Project Coordinator's Report

2021-2022

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

Compiled and Edited

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XXXI Biocontrol Workers Group Meeting

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12.10.22

Dr. S.N. Sushil
Director, ICAR-NBAIR &
Project Coordinator, AICRP-Biological Control

Date: 12/10/2022
Place: Bangalore

1. Introduction

AICRP on Biological Control was initiated during the year 1977 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.

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/biopesticides 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 other 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. The recent invasive managed through AICRP-BC initatives are tomato pinworm, *Tuta absoluta,* infesting tomato, the rugose spiraling whitefly, *Aleurodicus rugioperculatus* infesting coconut and oilpalm and the fall armyworm (FAW) *Spodoptera frugiperda* infesting maize. *Anagyrus* *lopezi*, a parasitoid of cassava mealy bug (CMB) was imported from International Institute of Tropical Agriculture (IITA) Republic of Benin. Mass production protocol of this parasitoid were standardized and several trainings have been provided to researchers, state department officials etc. and the development agencies. Another invasive pest to the chilli crop, *Thrips parvispinus*, posed seious threat to chilli and caused extensive damage. The Co ordingator unit of AICRP-BC at NBAIR stood to the expectations of Indian farmers requirements by identifying the pest and efforts are being made to develop ecofriendlly measures to bring down the pest incidence with support of AICRP-BC centres.

Currently AICRP-BC is having 36 centres (11 regular centres, 16 Contingency centres and 8 Voluntary centres) along with a PC cell.

2. Mandate of AICRP on Biological control of crop pests

2.1. To evolve effective biological control strategies for important insect pests, plant pathogens and nematodes.

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

3. Setup

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

Regular centres (Fully funded)

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

Contingecy centres

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. Kerala Agricultural University, Regional Agricultural Research Station, Kumarakom
18. Kerala Agricultural University, College of Agriculture, Vellayani
19. Dr. Y S R Horticultural University, Ambajipeta, Andhra Pradesh

20. Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal
21. Central Institute of Subtropical Horticulture, Lucknow
22. Central Plantation Crops Research Institute, Kayamkulam
23. Indian Institute of Rice Research, Hyderabad
24. Indian Institute of Millet Research, Hyderabad
25. Indian Institute of Horticultural Research, Bangalore
26. Indian Institute of Vegetable Research,Varanasi
27. National Centre for Integrated Pest Management, New Delhi

Voluntary Centres

28. National Rice Research Institute Cuttack
29. Sugarcane breeding Institute, Coimbatore
30. Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola
31. Sher-e-Kashmir University of Agricultural Science & Technology, Jammu
32. National Institute of Plant health Management, Hyderabad
33. University of Agricultural and Horticultural Sciences, Shimogga
34. Citrus Research Station, Dr. Y.S. R. Horticultural University, Tirupati
35. College of Agriculture, Tripura, Lembucherra, West Tripura

The results from the various experiments conducted at centres across the country during the year 2021-22 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 wasps

Cotesia ruficrus (Haliday) was reported to parasitize rice horn caterpillar, *Melanitis leda* (Linnaeus) (Lepidoptera: Nymphalidae) in Assam. In the comprehensive yet complicated food web associated with the niche of the recently invaded cassava mealybug (CMB) *Phenacoccus manihoti* Matile-Ferrero (Homoptera: Pseudococcidae), there was a multitrophic interaction structured vertically as well as horizontally. Altogether 45 species (recorded for the first time to be associated directly or indirectly with CMB): thