litchi (PAU, Ludhiana)

Variety	:	Region specific recommended variety
Treatments		Three 1. BIPM • Ploughing in orchard during March-April • Regular clean cultivation throughout the year • Regular collection and destruction of fallen infested fruits during May-June • Light trap @ 1 per acre during April • Releases of *T. embryophagum* @ 4000 parasitized eggs per tree 5-7 times at 7-10 days interval starting from initiation of flowering to colour break stage 2. Farmer's practice (chemical control) 3. Untreated control
Replications	:	Divide each block into 8 equal sized units (each unit = one replication)
Observations	:	Record the observations on total and infested fruits from 5 trees in each unit to work out per cent damage. Count total number of marketable fruits from 5 trees of each unit. After taking the average weight of 50 fruits, yield (kg/tree) of fruits will be calculated by dividing the

		number of fruits per tree with average weight of fruit and multiplying the value with 1000 to convert into kg per tree. Yield/acre (MT) will be calculated by multiplying fruit yield with number of trees/acre and dividing it by 1000 to convert to yield/acre in metric tons. Cost benefit ratio will also be calculated and per cent fruit infestation and yield loss on weight basis will be worked out.

PLANTATION CROPS

21. COCONUT

21.1 Surveillance of rugose whitefly in coconut and assessing the population of natural biocontrol agents [NBAIR, TNAU, AAU-J, KAU (all centers), DRYSRHU, CPCRI]

Methodology

- Observations on RSW incidence shall be made at monthly intervals from three pest infested gardens with varietal details, age of a and meteorological data
- Five palms shall be selected at random in each garden for observation
- Palm infestation should be recorded as

(i) Percentage of leaves infested/palm (no. of leaves infested by RSW /total leaf per palm)

(ii) Intensity of pest damage from four pest infested leaves per palm from the outer/middle whorl representing four directions (no. of leaflets infested by RSW/ total leaflets per leaf)

(iii) One leaflet from each observed sample leaf shall be collected and brought to laboratory for assessment live colonies, pest stages and natural enemies (total of 4 leaflet/palm) (20 leaflets/plot)

- The actual quantification (number/percentage) may be followed, than rating as low/ medium/high, for statistical analysis

21.2 Biological suppression of rugose spiralling whitefly in coconut (KAU- Kumarakom and Thrissur, DRYSRHU, CPCRI and TNAU)

Treatment details:

T1.	*Encarsia guadeloupae* natural conservation).
T2.	Foliar application of *Isaria fumosorosea* (pfu-5) @ 1×10^8 cfu/ml (Two sprays at 15 days intervals).
T3.	Foliar application of neem oil 0.5% (neem oil 5 ml + soap powder 10g /litre of water) (Two sprays at 15 days intervals).
T4.	Foliar water spray (2 sprays at 15 days intervals)

Ten palms per each treatment (palms with minimum 5-7 leaves infested with RSW with each leaf containing more than 10 live colonies with nymphs should be selected for experiment)

Observations:

Pre-treatment observations from all palms:

1. Total number of leaves/palm
2. Leaves infested with RSW/palm
3. Total leaflet and RSW infested leaflets /leaf (from 4 sample leaves/palm)
4. Collect 4 leaflets/palm & observation at laboratory for
   (i) number of live colonies/leaflet (live colony should be with either live eggs/nymphs/adults)
   (ii) number of healthy nymphs/leaflet
   (iii) number of parasitized nymphs (live & blackened) & nymphs with parasitoid emergence holes/leaflet

Post treatment observations (of all the parameters taken for pre-treatment) from all palms:

(1) 15 day after 1st spray
(2) 15 days after 2nd spray

Other observation

- Nut yield /palm (if treatment is imposed on yielding palms) at pre-treatment and at yearly interval
- Species of whitefly
- Variety of palm

Health management strategies adopted by farmer

21.3 Field evaluation of bio agents against rugose spiraling whitefly on coconut (UAHS-Shivamogga)

Variety	Local
Lay out	Randomized block design
Treatments	T_1 : *Isaria fumosorasea* (NBAIR) @ 5g /lt
	T_2 : *Encarsia guadeloupae* @ 600 adults per acre
	T_3 : *Beauveria bassiana* (UAHS-18) @ 1×10^8 Cfu/ ml - 3 ml /lt
	T_4 : *Metarhizium anisopliae* (UAHS-33) @ 1×10^8 Cfu/ ml - 3 ml /lt
	T_5 : *Lecanicillium lecanii* (UAHS-12) @ 1×10^8 Cfu/ ml - 3 ml /lt
	T_6 : Neem oil 1500 ppm @ 2 ml/litre of water
	T_7 : Untreated (check)
Replications	4
Methodology and observations	Number of sprays/ releases: 2- 3 sprays at weekly interval The pest population from randomly selected five plants before and after each spray / release of predator and yield / tree will be recorded

21.4 Management of Coconut Rugose spiralling whitefly using entomopathogenic fungi, *Isaria fumosorosea (*ANGRAU, Anakapalle)

Location	:	Farmers fields
Treatments	:	T1 : Spraying *Isaria fumosorosea* (pfu-5) @ 2×10^8 (5 ml /lt) oil formulation + field release of parasitoid *Encarsia guadeloupae*

		T2: Spraying *Isaria fumosorosea* (pfu-5) @ 2 × 10^8 (5 ml /lt) oil formulation + field release of predator, *Dichocrysa sp. nr. astur* @ 1000 eggs/ha T3: Spraying *Isaria fumosorosea* (pfu-5) @ 2 × 10^8 (5 g/lt) talc formulation + field release of parasitoid, *Encarsia guadeloupae* T4: Spraying *Isaria fumosorosea* (pfu-5) @ 5 g/lt @ 2 ×10^8 (5 g/lt) talc formulation + field release of predator, *Dichocrysa sp. nr. astur* @ 1000 eggs/ha T5: Spraying *Isaria fumosorosea* (pfu-5) @ 2 × 10^8 (5 g/lt) conidiated rice + field release of parasitoid *Encarsia guadeloupa* T6: Spraying *Isaria fumosorosea* (pfu-5) @ 2 × 10^8 (5 g/lt) conidiated rice + field release of predator, *Dichocrysa sp. nr. astur* @ 1000 eggs/ha T7 : Spraying Neem formulation 10000 ppm @ 1ml/lt Two- three sprays at 15 days interval covering the entire leaflet, fronds and directed lower side of leaves.
Replications	:	4
Design	:	Observational plot
Plot size		Separate blocks for each treatment with isolation distance
Observations	:	<u>Palm infestation :</u> Pre treatment count : 1. Percentage of leaves infested/palm (no. of leaves infested by RSW /total leaf per palm), 2. Intensity of pest damage from 10 pest infested leaflet/fronds per palm from the outer/middle whorl representing four directions (no. of leaflets infested by RSW/ total leaflets per leaf) 3. Ten leaflets from each palm for assessment live colonies (Low: 0-10 live egg spiral or adult/leaflet; Medium: 11-20 live egg spiral or adults/leaflet; Severe: more than 20 egg spirals or adults /leaflets), pest stages. Post treatment count on intensity of pest damage from four pest infested leaflet/fronds per palm from the outer/middle whorl representing four directions (no. of leaflets infested by RSW/ total leaflets per leaf) on 3, 7, 10 DAT. 10 leaflet from each palm for assessment live colonies. (Low: 0-10 live egg spiral or adult/leaflet; Medium: 11-20 live egg spiral or adults/leaflet; Severe: more than 20 egg spirals or adults /leaflets) on 3, 7, 10 DAT. <u>*Isaria* infection can be observed on eggs, nymphs, adults:</u>

		Mycelial growth on eggs (shrunken egg, dark brownish egg), nymphs (reddish spot, shrinken body, turn into pale yellowish brownish over the time), mummified adults (newly emerged adults unable to expand the wings, fly). Natural parasitism by *Encarsia guadeloupae*: 10 leaflet /per palm from lower fronts collected and maintained under laboratory conditions in the aerated contained with mesh or muslin cloth for 7-10 days. Natural parasitism may be determined by number pupae with circular exit holes/number of pupae without exit holes/100. Predation by *Dichocrysa sp. nr. astur*: Number of grubs , Number of eggs in10 leaflet/palm

21.5 Area-wide demonstration of biological suppression of black headed caterpillar using *Goniozus nephantidis* and *Bracon brevicornis* (ICAR-CPCRI, Kayamkulam)

Demonstration	**50 infested palms in endemic tracts**
Treatment	Augmentative release of *Goniozus nephantidis* and *Bracon brevicornis* @ 20 parasitoids/palm
observations	Pest incidence per leaflet, infested leaflets in a frond, parasitism percentage, pre-elease and post release data on pest incidence

21.6 Converging biological suppression approaches for area-wide management of coconut rhinoceros beetle (ICAR-CPCRI, Kayamkulam)

Village		Valiikunnan Panchayat, Mavelikara (1500 ha)
Technology intervention		✓ Delivery of *Metarhizium majus* for each members of Co-operative milk societies and *in situ* incorporation of *Clerodendron infortunatum* in the pest breeding sites ✓ Area-wide technology penetration through Farmer Field School ✓ Collaboration with local panchayat, State Department of Agricultural Development and Farmer's Welfare and Co-operative milk societies
Observations		Pre-treatment and post-treatment pest incidence level Palm health improvement

22. ARECANUT

22.1 Demonstration of *Heterorhabditis indica* (NBAIR culture) WP and *Metarihizium anisopliae* formulation for management of arecanut root grubs in malnad and costal regions of Karnataka (UAHS-Shivamogga)

Large scale demonstrations of biological pest management technologies using EPN ***Heterorhabditis indica*** **(NBAIR culture) and** ***Metarihizium anisopliae***, for the management of root grubs in Arecanut will be conducted in farmer fields of malnad and costal regions of Karnataka in collaboration with KVK and different NGO's operating in that area.

Location	Tirthahalli, Sagara, Hosanagara, and Soraba talluk of Shivamogga district. Sringeri, Koppa, Mudigere talluk of Chikmagalur district. Karnataka
Area	200 acres
Methodology	• Arecanut block where root grubs problem is associated will be selected • T_1: *Heterorhabditis indica* WP (NBAIR) @ 1.2×10^9 IJs ha^{-1} Applied at the time of larval emergence. T_2 : *Metarhizium anisopliae* (UAHS-48) @ 1×10^8 Cfu/ g - 30g/plant multiplied in 3kg of FYM T_3 : Chloropyriphos 20EC 2ml/lt
Replication	Divide each block into 8 equal sized units (each unit = one replication)
1. **Observations to be recorded**	• Plant damage due to white grub will be recorded • Root grub population per tree in the root zone will be recorded by digging pit around the tree and percent reduction in the root grub population will be recorded. • Yield per tree will be recorded
Collaboration	• KVK University of agriculture and horticulture sciences Shivamogga. • Active NGO's of the region.

23. COCOA

23.1 *In vivo* evaluation of effective bio control agents against *Phytophthora* Pod rot management in cocoa (DRYSRHU, Ambajipeta)

a. Pod Rot:

Layout: RBD

Treatments: 4

T_1- Spraying of *Trichoderma reesei* spore suspension (2×10^6 cfu/ml) (2-3 sprays at 15 days intervals during monsoon period)

T_2 – Soil application of 50 g of *Trichoderma reesei* along with 5kg Neem cake (once before onset of monsoon)
T_3 – Spraying of copper oxychloride (3g/litre of water) (2-3 sprays at 15 days intervals during monsoon period)
T_4- Untreated Control
Replications: 6
Location: Avidi village , Kothapet Mandal, East Godavari district

Observations to be recorded: Number of healthy pods, Number of infected pods, Percent reduction of the infected pods & Yield.

b. Stem Canker

Layout: RBD
Treatments: 5
T_1- Chiselling of canker area on the stem and application of *Trichoderma reesei* Paste formulation (2×10^6 cfu/ml) on the chiselled area. Need based application at quarterly intervals
T2 - Chiselling of canker area on the stem and application of *Trichoderma reesei* coir pith cake (one cake per each canker spot) Need based application at quarterly intervals
T_3 - Soil application of 50 g of *Trichoderma reesei* along with 5kg Neem cake (once)
T_4- Chiselling of canker area on the stem and application Copper oxychloride paste formulation based on the lesion size
T_5- Untreated Control
Replications: 5
Location: HRS. Ambajipet, Mandal, East Godavari district

Observations to be recorded: Percent reduction in canker lesion size and Yield data

VEGETABLE CROPS

24. TOMATO

24.1 Role of Habitat manipulation for pest management in Tomato (CAU-Pashighat)

T1: Tomato intercropped with Carrot and Marigold as border crop

T2: Tomato intercropped with Lentil and Coriander as border crop

T3: Tomato intercropped with Chickpea and Mustard as border crop

T4: Tomato intercropped with Field bean and Fennel as border crop

T5: Tomato intercropped with Pea and Dill as border crop

T6: Tomato intercropped with Buckwheat and Maize as border crop

T7: Tomato as sole crop

Season: Winter

Replications: 03

Design: RBD

24.2 Bio-intensive pest management of *Helicoverpa armigera, Tuta absoluta* and sucking pests of tomato (PJTSAU, Sun Agro, IIHR – *Tuta absoluta*)

Variety	:	Location specific popular variety
Plot size	:	8×5 m^2
Layout	:	Randomized Block Design.
Treatments	:	**T1 = BIPM** Seed treatment with *Trichoderma harzianum* @ 10g/kg of seeds. Raising marigold as trap crop Use of NBAIR pheromone traps @ 1 trap per plot. *Trichogramma achaeae / Trichogramma pretiosum* @ 50,000 /ha per release (6 releases) Azadirachtin 1500 ppm @ 2 ml/lit. *Lecanicillium lecanii* (NBAIR) 1×10^8 spores/ g @ 5g/lt for sucking pests *Pochonia chlamydosporia* for root knot nematode **T2 = Chemical control** Chlorantraniliprole 18.5% SC for *Tuta* and indoxacarb 14.5 SC for other pests **T3**= Spinetoram 11.7% SC 0.25ml/L **(only for IIHR)** **T4 = Untreated Control**
Replications	:	Five
Methodology and observations	:	The treatment applications will be started at initial occurrence of American pin worm. Six releases of parasitoids at weekly interval and three sprays of biopesticides will be given during evening hours at fortnightly interval. • Randomly select 10 plants/40m^2 crop area and observe all the leaves for presence of leaf mine / sucking pests caused by the larva. • Randomly select 10 plants/ 40m^2 crop area and observe all the fruits for presence of holes/ damage caused by the larva. • Observations will be recorded at fortnightly interval from fruit formation to last harvest. • Fruit damage percentage and yield. • Cost-benefit ratio.

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

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

24.4 Demonstration on bio-intensive management of insect pests of tomato (0.5-1.0ha) (New experiment) (YSPUHF, Solan)

Variety	:	Location specific popular variety

Treatments	:	**T1 = BIPM** Seed treatment with *Trichoderma harzianum* @ 10g/kg of seeds. Raising marigold as trap crop Use of pheromone traps @ 30 traps/ha. *Trichogramma achaeae/ Trichogramma pretiosum* @ 50,000/ ha per release (6 releases) Azadirachtin 1500 ppm @ 2 ml/lit. *Lecanicillium lecanii* (NBAIR) 1×10^8 spores/ g @ 5g/lt for sucking pests **T2 = Farmers practice** Chlorantraniliprole 18.5% SC for *Tuta* and indoxacarb 14.5 SC for other pests
Replications	:	5
Methodology and observations	:	The treatment applications will be started at initial occurrence of American pin worm. Six releases of parasitoids at weekly interval and three sprays of biopesticides will be given during evening hours at fortnightly interval. • Randomly selected 100 plants/ plot will be observed for the presence of larvae, leaf mines/ sucking pests. • Randomly selected 100 fruits will be observed for the presence of holes/ damage caused by the larva. • Observations will be recorded at fortnightly interval from fruit formation to last harvest. • Fruit damage (%) and yield will be recorded. • Cost-benefit ratio.

25. BRINJAL

25.1 Development of biocontrol based IPM module for the management of fruit and shoot borer, *Leucinodes orbonalis* (Guenee) in brinjal (AAU-Anand)

	Year of commencement	**:**	2020-21 *Kharif*
	Location	**:**	Agronomy farm, AAU, Anand
	Crop/variety	**:**	Brinjal ABH-1
	Treatments	**:**	03
	Repetition	**:**	10
	Design	**:**	Large plot sampling CRD
	Spacing	**:**	90 × 60 cm
	Plot size	**:**	27 × 20 m
Treatments			

<table>
<tr><td>T_1</td><td>BIPM module</td><td>1. Intercropping of brinjal with coriander (2:1 row)
2. Pheromone trap - Lucilure @ 40/ ha
3. Trichogramma chilonis @ 100000/ ha
4. Azadirachtin 10000 ppm (20ml/10 litre water)
5. Bacillus thuringiensis NBAIR BTG-1 (2×10^8 cfu/g) 1% WP (50g/ 10 litre water)
6. Entomopathogenic nematode (EPN) Steinernema sp ? 1% WP (80g/ 10 litre water)</td></tr>
<tr><td>T_2</td><td>Chemical module/ Farmers' practice</td><td>Emamectin benzoate 5 SG (0.0025%) 5g/ 10 litre water - Three sprays at fifteen days interval with the initiation of pest.</td></tr>
<tr><td>T_3</td><td>Untreated control</td><td>-</td></tr>
<tr><td></td><td>Methodology</td><td>• Pheromone trap will be installed from 30 DAT
• Eight releases of Trichogramma chilonis @ 100000/ ha at weekly interval will be made with the initiation of pest
• Three sprays of azadirachtin, two sprays of Bt and one spray of EPN will be carried out during the cropping season.
Spray schedule
<table><tr><th>Bioagent/Biopesticide</th><th>Spray</th><th>DAT</th></tr><tr><td>Azadirachtin</td><td>First</td><td>30</td></tr><tr><td>Bt</td><td>Second</td><td>45</td></tr><tr><td>EPN</td><td>Third</td><td>60</td></tr><tr><td>Azadirachtin</td><td>Fourth</td><td>75</td></tr><tr><td>Bt</td><td>Fifth</td><td>90</td></tr><tr><td>Azadirachtin</td><td>Sixth</td><td>105</td></tr></table></td></tr>
<tr><td></td><td>Observations</td><td>Observations on catches of Leucinodes orbonalis in pheromone trap will be recorded at weekly interval from the installation of pheromone trap
Shoot damage (%) – Ten plants will be randomly selected from each subplot and observations on damages shoots will be recorded at weekly interval after 15 DAT
Fruit damage (%) - The observations on fruit damage on number and weight basis will be recorded from net plot area from each treatment at each picking
Fruit yield (healthy marketable fruit) - kg/plot</td></tr>
</table>

25.2 Bio-intensive insect and nematode (RKN) management in brinjal (OUAT; IIHR; Sun Agro)

Variety	:	Variety will be selected as per the university

		recommendation
Plot size	:	8 × 5 m
Layout	:	Randomized Block Design.
Treatments	:	T1 = BIPM **For sucking pests** Azadirachtin 1500 ppm @ 2ml/lt *Lecanicillium lecanii* (NBAIR strain) 1 × 10^8 spores/ml @ 5g/lt **For BSFB** Mass trapping by all centres, traps by Sun Agro Release of *Trichogramma chilonis* multiple insecticide tolerant strain @100,000/ha, 8-10 releases at weekly interval from initiation of flowering. *Bacillus thuringiensis* NBAII BtG4 2% (not for AAU-J) **For Ash weevil** Entomopathogenic nematode (NBAIR) @ 2 billion IJs / ha, twice during season. **For mealybug** *Cryptolaemus montrouzieri* @ 5 grubs / plants or 1500/ha, twice at 15 days interval. T2 = Chemical Control Based on each university recommendation for insect pest on brinjal. 4-6 sprays depending upon pest species. T3: Untreated control
Replications	:	Eight
Methodology and observations	:	1. Pre-treatment incidence on shoot infestation and catches from pheromone traps. 2. Post treatment counts of infestation at shoot and fruit stage of crop at fortnightly interval. 3. Yield of healthy marketable fruits and cost-benefit ratio.

25.3 Bio-efficacy of microbial agents against *Myllocerous subfasciatus* on brinjal (IIHR)

Variety	:	Variety will be selected as per the institute recommendation
Plot size	:	8x5 m
Layout	:	Randomized Block Design.
Treatments	:	Treatments T1: *Metarhizium anisopliae* (IIHR Strain) oil formulation @ 1ml/l T2: *Beauveria bassiana* (IIHR Strain) WP formulation 10g/l T2: *Metarhizium anisopliae* (Biometa, AAU strain) (1x108 spores /g) @ 5g/ litre T3: *Beauveria bassiana* (Biosona, AAU strain) (1x108 spores /g) @ 5g/ litre T4: *Metarhizium anisopliae* (Ma-4) NBAIR strain (1x108 spores /g) @ 5g/ litre

		T5: *Beauveria bassiana* (Bb-5a) NBAIR strain (1x108 spores /g) @ 5g/ litre T6: *Heterorhabditis indica* @ 2.5 10^9 IJs ha^{-1} T7: Imidacloprid @ 20 g ai/ha T8: Untreated control
Replications	:	Three
Methodology and observations	:	Pre and post treatment infestation at fortnightly interval. If possible destructive sampling may be done ro count the grubs Yield of healthy marketable fruits and cost-benefit ratio.

25.4 Bio-efficacy of microbial agents against leaf hopper in brinjal (UBKV-Pundibari)

Variety	:	Any recommended brinjal variety
Location	:	Instructional Farm, UBKV
Season	:	Pre-kharif
Plot size	:	6 × 5m
Layout	:	Randomized Block Design.
Treatments	:	Treatments T1: *Metarhizium anisopliae* NBAIR strain (1×10^8spores/g) @ 5 g /lit. T2: *Lecanicillium lecanii* NBAIR strain (1×10^8spores/g) @ 5g/lit. T3: *Beauveria bassiana* NBAIR strain (1×10^8spores/g) @ 5g/lit. T4: Azadirachtin 3000ppm @ 2.5 ml/lit. T5: Standard check (Any systemic insecticide) T6: Untreated control
Replications	:	Four
Methodology and observations	:	• Population of leaf hoppers will be recorded from 3 leaves (top, middle and lower) of each plant of randomly selected 5 plants per plot at 1 day before spraying, 3 days and 7 days after spraying. • Yield (q/ha) to be recorded.

26. OKRA

26.1 Management of hoppers, aphids and Whitefly on Okra by oil based formulation of *Metarhiziumanisopliae* IIHR Strain (ICAR-IIHR)

T1	*M. anisopliae* (oil based formulation) @ 0.25ml /l
T2	*M. anisopliae* (oil based formulation)@ 0.5ml/l
T3	*M. anisopliae* (oil based formulation) @ 1ml/l
T4	Standard check – Imidacloprid @0.3ml/l
T5	Unsprayed (control)

Design: RBD, **Replication:** 4, **Plants/replication:** 10plants/replication: 10 sprays (entire crop duration) weekly

Observations:

1. Population of hoppers and thrips a day before application and 3rd, 7th day after application. (4 leaves/plant)
2. Record hopper damage symptoms and YVMV incidence.
3. Marketable Yield at harvest replication wise in each treatment

26.2 Evaluation of *Neoseiulus indicus* for the management of spider mites on okra (KAU, Thrissur)

Plot size	:	8 × 5m=40 m^2
Replications	:	03
Design	:	RBD
Date of sowing	:	As per the package of practice
Treatments*	:	T1: Release of predatory mites @10 mites/plant T2: Release of predatory mites @20 mites/plant T3: Release of predatory mites @30 mites/plant T4: Spiromesifen 100 g a.i/ha T5: Control
Observations	:	• Pre and post count of spider mite/cm^2 of leaf at three days interval • Number of arthropod natural enemies (all stages) from 5 randomly selected plants in each plot (Number/Plant). • Yield (kg/plot).

*No. of releases: Three, at ten days interval starting from first observation of mite infestation

26.3 Efficacy biocontrol agents for management of fruit borer, *Earias vittella* on bhendi (IIVR-Varanasi)

Variety	:	Variety will be selected as per the university recommendation
Plot size	:	8 x 5 m
Layout	:	Randomized Block Design.
Treatments	:	T1: *Metarhizium anisopliae* (NBAIR) 1×10^8 spores/ g @ 5g/lt T2: *Beauveria bassiana* (NBAIR) 1×10^8 spores/ g @ 5g/lt T3: *Trichogramma chilonis* @50,000 parasitoids/ha, 6 releases at weekly interval. T4: *Bacillus thuringiensis* @ 1 kg/ha T5: Azadirachtin 1500 ppm@ 2 ml/lit T6: University recommended insecticide, 2-4 sprays. T7: Untreated control
Replications	:	Three

Methodology and observations	:	Releases of parasitoids at weekly interval and three sprays of entomopathogens, and azadirachtin will be followed at fortnightly interval. The observations will be recorded on five randomly selected plants/ plot. 1. Pre and post- treatment counts on fruit infestation at weekly interval. 2. Yield of healthy marketable fruits at each picking.

26.4 Evaluation of biointensive IPM module against key pests of okra (AAU-J).

Target pests: Jassids/ Thrips/ Whiteflies/ shoot and fruit borer

Location: Neul Gaon, Jorhat (farmer's field).

Season: *Kharif*, 2020

Variety: Locally recommended variety

Area cover: 1ha (to be covered)

(The whole area will be divided into 10 sub plots to serve as 10 replication. A distance of at least 200m will be maintained in between IPM and farmer practice plots. Analysis will be done using 't'-test)

Treatment : 2 (BIPM and farmers practice)

a) BIPM treatments include:

- Yellow sticky traps @20/ha for maintaining of sucking pests.
- Rogue out the YVMV affected plant from time to time.
- Application of *Beauveria bassiana* @ 1×10^8 cfu/@5g/lit.
- Application of NSKE @ 5%
- Release of *Trichogramma chilonis* @ 100,000 per ha starting from 35 days after sowing 4-5 times at 10 days interval or coinciding with the emergence of *Earis* sp.
- Application of profenofos 50% EC @2ml/per lit.(at 2-3 sprays as need based)

b) Farmers practice

Alternate spray of cypermethrin 10EC @2ml/lit and lamda cyhalothrin 2.5%EC @ 1.5ml/lit.

Observations to be recorded:

- Record of sucking pest from 10 randomly selected plants on each leaves from top, middle and bottom before treatment and 7 and 10 days after treatment.

- Number of fruit borer larvae on 10 randomly selected plant before and 7 and 10 days after treatments.
- Per cent fruit damaged by borers.
- Yield at each harvest.

26.5 Bio-intensive pest management in okra (AAU-Anand)

	Year of commencement	:	2020-21 *Kharif*
	Location	:	Farmers' fields, Village - Umreth, District - Anand
	Crop/variety	:	Okra - Local/hybrid
	Area	:	2 ha
	Treatments	:	02
	Repetition	:	10
	Design	:	Large plot sampling CRD
	Spacing	:	60 x 30 cm
	Plot size	:	1 ha for each treatment
	Treatments		
T_1	BIPM module		1. Installation of pheromone trap for *Helicoverpa armigera* & *Earias vittella* @ 40 traps/ha at 30 DAS. 2. Six releases of *Trichogramma chilonis* @ 50000/ ha at weekly interval with the initiation of pest. 3. Two sprays of *Bacillus thuringiensis* NBAIR BTG4 ($2x10^8$ cfu/g) 1% WP (50g/ 10 litre water). First spray with the initiation of lepidopteran pest and subsequent spray at ten days interval 4. One spray of Azadirachtin 10000 ppm (1% EC) (20ml/ 10 litre water) with the initiation of sucking pest and subsequent spray with *Lecanicillium lecanii* NBAIR Vl-8 ($2x10^8$ cfu/g) 1% WP (50g/ 10 litre water) at ten days interval.
T_2	Chemical module/ Farmers' practice		-
	Methodology & Observations		Total 10 quadrates will be made in each treatment. Each quadrate will serve as one replication. **Observations on catches** of *Helicoverpa armigera* and *Earias vittella* in pheromone trap will be recorded at weekly interval from the installation of pheromone trap. The observations on **larval population** of *H. armigera* and *E. vittella* will be recorded from ten randomly selected plants per repetition at weekly interval with the initiation of

		pest. The observations on **sucking pest population/plant** will be recorded from ten randomly selected plants per repetition at weekly interval with the initiation of pest. **Fruit damage (%)** - The observations on fruit damage on number and weight basis will be recorded from each treatment at each picking. **Fruit yield** (healthy marketable fruit) q/ha **C:B ratio**

27. CABBAGE

27.1 Influence of habitat manipulation on incidence and severity of pest damage on cabbage (AAU-Anand)

	Year of commencement	**:**	2020-21 *Rabi*
	Location	**:**	Agronomy farm, AAU, Anand
	Crop/variety	**:**	Cabbage - Sutton Express
	Treatments	**:**	05
	Replication	**:**	04
	Design	**:**	Randomized block design (RBD)
	Spacing	**:**	60 x 60 cm
	Plot size	**:**	Gross- 4.2 x 7.2 m Net-3.0 x 6.0 m
	Treatments		
T_1	Cabbage intercropped with mustard and cowpea		
T_2	Cabbage intercropped with mustard and oats as border crop		
T_3	Cabbage intercropped with cowpea and oats as border crop		
T_4	Cabbage with oats as border crop		
T_5	Cabbage as sole crop		
	Methodology and observations		Main crop, inter crop and border crop will be raised as per recommended agronomic practices. Five plants will be randomly selected from each subplot and observations will be recorded at weekly interval after 25 DAT. 1. Larval population/ plant 2. Aphid population/plant 3. Aphid parasitization (%) by *Diaeretiella* sp.

		4.	Natural enemies/plant (coccinellids and syrphid fly)
		5.	Yield (healthy marketable cabbage heads) - kg/plot

27.2 Field evaluation of ICAR-NBAIR entomopathogenic strains against cabbage aphid (*Brevicoryne/Myzus*) and *Plutella xylostella* (DBM) (IIVR), AAU- Jorhat, MPKV and CAU Pashighat

Plot size 8x5m=40 m^2
Rep 03
Design: RBD
Treatments=6
Total area required = 240m^2 (40x 6) for each centre
Date of sowing: As per the package of practice

Treatments

1. Bb-5a isolate of *Beauveria bassiana*
2. Bb-45 isolate of *Beauveria bassiana*
3. Ma-4 isolate of *Metarhizium anisopliae*
4. Vl-8 isolate of *Lecanicillium lecanii*
5. Recommended Insecticide application
6. Control (Untreated)

Four rounds of foliar sprays of oil formulations of entomopathogenic fungi at the spore dose of 1×10^8 cfu/ml (5ml/liter) has to be given at 15 days interval

Observations:

- Pre and post count of aphids (nymphs and adults)
- Yield

27.3 Bio-intensive pest management in cabbage (AAU-Anand)

	Year of commencement	:	2020-21 *Rabi*
	Location	:	Farmers' fields, Village -Navli, District - Anand
	Crop/variety	:	Cabbage - Local/hybrid
	Area	:	2 ha
	Treatments	:	02
	Repetition	:	10
	Design	:	Large plot sampling method (CRD)
	Spacing	:	60 × 60 cm

	Plot size	:	1 ha for each treatment
	Treatments		
T_1	BIPM module		1. Installation of pheromone trap for *Plutella xylostella* @ 12 traps/ha at 30 DAT 2. Eight releases of *Trichogramma chilonis* @ 100000/ ha at weekly interval with the initiation of pest 3. Two sprays of *Bacillus thuringiensis* NBAIR BTG4 ($2x10^8$ cfu/g) 1% WP (50g/ 10 litre water). First spray with the initiation of lepidopteran pest and subsequent spray at ten days interval 4. One spray of Azadirachtin 10000 ppm (1%EC) (20ml/ 10 litre water) with the initiation of sucking pest/aphid and subsequent spray with *Lecanicillium lecanii* NBAIR Vl-8 ($2x10^8$ cfu/g) 1% WP (50g/ 10 litre water) at ten days interval.
T_2	Chemical module/ Farmers' practice		-
	Methodology & Observations		Total 10 quadrates will be made in each treatment. Each quadrate will serve as one replication. **Observations on catches** of *Plutella xylostella* in pheromone trap will be recorded at weekly interval from the installation of pheromone trap. The observations on **larval population/plant** of lepidopteran pest will be recorded from ten randomly selected plants per repetition at weekly interval with the initiation of pest. The observations on **aphid population/plant** will be recorded from ten randomly selected plants per repetition at weekly interval with the initiation of pest. **Fruit damage (%)** - The observations on fruit damage on number basis will be recorded from each treatment at each picking. **Yield** (healthy marketable cabbage heads) **q/ha** **C:B ratio**

28. CHILLI

28.1 Management of thrips, aphids and Whitefly on chilli by oil based formulation of *Metarhizium anisopliae (IIHR Strain) (ICAR-IIHR)*

T1	*M. anisopliae* (oil based formulation) @ 0.25ml /l

T2	*M. anisopliae* (oil based formulation)@ 0.5ml/l
T3	*M. anisopliae* (oil based formulation) @ 1ml/l
T4	Standard check – Imidacloprid @0.3ml/l
T5	Unsprayed (control)

Design:RBD , Replication: 4, Plants/replication: 10plants/replication

Observations:

1. Population of white fly, aphids and thrips a day before application and 3rd, 7th day after application. (4 leaves/plant)
2. Record hopper damage symptoms and ChLCVincidence.
3. Marketable Yield at harvest replication wise in each treatment

28.2 Screening of promising isolates of entomopathogenic fungi for management of mites in chillies (continuing experiment) (KAU- Kumarakom)

Variety	:	Location specific recommended variety
Layout	:	Randomized Block Design.
Treatments	:	T1: NBAIR Bb-5a isolate of *Beauveria bassiana* T2: NBAIR Ma-4 isolate of *Metarhizium anisopliae* T3: NBAIR Ma-6 isolate of *Metarhizium anisopliae* T4: NBAIR Vl-8 isolate of *Lecanicillium lecanii* T5: Spiromesifen 22.9SC@ 96 g ai ha^{-1} T6: Untreated control
Replications		Four
Mode of application	:	Four rounds of foliar sprays of oil formulations of entomopathogenic fungi at the spore dose of $1x10^8$cfu/ml (5ml/liter) to be given at 15 days interval
Observations	:	➢ Pre and post count of whiteflies ➢ Yield

29. CUCUMBER

29.1 Evaluation of BIPM against fruit flies *Deccaus bactrocera* sp. against cucumber (AAU-Jorhat)

Location: Experimental farm, Dept. of Horticulture

Plot size: 400m^2 (Whole plot will be divide into8 sub plots, represents as individual replication)

Season: *Kharif*, 2020

Variety: locally recommended

Treatments: 3 (BIPM, conventional and farmer practices)

1) **BIPM practices**
   - Good agricultural practices (racking, weeding)
   - Installation of cue lure @ 15/ha for monitoring
   - Destruction of damaged fruits
   - Spray of neem based insecticides
   - Spray of spinosad 45SC @ 0.3ml/lit
2) **Conventional practices**
   - Jaggary 1% + malathion 50 EC@2ml per litre of water
3) **Farmers practice**
   - Untreated control practice

Application of treatments

- The botanical treatment, NSKE5% and spinosad will be sprayed during evening hours.
- Untreated control plots will be maintained 200m away from BIPM plots.
- First spray of will be started when fruit flies be trapped in pheromone traps.
- No management practices will be followed in case of untreated control plots except water spray.

Observation to be recorded

- For pre and post treatment observation 5 plants will be selected randomly from each sub plots and per cent damaged fruits will be recorded after imposing each treatment at 7 and 10 day interval.
- Epilachna bettle, flea beetle red pumpkin beetle will be observed in each sub plot considering randomly selected 5 plants.
- Both nymphs and adult of aphid will also be collected on the basis of number of population per leaf.
- Natural enemy complex will also be recorded per plant basis.
- Yields of marketable fruits at each harvest will be pooled together to get the average yield.

30. Onion

30.1 Efficacy of different biocontrol agents against onion thrips (*Thrips tabaci* L.) (AAU-Anand)

	Year of commencement	:	2020-21 *Rabi*
	Location	:	Agronomy farm, AAU, Anand
	Crop/variety	:	Onion - Talaja local
	Treatments	:	08
	Replication	:	03
	Design	:	Randomized block design (RBD)
	Spacing	:	60 x 60 cm
	Plot size	:	Gross - 3.0 x 4.8 m Net - 1.8 x 3.6 m

Treatments

	Treatments	Concentration	Dosage/ 10 litre water
T_1	*Lecanicillium lecanii* NBAIR Vl8 – 1%WP	$2x10^8$ cfu/g	50 g
T_2	*Beauveria bassiana* NBAIR Bb5a - 1%WP	$2x10^8$ cfu/g	50 g
T_3	*Metarhizium anisopliae* NBAIR Ma4 - 1%WP	$2x10^8$ cfu/g	50 g
T_4	*Steinernema carpocapsae* NBAIR strain - 1%WP	-	80 g
T_5	*Pseudomonas fluorescens* NBAIR *Pf*DwD-1%WP	$2x10^8$ cfu/g	50 g
T_6	Azadirachtin 10000	0.2 %	20 ml
T_7	Dimethoate 30 EC	0.003	10 ml
T_8	Untreated control	-	-

	Methodology and observations	First spray will be carried out with the initiation of pest and subsequent two sprays will be carried out at ten days interval. Five plants will be randomly selected from net plot area and observations will be recorded. Number of thrips per plant will be recorded before treatment application and at 3rd, 7th and 10th day after each spray. 1. No. of thrips/ plant 2. Bulb yield - kg/plot

31. Capsicum

31.1 Evaluation of entompthogenic fungi, *Beauveria bassiana* (NBAIR-Bb-5a) and ***Lecanicillium leccani* (NBAIR-VL 15) against sucking insect pests of capsicum in open field condition (UAS Raichur)**

Objectives	:	To generate the specific data on bioefficacy of *Beauveria bassiana* (NBAIR-Bb-5a) against sucking pests of capsicum under open condition (CIB and RC registration).
Location	:	Biocontrol Field, MARS, Raichur
Crop	:	Capsicum
Variety/ Hybrid	:	Indra
Design	:	RBD
Treatments	:	7
Replication	:	3
Plot Size	:	54sqm
Treatment Details		T_1: *B.bassiana* @ 1×10^8 @ 5 gm/l (NBAIR-Bb-5a) @ 5.0 g/l T_2: *L. leccani* @ 1×10^8 @ 5 gm/l (NBAIR-VL-8) @ 5.0 g/l T_3: *L. leccani* @ 1×10^8 @ 5 gm/l (NBAIR-VL-15) @ 5.0 g/l T_4: *M. anisopliae* @ 1×10^8 @ 5 gm/l (NBAIR-Ma 4) @ 5.0 g/l T_5: *Isaria fumosorosea* (NBAIR strain) @ 1×10^8 @ 5.0 g/l T_6 : Azadirachtin 1500ppm @ 2 ml/lit T_7 : Untreated control
Methodology	:	• Average number of sucking pest population / 3 leaves, *viz.*, thrips, aphids, mites and whiteflies will be counted and recorded. • Cadavers without apparent sporulation along with leaves will be brought in the laboratory and incubated under optimal condition. After 5 days cadavers were observed for signs of fungal infection and sporulation. • The population of other sucking pests will also be recorded. • Yield (q/ha) to be recorded.

32. Amaranthus

32.1 Efficacy of capsule formulations of *Beauveria bassiana* in managing amaranthus leaf webber *Hymenia recurvalis* (KAU- Vellayani)

Technical Programme:

Crop	:	Amaranthus
Major Pest	:	Amaranthus leaf webber, *Hymenia recurvalis*

Treatments	:	T1 - Capsule formulation of *B. bassiana* KAU isolate T2 - Capsule formulation of *B. bassiana* NBAIR isolate (Bb5) T3 - Talc formulation of *B.bassiana* (NBAIR isolate) T4 - Talc formulation of *B.bassiana* (KAU isolate) T5 – Spore suspension of KAU isolate @10 ^{8} spores mL-1 T6- Spore suspension of NBAIR isolate @10 ^{8} spores mL-1 T7- Untreated check
No. of Replications	:	3
Unit plot size Area	: :	5 x 5 m^2 525 m^2

No. of sprayings: 3

Observations to be recorded

1. Pre count of leaf webber
2. Post count of leaf webber
3. Precount of Predators
4. Post count of Predators
5. Yield per plot

SPICE CROPS

33. GINGER

33.1 To test the *Trichoderma* formulation developed as a component of integrated management of ginger rhizome rot under field condition (Nagaland University, Medziphema)

Crop	:	Ginger
Variety	:	Nadia
Layout of plots	:	Randomized Block Design (RBD)
Plot size	:	1 x 2m sq.
Replications	:	03
Treatments	T_1	Seed rhizome treatment with *Trichoderma* formulation and planting
	T_2	Field soil treatment with *Trichoderma* formulation and planting
	T_3	Hot water treatment of seed rhizomes at 51°C for 10 mnts and planting
	T_4	Hot water treatment as above + *Trichoderma* treatment and planting
	T_5	Field soil solarization for 4 weeks and seed rhizome planting
	T_6	Field soil solarization as above + seed rhizome treatment with *Trichoderma* and planting

	T_7	Soil solarization as above + Trichoderma soil treatment and planting
	T_8	Seed rhizome treatment with Copper oxychloride (COC) @ 3g/kg seed rhizomes and planting (for comparison)
	T_9	Seed rhizome planting without any treatment (Control)

34. POLYHOUSE INSECT PESTS

34.1 Management of sucking pests on cucumber using anthocorid predator, *Blaptostethus pallescens* under polyhouse condition (KAU-Thrissur)

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

34.2 Management of sucking pests in Tomato under polyhouse condition (PAU, Ludhiana

Variety		Variety will be selected as per the university recommendation Plot
Plot size		2x2m
Layout		RBD
Treatments		T1 • Spray of Azadiractin5%@ 2ml/L • Yellow sticky trap @4/250 sq.m T 2 • *Lecanicillium lecanii* $1X10^8$ spore/ g @ 10g/lt

		• Yellow sticky trap @4/250 sq.m T 3 • *Chrysoperla zastrowi sillemi* @ 4 larvae / plant, 2-3 releases (weekly) to be made. • Yellow sticky trap @4/250 sq.m T4. Chemical control T5. Untreated control 2-3 sprays will be made at 10 days interval on appearance of pest
observations		• Population of sucking pests from 10 randomly selected will be recorded at weekly interval • Marketable yield

34.3 Evaluation of biocontrol agents for the control of sucking pests in capsicum under polyhouse (IIHR)

Variety	:	Variety will be selected as per the university recommendation
Plot size	:	2x2 m
Layout	:	Randomized Block Design.
Treatments	:	T1: *Metarhizium anisopliae* (NBAIR) $1X10^8$ spore/ g @ 5g/lt T2: *Metarhizium anisopliae* (IIHR) oil based formulation @ 1ml/1L for only IIHR T3: *Lecanicillium lecanii* (NBAIR) $1X10^8$ spore/ g @ 5g/lt T4: *Beauveria bassiana* (NBAIR) $1X10^8$ spore/ g @ 5g/lt T5: *Chrysoperla zastrowi sillemi* @ 4 larvae / plant, 2-3 releases(weekly) to be made. T6: Five (weekly) releases of *Blaptostethus pallescens* @ 30 nymphs/ m row length T7: Azadirachtin @ 2ml/L of 1500ppm T8: Insecticide as per label claim / University recommendation T9: Control
Replications	:	Three
Observations	:	2-3 sprays will be made at 10 days interval on appearance of pest Population of sucking pests from 10 randomly selected plants before spray / release of predator, 5, 7 and 10 days after spray / release of predator. Marketable yield

34.4 Management of phytophagous mites on cucumber using *Blaptostethus pallescens* and *Neoseiulus longispinosus* under polyhouse condition (New experiment) (YSPUHF, Solan)

Variety	:	University recommended variety
Plot size in polyhouse	:	3x2 m
Layout	:	Randomized Block Design.
Treatments	:	T1: *Blastostethus pallescens* @ 10 nymphs/m row twice at 15 days interval T2: *Blastostethus pallescens* @ 20 nymphs/ m row twice at 15 days interval T3: *Neoseiulus longispinosus* @ 1:30 (predator: prey) twice at 15 days interval T4: *Neoseiulus longispinosus* @ 1:20 (predator: prey) twice at 15 days interval T5: Spiromesifen 45SC @100g.a.i ha^{-1} twice at 15 days interval or recommended insecticide for use in polyhouse T6: Control
Replications	:	Five
Observations	:	5. Pre-treatment count of mites 6. Post treatment count of mites at 7 and 14 DAT 7. Yield

34.5 Field evaluation of anthocorid bug, *Blaptostethus pallescens* against spider mite, *Tetranychus urticae* infesting carnation in Kashmir (Poly house) (SKSUAT-Srinagar)

Crop	:	Carnation (*Dianthus caryophyllus* L.)
Variety	:	Canadian Red & Dark Dona
Location	:	Shalimar campus
Treatments	:	04 (08 weekly releases) T1 = @25 bugs/plant/release T2= @50 bugs/plant/release T3= @100 bugs/plant/release T4= Hexythiazox 5.45 EC @0.4ml/ litre of water (2prays) T5= Untreated check
Replications	:	05 (Each replication will consist of 10 plants)
Experimental Design	:	RBD
Area to be covered	:	Poly house

Likely duration	:	03 years
Methodology		Laboratory reared 8- days old nymphs of *Blaptostethus pallescens* will be released twice/ week @ 25,50 and 100 bugs/ plant on carnation in the poly house of SKUAST-K. A total of eight releases will be made from June- July' 2019. Prior to first release pretreatment data on average population of mites /leaf will be recorded. After every treatment similar observations shall be made every week.
Observations	:	➢ Average mite population/leaf/flower ➢ Crop damage or petal distortion ➢ Effect of weather parameter on mites' population ➢ % Decline in mites' population in response to treatment ➢ Comparison of data with untreated check ➢ C: B ratio

34.6 Evaluation of biocontrol agents for the control of sucking pests in capsicum under protected cultivation (UAHS-Shivamogga)

Variety	Indra
Lay out	Randomized block design
	T_1 : *Metarhizium anisopliae* (UAHS-33) @ 1 x 10^8 Cfu/ ml - 3 ml /lt
	T_2 : *Lecanicillium lecanii* (UAHS-12) @ 1 x 10^8 Cfu/ ml- 3 ml /lt
	T_3 : *Beauveria bassiana* (UAHS-18)@ 1 x 10^8 Cfu/ ml- 3 ml /lt
	T_4 : Azadirachtin 1500 ppm @ 2 ml/litre of water
	T_5 : Chemical control (malathion 50EC @ 4 ml/litre of water)
	T_6 : Untreated (check)
Replications	4
Methodology and observations	Number of sprays/ releases: 2-3sprays at weekly interval The aphid population from randomly selected five plants before and after each spray and yield will be recorded

34. 7 Biological control of bacterial wilt of capsicum under protected cultivation (UAHS-Shivamogga)

Variety	Indra
Lay out	Randomized block design

	T_1 : *Trichoderma harzianum* (UAHS-3) @ 1 x 10^8 Cfu/ g @ 10 kg/ha multiplied in 250 kg FYM 10 days prior to its application and apply at the time of sowing
	T_2 : *Bacillus subtilis* (UAHS-147) @ 1 x 10^8 Cfu/ g @ 10 kg/ha multiplied in 250 kg FYM 10 days prior to its application and apply at the time of sowing
	T_3 : *Pseudomonas fluorescens* (UAHS-56) @ 1 x 10^8 Cfu/ g @ 10 kg/ha multiplied in 250 kg FYM 10 days prior to its application and apply at the time of sowing
	T_4 : *B. subtilis* (UAHS-147) + *P. fluorescens*(UAHS-56) + *T. harzianum* (UAHS-3) @ 1 x 10^8 Cfu/ g @ 3kg each /ha multiplied in 250 kg FYM 10 days prior to its application and apply at the time of sowing
	T_5 : chemical control
	T_6 : Untreated (check)
Replications	4
Methodology and observations	• Observations regarding plant growth parameters and disease incidence will be taken at different intervals after application • Yield will be recorded

35. Casava KAU all the centres, TNAU, NBAIR New

1. **Survey for incidence of *Phenacoccus manihoti*- the recent invasive mealybug on cassava**
2. **Host range of *P. manihoti* across agricultural and horticultural crops**
3. **Survey and utilization of natural enemies of *P. manihoti*- including possible classical biological control using *Anagyrus lopezi***

36. Large scale field demonstration trials (GBPUAT, Pantnagar)

Rice-100 acre
Tomato-20 acre
Pea- 25 acre

Location: Farmers fields of District Nainital of Uttarakhand.
Methodology:
Step 1. Plastic mulching (soil solarization) of nursery beds and fields: It is a low-cost technique to reduce losses due to soil borne insect pests and diseases of the nursery. Under the technique, nursery beds are prepared 5-8 weeks in advance of seed sowing, irrigated and covered with a transparent polythene sheet (50-100 u thick) which is removed 3-4 days ahead of the seed sowing.
Step 2. Use of bioagents:

i. Seed treatment through biopriming: Seeds are mixed with the formulated BCAs @ 8-10g/kg and incubate under moist conditions for 24 to 48h before sowing.

ii. Rhizome treatment: Rhizomes dipped in solution of bioagent (@ 8-10 gram/ liter water) for 30 minutes, dried in shade and planted.
iii. Seedling treatment: Before transplanting roots of seedlings dipped in solution of bioagents @ 8-10 g/ liter for about 30 minutes.
iv. Spray: @ 8-10 g/ liter on standing crop at 10-12 days intervals
v. Drench: @ 8-10 g/ liter in soil in the nurseries from time to time.

Step 3. Bio-composting including vermi composting: Vermicompost is more nutritious than traditionally used undecomposed FYM and gets ready in lesser time. It reduces the cost of production, increases plant health and improves fertility and water holding capacity of the soil. Cattle dung, crop residue, green manure and other farm wastes are used by the earthworms to convert these to nutritious compost. It can be prepared in pits (with variable dimensions as per convenience and use) filled with animal dung and other waste material available on farm. Thereafter, earthworms are released in the pits where they increase in population and convert the waste material to 'nutritious vermicompost' in about 3 months.

Step 4. Value addition of vermicompost and FYM: Before use vermicompost is supplemented with bioagents @ 1Kg/q. This increases the nutritive value of the compost and provides opportunity to the bioagent to grow faster on the compost so that it can compete well with plant pathogens in the soil. Further, it facilitates rapid spread of bioagents in the soil.

Step 5. Need based use of safe chemicals for the control of insect pest.

37. PLANT DISEASES EXPERIMENTS

37.1 The bio-control efficacy of identified biocontrol agents towards rice sheath blight (*Rhizoctonia solani)* disease will be assessed by potted plant method ICAR-NRRI, Cuttack in collaboration with ICAR-NBAIR, Bengaluru

Treatments (6) and replications (4):

1. NBAIR-PFDWD isolate of *Pseudomonas fluorescens*
2. NBAIR-PEOWN isolate of *Pseudomonas entomophila*
3. NBAIR-BATP isolate of *Bacillus albus*
4. NBAIR-BtoyPS isolate of *Lysinibacillus sphaericus*
5. NBAIR-TATP isolate of *Trichoderma asperellum*
6. Recommended Fungicide application
7. Control (Untreated)

Data parameters:

- Lesion Number: The lesion number will be recorded 21 days after inoculation of different isolates of *Rhizoctonia solani* on the rice cultivar.
- Lesion Height: The lesion height will be recorded 21 days after inoculation of different isolates of *Rhizoctonia solani* on the rice cultivar.
- Relative Lesion Height: RLH = Maximum height at which lesion appear/plant height x100.

- Percent Disease Index (PDI) - PDI will be calculated 21 days after inoculation by the formula given by Wheeler.
- PDI = (Sum of all ratings ×100)/ (Total no. of observations × Maximum rating scale)
- Disease severity% = [Σ (Disease index × number of plants)/ (total number of plants × highest disease index)] × 100%
- Bio-control efficacy% = [(Disease severity of control − disease severity of treatment)/disease severity of control] × 100% will be calculated.

37.2 The bio-control efficacy of identified biocontrol agents towards Rice Blast (*Magnaporthe oryzae*) and Rice brown spot (*Bipolaris oryzae*) strain will be assessed by potted plant method

Disease Assessment

- Five leaves from top of each culm will be taken for observation. Now the disease area will be calculated and scoring done according to the rating scale of 0-9 developed by International Rice Research Institute and then it will be converted into per cent disease intensity by using formula
- Disease intensity (%) = (Area of disease score/9) × 100
- Disease scoring area (%) = (Area of leaf affected/Total leaf area) × 100

37.3 Field evaluation of ICAR-NBAIR strains against Rice Blast (*Magnaporthe oryzae*), Brown spot (*Bipolaris oryzae*) and sheath blight (*Rhizoctonia solani*) (ICAR-NRRI, Cuttack).

Plot size: 20-25 Sq.m.
Replications: 04
Design: RBD
Date of sowing: As per the package of practice

Treatments:
1. NBAIR-PEOWN isolate of *Pseudomonas entomophila*
2. NBAIR-BATP isolate of *Bacillus albus*
3. NBAIR-BtoyPS isolate of *Lysinibacillus sphaericus*
4. NBAIR-PFDWD isolate of *Pseudomonas fluorescens*
5. NBAIR-TATP isolate of *Trichoderma asperellum*
6. Recommended fungicide application
7. Control (Untreated)

Observations:
- Scoring and calculation of Percent disease index (Rice blast -7 days interval, brown spot - 7 days interval, sheath blight - 7 days interval).
- Growth promotion character viz., plant height (cm), biomass (gm)
- Yield (kg/plot)

Note: Four rounds of foliar sprays of talc and liquid formulations of entomopathogenic fungi and bacteria at the dosage of 10^8 cfu/ml has to be given at 14 days interval.

37.4 Evaluation of bio-agents consortia in glasshouse and in field for crop health management in rice (GBPUAT-Pantnagar).

Variety	:	Pant Dhan 4
Plot size	:	4×2.5 m^2
Treatment	:	11
Replication	:	03
Glasshouse experiment	:	In pots (2 kg capacity) with same treatments and replications
Treatments	:	1. Th-17 + Psf-173 2. Th-17+ Psf-2 3. Th-17 + Th-14 4. Th-14+ Psf-2 5. Th-17 (positive control) 6. Th-14 (positive control) 7. Psf-2 (positive control) 8. Psf-173 (positive control) 9. Th-14 + Psf-173 (Standard check) 10. Carbendazim 11. Control (Negative control)
Methodology		**In field:** ❖ Bioagents along with vermicompost (50g/500g) before sowing in the nursery. ❖ Seed bio-priming @ 10g/kg seed. ❖ Seedling dip treatment (10g/lit) for 20-30 min. before transplanting. ❖ Three foliar sprays along with drenching with bioagents @ 10g/l (1st at 30 days after sowing and 2nd and 3rd at 45 days interval). **Observations :** ❖ Tiller/hills. ❖ Disease incidence and disease severity of different diseases at 90-100 DAT. ❖ Yield / plot and q/ha. **In glasshouse :** ❖ Soil will be pre inoculated with *Rhizoctonia* (5g inoculum/pot) one week before sowing followed by bioagents along with vermicompost (10g/100g) per pot ❖ Three foliar sprays along with drenching with bioagents (at 15 days interval) **Observations :** ❖ Per cent seed germination 10 DAS ❖ Plant stand at 30 and 45 DAS ❖ Plant Growth at 45 DAS

37.5 Demonstration of *Trichoderma* spp for the management of *Fusarium* wilt in pigeon pea (1 ha) (AAU-Anand)

Variety	:	Location specific variety
Treatments	:	T1: Seed treatment - *Trichoderma harzianum* @ 10g/ kg seeds Soil application of *Trichoderma harzianum* @ 10 kg/ha multiplied in 250 kg FYM 10 days prior to its application and apply at the time of sowing T2: Chemical Control T3: Control
Replications	:	Divide each block into 8 equal sized units, each unit to be considered as replication (each unit= one replication)
Observations	:	Disease incidence (%)/Plant stand (%) at 30, 45, 60 DAS Yield (q/ha)

37.6 Biological control of plant disease using antagonistic organisms in brinjal (UBKV-Pundibari)

Crop	Recommended variety of Brinjal of the zone
Location	Instructional Farm, UBKV
Season	Pre-kharif
Layout	Randomized Block Design
Plot size	5 m × 4m
Treatments	Seven T1: Seed treatment of *Trichoderma* sp. (UBKV culture) T2: Soil treatment of *Trichoderma* sp. (UBKV culture) T3: Seed treatment of Flurorescent pseudomonad (UBKV culture) T4:Soil treatment of Flurorescent pseudomonad (UBKV culture) T5: Seed treatment of *Trichoderma* sp. + Flurorescent pseudomonad T6: Soil treatment *Trichoderma* sp. + Flurorescent pseudomonads T7: Control
Replication	3
Mode of application	Seed treatment with bioagents. Five grams of talc formulation of bioagents with 1 kg of seeds Soil treatment with bioagents. Five grams of talc formulation of bioagents with 1 kg of vermicompost, incubate for 7-15 days and application in field
Observations	• Shoot and root growth • Soil borne disease • Yield • Population of the bioagent before and after application

37.7 Large Scale Demonstration of biocontrol technologies against the soft rot of ginger (UAHS-Shivamogga)

Large scale demonstrations of biocontrol technologies using bioagents, *Trichoderma harzianum , Bacillus subtilis,* and *Pseudomonas fluorescens* for the management of soft rot of ginger will be conducted over an area of 200 acres of farmer fields of malnad and region of Karnataka in collaboration with KVK and different NGO's operating in that area.

Location	Shikaripura, Sagara and Soraba talluk of Shivamogga district of Karnataka
Area	200 acres
Methodology	Ginger blocks where soft rot is a problem will be selected • T_1: Enrichment of FYM with bioagents *Trichoderma harzianum* (UAHS-25) *Bacillus subtilis* (UAHS-72) and *Pseudomonas fluorescens* (UAHS-8) @ 4 kg each / ha (10 days prior to its application) • T_2: Rhizome treatment with 10 g of *Trichoderma harzianum,* (UAHS-25) 10g of *Bacillus subtilis,* (UAHS-72) and 10g of *Pseudomonas fluorescens* (UAHS-8) during the planting • T_3 : Farmers' practice (as per sprays recommended insecticide at each place as per university recommendation or label claim).
Replication	Divide each block into 8 equal sized units (each unit = one replication)
Observations	Germination %, Disease incidence (%), Plant stand (%) and Yield (q/ha) will be recorded.
Collaboration	• KVK University of agriculture and horticulture sciences Shivamogga. • Active NGO's of the region.

37.8 Field efficacy of different combinations of *Trichoderma harzianum* and *Pseudomonas fluorescens* against the early blight of tomato (AAU-Anand)

Year of commencement	**:**	2020-21 *Kharif*
Location	**:**	Agronomy Farm, AAU, Anand
Crop & Variety	**:**	Tomato, AT-3
Treatments	**:**	08
Replications	**:**	03
Design	**:**	Randomized Block Design
Spacing	**:**	90 x 60 cm
Plot size	**:**	Gross : 5.4 x 6.0 m Net : 3.6 x 4.8 m

Treatments:

1. Th (SA + RD + FS)
2. Pf (SA + RD + FS)

3. Th + Pf (SA + RD + FS)
4. Th (SA + RD) + Azoxystrobin 23% SC (FS)
5. Pf (SA + RD) + Azoxystrobin 23% SC (FS)
6. Th+ Pf (SA + RD) + Azoxystrobin 23% SC (FS)
7. Azoxystrobin 23% SC (RD) + Azoxystrobin 23% SC (FS)
8. Untreated control

Note:

Th = *Trichoderma harzianum* (AAUBC- Th1)
Pf = *Pseudomonas fluorescence* (NBAIR strain)
SA = Soil application, RD = Root dip treatment FS = Foliar spray

Methodology:

Soil application (SA)

Standard protocol will be followed for enriching biopesticides. *T. harzianum* (2×10^6 cfu/g) and *P. fluorescens* (2×10^8 cfu/g) will be enriched in vermicompost separately and in combination as per the treatments. The formulation (2.5 kg) will be mixed with 100 kg vemicompost for enrichment and applied in 1 ha area. The enriched biopesticide will be applied based on plot size of each treatment.

Root dip treatment (RD)

The seedling roots will be dipped in the suspension of Th (10 g/litre), Pf (10 g/litre), and Th + Pf (5 g each/litre) for 30 min just before transplanting in the field.

Foliar spray (FS)

Th (5 g/litre), Pf (5 g/litre), Th + Pf (each with 5 g/litre) and Azoxystrobin 23% SC (1.0 ml/litre) will be applied as foliar sprays.

Observations

1. Germination%
2. Per cent disease intensity (PDI)
3. Ancillary observations on plant growth parameters (Plant height, Number of branches/ plant, Fruit weight/ plant)
4. Marketable fruit yield (kg/plot)
5. C:B ratio

Note:

The percent disease intensity (PDI) will be calculated by using 0–5 disease rating scale given by Pandey et al. (2002)

$$PDI = \frac{\text{Sum of all disease ratings}}{\text{----------}} \times 100$$

Total no. of observations (sample) x 5

Scale	Description
0	No symptoms on the leaf
1	0-5 percent leaf area infected and covered by spot
2	6-20 percent leaf area infected and covered by spot, some spots on petiole
3	21-40 percent leaf area infected and covered by spot, spots also seen on petiole, branches
4	41-70 percent leaf area infected and covered by spot, spots also seen on petiole, branches, stem
5	>71 percent leaf area infected and covered by spot, spots also seen on petiole, branch, stem, fruits

37.9 Field efficacy of different combinations of *Trichoderma harzianum* and *Pseudomonas fluorescens* against the early blight of potato (AAU-Anand)

Year of commencement	**:**	2020-21 *Rabi*
Location	**:**	Agronomy Farm, AAU, Anand
Crop & Variety	**:**	Potato, Kufri Badshah
Treatments	**:**	08
Replications	**:**	03
Design	**:**	Randomized Block Design
Spacing	**:**	45 x 15 cm
Plot size	**:**	Gross : 2.70 x 3.00 m Net : 1.80 x 2.70 m

Treatments:

1. Th (SA + ST + FS)
2. Pf (SA + ST + FS)
3. Th + Pf (SA + ST + FS)
4. Th (SA + ST) + Kresoxim-methyl 44.3% SC (FS)
5. Pf (SA + ST) + Kresoxim-methyl 44.3% SC (FS)
6. Th+ Pf (SA + ST) + Kresoxim-methyl 44.3% SC (FS)
7. Kresoxim-methyl 44.3% SC (ST) + Kresoxim-methyl 44.3% SC (FS)
8. Untreated control

Note:

Th = *Trichoderma harzianum* (AAUBC- Th1)
Pf = *Pseudomonas fluorescence* (NBAIR strain)
SA = Soil application, ST = Seed treatment FS = Foliar spray

Methodology:

Soil application (SA)

Standard protocol will be followed for enriching biopesticides. *T. harzianum* (2×10^6 cfu/g) and *P. fluorescens* (2×10^8 cfu/g) will be enriched in vermicompost separately and in combination as per the treatments. The formulation (2.5 kg) will be mixed with 100 kg vemicompost for enrichment and applied in 1 ha area. The enriched biopesticide will be applied based on plot size of each treatment.

Seed treatment (ST)

The seeds will be dipped in the suspension of Th (10 g/litre), Pf (10 g/litre), and Th + Pf (5 g each/litre) for 30 min just before planting in the field.

Foliar spray (FS)

Th (5 g/litre), Pf (5 g/litre), Th + Pf (each with 5 g/litre) and Azoxystrobin 23% SC (1.0 ml/litre) will be applied as foliar sprays.

Observations

1. Germination%
2. Per cent disease intensity (PDI)
3. Ancillary observations on plant growth parameters (Plant height, Number of branches/ plant, Number of tubers/ plant, Tuber weight/ plant)
4. Marketable tuber yield (kg/ plot)
5. C:B ratio

Note:

The percent disease intensity (PDI) for early blight of potato crop will be recorded based on the leaf parts affected at 0–5 scale (Granovsky and Peterson, 1954)

0 = Disease free
1 = up to 10%
2 = 11–25%
3 = 26–50%
4 = 51–75%
5 = > 75% leaf area affected

$$PDI = \frac{\text{Sum of all disease ratings}}{\text{Total no. of observations (sample)} \times 5} \times 100$$

37.10 Evaluation of microbial antagonist for the management of ginger rot disease AAU, Jorhat

Target pests: *Ralstonia solanacearum* and *Pythium aphanidermatum*

Location: Dergaon, Golaghat (farmer's field).

Season: *Kharif*, 2020

Variety: Locally recommended variety

Area cover: 1ha (to be covered)

Treatment: 7

Replication: 3

T_1: Seed treatment with *Pseudomonas fluorescens* (AAU Culture)@ $1x10^8$ cfu/ml (5g/ltr)

T_2: T_1 + spraying of *Trichoderma asperellum* (AAU Culture)@ $1x10^8$ cfu/ml (5g/ltr)

T_3: T_1 + spraying of *Trichoderma harzianum* (AAU Culture)@ $1x10^8$ cfu/ml (5g/ltr)

T_4: T_1 + spraying of *Trichoderma asperellum* (Commercial formulation)@ $1x10^8$ cfu/ml (5g/ltr)

T_5: T_1 + spraying of *Trichoderma harzianum* (Commercial formulation)@ $1x10^8$ cfu/ml (5g/ltr)

T_6: Soil drenching of Copper hydroxide 2g/L @6 litres/m2

T_7: Untreated check

Mode of application: Seed treatment with biopesticide followed by foliar application at @15, 30, 45, 60 days after sowing

Observations to be recorded:

- Record of infected plant during vegetative stage
- Estimation of disease intensity
- Record of infected ginger after harvest
- Yield data.

Note: Experiment will be conducted with collaboration Department of Plant Pathology, AAU, Jorhat

37.11 Ecofriendly management of stem rot, *Macrophomina phaseolina* in sesame using biocontrol agents (ANGRAU, Anakapalle)

Name of the PI & Co PI	:	Dr.M.Visalakshi, Principal Scientist (Entomology) Mrs. Shaik Haseena, Scientist (Plant pathology)
Location	:	Agricultural Research Station, Yelamanchili , Visakhapatnam district
Plot size	:	6x4.5 m
Replications	:	03
Design	:	RBD
Date of sowing	:	Kharif season, 2020
Treatments	:	T1: NBAIR - *Trichoderma asperillum* seed treatment @ 10 g/kg seed + *Trichoderma asperillum* soil drenching @ 5kg/ha T2: NBAIR - *Pseudomonas fluorescence* seed treatment @ 10 g/kg seed + *Pseudomonas fluorescence* soil drenching @ 5kg/ha T3: NBAIR - *Trichoderma asperillum* seed treatment @ 10g/kg seed + *Pseudomonas fluorescence* soil drenching @ 5kg/ha T4: NBAIR - *Pseudomonas fluorescence* seed treatment @10 g/kg seed+ *Trichoderma asperillum* soil drenching @ 5kg/ha T5: NBAIR -*Trichoderma harzianum* seed treatment @ 10g/kg seed+ *Trichoderma harzianum* soil drenching @ 5kg/ha T6: NBAIR - *Trichoderma harzianum* seed treatment @ 10g/kg seed T7: NBAIR - *Trichoderma asperillum* soil drenching @ 5kg/ha T8: NBAIR - *Pseudomonas fluorescence* soil drenching @ 5kg/ha T9: Carbendazim seed treatment @1g/kg seed + carbendazim soil drenching @ 5kg/ha T10: Untreated Control Soil drenching at 30 and 60 days after sowing
Observations	:	Germination (%) Root and shoot length (cm) Stem rot incidence (%) at 30 and 60 days after sowing Grain yield (kg/ha)

37.12 Development of IPM module for the management of rhizome rot (Fungi and bacteria) and shoot borer in Ginger (CAU, Pasighat)

T1: Microbials based pest management: Trichoderma seed treatment (0.1%), Trichoderma soil application (5%), *Pseudomonas putida* soil application (5%) and *Beauveria bassiana* shoot borer management (0.05%)

T2: Plant products based pest management: Biofumigation with cabbage/mustard crop residues, Neem cake (0.8t/acre), mulching with *Vitex negundo* green leaves (4t/acre) and Neem oil (0.5%) for shoot borer management

T3: Cow byproducts based pest management: Soil application of Ghanajeevamruta (400 kg/acre), Seed treatment with Beejamruta, Soil drenching with Jeevamruta (200L/acre), Agniastra (5%) for shoot borer management

T4: Conventional pest management: Soil solarization, hot water treatment, Mancozeb rhizome treatment @240g/acre and soil drenching @0.3%, and Dimethoate @0.02% for shoot borer management

T5: Untreated control

Season: Summer

Replications: 04

Design: RBD

37.13 Management of *Phytophthora* disease in black pepper nursery using biocontrol agents (KAU, Thrissur)

Design: CRD Variety: Panniyur -1
Treatments: 7 Replications: 3

T1	*Trichoderma viride* (KAU strain) @ 1g/ kg of potting mixture
T2	Soil drenching of PGPR consortium (KAU) @ 2 %
T3	Soil drenching at the time of planting + Foliar application of *Pseudomonas fluorescens* (KAU strain) at 15 days interval (2%)
T4	*Trichoderma viride* @ 1g/ kg of potting mixture + Foliar application of *Pseudomonas fluorescens* (KAU strain) at 15 days interval (2%)
T5	Soil drenching of PGPR consortium at the time of planting + Foliar application of PGPR at 15 days interval (2%)
T6	Soil application of COC at the time of planting + Foliar application at 15 days interval (0.2%)
T7	Untreated control

Observations: Per cent survival of plants

37.14 Management of *Fusarium* wilt in vegetable cowpea using microbial agents (KAU-Vellayani)

Crop	:	Cowpea
Disease	:	Fusarium wilt
Treatments	:	T1 - Seed treatment with *P.flourescence* (KAU srain)@ 10g /kg + Soil drenching @ fortnightly intervals + foliar drenching @fortnightly intervals T2 – Basal application of *Trichoderma sp.* KAU starin (multiplied in cowdung + neemcake 9:1 ratio) @ 250 g /plant + monthy soil application T3 – TI + T2 T4 – IDM – T3 + need based application of copper oxy chloride @ 2g/L foliar spray / 4g/ L soil drenching T5 – Chemical fungicide Carbendazim @ 2g/L –need based T6 - Untreated check
No. of Replications	:	3
Unit plot size Area	: :	10 x 10 m^2 2400 m^2(0.24 ha)

No. of sprayings: 5 No.of soil drenching - 3 No. of basal applications – 3

Observations to be recorded

1. No.of plants infested with Fusarium wilt
2. Degree of infection (low, moderate, severe)
3. Incidence of other diseases and pests
4. Yield per plot

37.15 Screening of promising isolates antagonistic fungi and bacteria against bacterial wilt of Tomato (*Ralstonia solanacearum*) (KAU- Kumarakom)

Variety	:	Akshay
Plot size	:	4x5m=20 m^2
Replications	:	Seven
Design	:	RBD
Treatments	:	1. NBAIR-PFDWD isolate of *Pseudomonas fluorescens* 2. KAU strain of *P. fluorescens* 3. Soil drenching of Copper hydroxide 2g/L @6 litres/m^2 4. Control (Untreated)

Method of application of bioagents	:	Talc based formulations of the bioagents 2×10^8 c.f.u./g will be applied as seed treatment @5g/kg of seed, seedling dip (2%) at the time of transplanting and soil drenching (2%) at 30 DAP.
Observations	:	● Per cent wilt incidence at 15,30,45,60,75 DAP ● Growth promotion characters *viz*., plant height (cm), biomass (g) ● Yield (kg/ha)

37.16 Management of Powdery mildew (*Uncinula necator*) of Grape by using Biocontrol agents (MPKV)

Design of Experiment: RBD, Replication Three with 4 plants in each replications, Treatment 8, Variety: Thompson seedless, Spacing: 3.0 m x 1.5 m

Methodology and Observations:

Sl. No.	Treatments	Dose (ml/L)
T_1	*Trichoderma harzianum*	5 g or lml/L
T_2	*Bacillus subtilis*	5 ml/L
T_3	*Ampelomyces quisqualis*	1.0 g or lml /L
T_4	*Trichoderma harzianum* + *Bacillus subtilis*	5 g or lml/L + 5 lml L
T_5	*Trichoderma harzianum* + *Ampelomyces quisqualis*	5 g or lml/L + 1.0 g or lml /L
T_6	*Bacillus subtilis* + *Ampelomyces quisqualis*	5 ml/L+ 1.0 g or lml /L
T_7	Sulphur	2.0 g/L
T_8	Untreated control	-

Observations recorded:

a. Percent disease index on leaves and berries 15 days interval
b. Per cent disease over control
c. Yield

Method of recording observation:

All the treatments were applied into three replications at the appearance of disease symptoms. All the agronomical practices were followed as and when required. Four fungicidal sprays were given at an interval of 15-days, by using knapsack sprayer with hollow cone nozzle with water 1000 l/ha. For recording observations on disease incidence, 10 canes per vine were

selected and on each cane 10 leaves starting from the bottom were observed in respect of disease on leaves by following 0-4 scale as given below:

Scale	Incidence of disease (%)
0	No disease
1	1-25
2	26-49
3	50-75
4	More than 75

PDI was calculated as follows with help of 0-4 scale:

Percent disease index (PDI) =

$$\frac{\text{Sum of numerical rating}}{\text{Total No. of leaves observed}} \times \frac{100}{\text{Maxi Grade(s) (4)}}$$

Disease incidence was monitored regularly 15 days after each spray by using the above mentioned scale and finally means of observations on PDI (Percent Disease Index) were statistically analysed.

37.17 Screening of promising isolates of antagonistic fungi and bacteria against bacterial wilt of Tomato (*Ralstonia solanacearum*) under field conditions (ICAR-NBAIR)

Variety	:	Akshay
Plot size	:	4x5m=20 m^2
Replications	:	5
Design	:	RBD
Treatments	:	1. NBAIR-PFDWD strain of *Pseudomonas fluorescens* (2%) 2. NBAII63 strain of *Bacillus megaterium* (1%) 3. NBAIR-TATP isolate of *Trichoderma asperellum* (2%) 4. Soil drenching of Copper hydroxide 2g/L @ 6 litres/m^2 5. Control (Untreated)
Method of application of bioagents	:	Talc based formulations of the bioagents 2×10^8 c.f.u./g will be applied as seed treatment, seedling dip at the time of transplanting and foliar spray (2%) at 20 DAP, 35 DAP, 50 DAP and soil drenching (2%) at 30 DAP, 45 DAP, 60 DAP
Observations	:	• Per cent wilt incidence at 15, 30, 45, 60, 75 DAP • Growth promotion characters *viz*., plant height (cm), number and weight of fruits/plant (gm) • Yield (kg/ha)

37.18 Evaluation of microbial antagonists for the management of diseases (Powdery mildew/Ascochyta blight/Rust) in pea (PAU-Ludhiana)

Variety; Recommended variety

Treatments

1 *Pseudomonas flouresecence* (NBAIR formulation)
2. *Trichoderma harzanium* (NBAIR formulation)
3. *Pseudomonas flouresecence* (local if available)
4. *Trichoderma asperellum* (Commercial formulation)
5. *Pseudomonas fluorescence* (Commercial formulation)
6. Chemical control (Seed Treatment with 3g /kg of seed and spray the crop thrice with 200g Sulfex and 400g Indofil M45 per acre at an interval of 10 days.)
7. Untreated control

Replications: Four

Mode of application Seed Treatment: @ 10g/kg,

Soil Treatment: mix formulation @1 kg with 100kg FYM per acre and broadcast uniformly in one a acre of land

Foliar spray: Three foliar sprays @ 10g/litre at 10 days interval

Observation to be recorded: 1) Disease incidence to be recorded per square meter per replication

2) Disease severity
3) Yield

37.19 Evaluation of microbial antagonists for the management of foot rot of kinnow caused by *Phytophthora* spp. (2nd year) (PAU-Ludhiana)

1. *Pseudomonas fluorescence* (NBAII- Pf DWD) (Talc formulation)
2. *Pseudomonas fluorescence* Commercial (Talc formulation)
3. *Trichoderma asperellum* Commercial (Talc formulation)
4. *Trichoderma harzianum* Commercial (Liquid formulation)
5. Chemical control (Curzate M-8 @ 25g/10 litre water/ tree)
6. Untreated control.

Replication : Four with three trees per replica

Soil application @ 2.5 kg completely dried FYM enriched with 100 g of formulation per tree

Observation: Number of foot rot tree and yield parameters

37.20 Evaluation of effective fungal and bacterial antagonists, fungicide and their integration against sugarcane red rot (ICAR-SBI, Coimbatore)

Variety	:	CoC 671
Plot size	:	4 x 6m=24 m^2
Replications	:	4
Design	:	RBD
Treatments	:	1. SBI strain of *Trichoderma harzianum* (1%) 2. SBI strain of *Paenibacillus alvei* (1%) 3. *Trichoderma harzianum* (0.5%) + *Paenibacillus alvei* (0.5%) 4. Thiophanate methyl/ Azole (0.05%) + *Paenibacillus alvei* (0.5%) 5. Thiophanate methyl/ Azole (0.1%) 6. Inoculated control (Untreated) 7. Uninoculated control (Untreated)
Method of treatment	:	• Liquid formulations of the bioagents 1-2×10^8 c.f.u./ml and fungicide will be applied as sett treatment using Sett Treatment Device developed at Plant Pathology Lab, Sugarcane Breeding Institute • Secondary application will be done on 60 and 120 DAP with their respective bioagents and fungicide invidually/ alternatively/ in combination.
Observations	:	• Per cent germination (30DAP) • Per cent Disease incidence (45DAP, 60DAP, 90DAP) • No. of healthy shoots/ stalks (120DAP, 180DAP, 240DAP) • Yield (kg/ha)
Location	:	Endemic fields in sugar factory areas

37.21 Management of *Fusarium* wilt/ root rot of pea through biological control agents (YSPUHF, Solan)

Variety	:	Pb-89 or other university recommended variety
Plot size	:	3 × 2 m
Layout	:	Randomized Block Design.
Treatments	:	1. Seed treatment with *Pseudomonas flouresecence* @ 10g/kg seed 2. Seed treatment with *Trichoderma asperellum* @10g/kg seed 3. Seed treatment with *Pseudomonas flouresecence* @ 10g/kg seed + soil application of *Trichoderma asperellum* after mixing with FYM (10g/Kg FYM) @40g/m^2 4. Seed treatment with *Trichoderma asperellum* @10g/kg

		seed+ soil application of *Trichoderma asperellum* after mixing with FYM (10g/Kg FYM) @40g/m^2 5. Seed treatment with *Pseudomonas flouresecence* @ 10g/kg seed + soil application of *Pseudomonas flouresecence* after mixing with FYM (10g/Kg FYM) @40g/m^2 6. Seed treatment (2g/ kg of seed) + soil drenching (2g/ L) with carbendazim Control (no treatment)
Replications	:	Three
Observations	:	i) Disease incidence (%) ii) Pod yield (kg/plot) iii) C:B ratio

37.22 Management of major diseases of rice with *Bacillus subtilis* (TNAU strain) (TNAU-Coimbatore)

Treatments

T1 – Soil application of *Bacillus subtilis* (TNAU strain) @2.5Kg/ha
T2 – Seed treatment of *Bacillus subtilis* (TNAU strain) @10gm/Kg of seed
T3 - Seedling dip of *Bacillus subtilis* (TNAU strain) @2.5Kg/seedlings required for one ha
T4 – Foliar spraying of *Bacillus subtilis* (TNAU strain) @20gm/lit on 45^{th} and 60^{th} days after transplanting
T5 – T1+T2+T3+T4
T6 – Azoxystrobin @0.1% (1ml/lit.)
T7 – Control

Replications -3
TNAU strain of *Bacillus subtilis* available in Department of Plant Pathology, TNAU, Coimbatore will be used in the field trial
Observations to be recorded:
Severities (PDI) of the following disease of rice

i. Blast
ii. Sheath blight
iii. Brown spot
iv. Sheath rot
v. Grain discoloration

36.23 Experiment No. 14 Bio-intensive management of wilt and dry root rot complex in chickpea (UAS-Raichur)

Treatment Details		**T1** : Seed treatment with local strain *Trichoderma viride* (10 g/kg) + soil application of FYM (250 kg/ha) enriched with local strain *T. viride* (2.5 kg)
		T2: Seed treatment with talc based formulation of local strain *Pseudomonas fluorescence* (10 g/kg of seeds) + soil application of FYM (250 kg /ha) enriched with local strain *P. fluorescens* (2.5 kg/ha)
		T3: Seed treatment with *P. fluorescens (*NBAIR-PFDWD) (10 g/kg) + soil application of FYM (250 kg/ha) enriched with *P. fluorescens (*NBAIR-PFDWD) (2.5 kg)
		T4: Carbendazim @ 1gm/lit
		T5: Control
Replications		4
Methodology		Per cent disease incidence and grain yield will be recorded and analysed statistically.

36.24 Experiment No. 15 Bio-intensive management of chilli wilt and powdery mildew (UAS-Raichur)

Crop	:	Chilli
Treatment Details		**T1** : Seed treatment with local strain *Trichoderma viride* (10 g/kg) + soil application of FYM (250 kg/ha) enriched with local strain *T. viride* (2.5 kg)
		T2: Seed treatment with talc based formulation of local strain *Pseudomonas fluorescence* (10 g/kg of seeds) + soil application of FYM (250 kg /ha) enriched with local strain *P. fluorescens* (2.5 kg/ha)
		T3: Seed treatment with *P. fluorescens (*NBAIR-PFDWD) (10 g/kg) + soil application of FYM (250

		kg/ha) enriched with *P. fluorescens (*NBAIR-PFDWD) (2.5 kg)
		T4: Carbendazim @ 1gm/lit
		T5: Control
Replications		4
Methodology		Per cent disease incidence will be recorded and dry chilli yield will be recorded.

37.25 Field evaluation of ICAR-NBAIR antagonistic organisms against Maize Turcicum leaf blight (*Exserohilum turcicum*) (SKUAST-Jammu)

Plot size	:	1 x 5 cents for each treatment, 1 cent = 8x5 m^2
Replications	:	04
Design	:	RBD
Date of sowing	:	As per the package of practice
Variety		High yielding variety susceptible to Turcicum leaf blight
Treatments	:	1. NBAIR-PFDWD strain *Pseudomonas fluorescens* 2. BC1 strain *Trichoderma asperellum* (Local strain, Jammu) 3. BC2 strain *Pseudomonas fluorescens* (Local strain, Jammu) 4. Recommended fungicide application 5. Control (Untreated)
Observations	:	**Turcicum leaf blight** ● Scoring and calculation of Percent disease index (for maize turcicum leaf blight) at 3 and 7 Days After Spray ● Growth promotion character viz., plant height (cm), biomass (gm) ● Yield (q/ha)

Note: Four rounds of foliar sprays of talc and liquid formulations antagonistic organisms at the 10^8 cfu/ml has to be given at 14 days interval starting from 25 Days after Sowing.

37.26 Field evaluation of ICAR-NBAIR antagonistic organisms against Wheat Yellow rust (*Puccinia striiformis* f. sp. *tritici*) (SKUAST-Jammu)

Plot size	:	8x5m=40 m^2
Replications	:	04
Design	:	RBD
Date of sowing	:	As per the package of practice
Treatments	:	1. NBAIR-PFDWD strain *Pseudomonas fluorescens* 2. BC1 strain *Trichoderma asperellum* (Local strain, Jammu) 3. BC2 strain *Pseudomonas fluorescens* (Local strain, Jammu) 4. Recommended fungicide application

		5. Control (Untreated)
Observations	:	**Wheat Yellow Rust** ● Scoring and calculation of Percent disease index (for wheat yellow rust) at 3 and 7 Days After Spray ● Growth promotion character viz., plant height (cm), biomass (gm) ● Yield (q/ha)

Note: Four rounds of foliar sprays of talc and liquid formulations antagonistic organisms at the 10^8 cfu/ml has to be given at 14 days interval starting from 75 Days after Sowing.

37.27 Field evaluation of ICAR-NBAIR antagonistic organisms against Chick pea Fusarium wilt (*Fusarium oxysporum f. sp. ciceris*) (SKUAST-Jammu)

Plot size	:	1 x 5 cents for each treatment, 1 cent = 8x5 m^2
Replications	:	04
Design	:	RBD
Date of sowing	:	As per the package of practice
Variety		High yielding variety susceptible to pod borer
Treatments	:	1. NBAIR-PFDWD strain *Pseudomonas fluorescens* 2. BC1 strain *Trichoderma asperellum* (Local strain, Jammu) 3. BC2 strain *Pseudomonas fluorescens* (Local strain, Jammu) 4. Recommended fungicide application 5. Control (Untreated)
Observations	:	**Chick pea Fusarium wilt** ● Scoring and calculation of Percent disease index (for Chick pea Fusarium wilt) at 3 and 7 Days After Spray ● Growth promotion character viz., plant height (cm), biomass (gm) ● Yield (q/ha)

Note: Four rounds of foliar sprays of talc and liquid formulations antagonistic organisms at the 10^8 cfu/ml has to be given at 14 days interval starting from 75 Days after Sowing.

37.28 Field evaluation of ICAR-NBAIR antagonistic organisms against Mustard White rust (*Albugo candida*) (SKUAST-Jammu)

Plot size	:	8x5m=40 m^2
Replications	:	04
Design	:	RBD
Date of sowing	:	As per the package of practice
Treatments	:	1. NBAIR-PFDWD strain *Pseudomonas fluorescens* 2. BC1 strain *Trichoderma asperellum* (Local strain, Jammu) 3. BC2 strain *Pseudomonas fluorescens* (Local strain, Jammu)

		4. Recommended fungicide application 5. Control (Untreated)
Observations	:	**White rust** ● Scoring and calculation of Percent disease index (for Mustard White rust) at 3 and 7 Days After Spray ● Growth promotion character viz., plant height (cm), biomass (gm) ● Yield (q/ha)

Note: Four rounds of foliar sprays of talc and liquid formulations of antagonistic organisms at the 10^8 cfu/ml has to be given at 14 days interval starting from 75 Days after Sowing.

37.29 Field evaluation of ICAR-NBAIR entomopathogenic strains against field Pea Rust (*Uromyces viciae-fabae*) (SKUAST-Jammu)

Plot size	:	8x5m=40 m^2
Replications	:	07
Design	:	RBD
Date of sowing	:	As per the package of practice
Treatments	:	1. NBAIR-PFDWD isolate of *Pseudomonas fluorescens* 2. Recommended fungicide application 3. Control (Untreated)
Observations	:	**Field Pea Rust** ● Scoring and calculation of Percent disease index (for Field pea rust) at 3 and 7 Days After Spray ● Growth promotion character viz., plant height (cm), biomass (gm) ● Yield (q/ha)

Note: Four rounds of foliar sprays of talc and liquid formulations of entomopathogenic bacteria at the **Three spore dosages of 10^6, 10^8, 10^{10} cfu/ml** has to be given at 14 days interval starting from 75 Days after Sowing.

38. Frontline Demonstrations (CAU-Pasighat)

Location: East Siang district, Arunachal Pradesh

Area to be covered: 2 hectares

No. of demonstrations: 4 (one each on Maize, Mustard, Cabbage and Tomato)

Technology to be demonstrated:

1. Biointensive pest management in Cabbage
2. Biocontrol based pest management in Tomato

3. Management of major pest in Maize by using effective bio-control agents
4. Biological control of insect pest of Mustard

Details of Technology:

1. **Biointensive pest management in Cabbage**

Raising of mustard as trap crop, 5 releases of *Trichogramma chilonis@* 100,000/release against *Plutella xylostella*, at 30 days after transplanting, spraying of *L. lecanii*-1×108 spore/ ml @ 5ml/lt against cabbage aphid and three sprays NBAII BtG4 2% against lepidopteron pests or *Beauveria bassiana*/*Metarhizium anisopliae* @0.05% and alternative sprays with Neem oil (1500 ppm) @2 ml/lt water based on availability of bioagents.

2. **Biocontrol based pest management in Tomato**

Seed treatment with *Trichoderma harzianum@* 10g/kg of seeds; raising marigold as trap crop; inoculative sixrelease of *T. pretiosum@* 50,000 / release, alternative application of *Beauveria bassiana*/*Metarhizium anisopliae* @0.05% or NBAII BtG4 2% against fruit borers and spraying of azadirachtin 1500 ppm @ 2 ml/lit; and *L. lecanii* (NBAIR) 1×108 spores/ g @ 5g/lit for sucking pests.

3. **Management of major pest in Maize by using effective bio-control agents**

Spraying of *Beauveria bassiana*/*Metarhizium anisopliae* @0.05%, Bt 2%, Neem oil 1500 ppm @2 ml/lt water and *Steinerema carpocapsae*/*Heterorhabditis bacteriophora* NBAIR strain on alternate basis for the management of fall army worm in maize.

4. **Biological control of insect pest of Mustard**

Spraying of Neem oil 1500 ppm @ 2 ml/lit; and *L. lecanii* (NBAIR) 1×108 spores/ g @ 5g/lit against aphids and application of *Beauveria bassiana/Metarhizium anisopliae* @0.05% and Bt 2% for defoliators.

Source of Technology:

1. Biointensive pest management in Cabbage: NBAIR Bengaluru, TNAU Coimbatore and AAU Jorhat

2. Biocontrol based pest management in Tomato: NBAIR Bengaluru and IIVR Varanasi

3. Management of major pest in Maize by using effective biocontrol agents: NBAIR Bengaluru

4. Biological control of insect pest of Mustard: NBAIR Bengaluru

Observations to be recorded:

1. Survey and surveillance of major and minor pest complex
2. Seasonal abundance of natural enemies
3. Percent incidence of major crop pests
4. Percent damage by major crop pests
5. Crop yield
6. Cost benefit ratio
7. Farmers feed back

Expected outcome

Front line demonstrations on bio-intensive pest management in major crops will helps the farmers to understand about the importance of biological control of crop pests and that knowledge is much needed by the farmers for the eco-friendly pest management and to produce pesticide residue free food from potential North eastern region of India. Through farmers capacity building training programmes they will gain the first hand knowledge on how to differentiate between crop pests and natural enemies, also mass production, field release, conservation and encouragement of the latter in different agricultural and horticultural crop ecosystems. By adopting the demonstrated FLD's the cost of cultivation reduces and thereby farmers' income and livelihood status could be improved. Besides this, the technology may be transferred to the other farmers directly and also helps in increasing the awareness among the farmers.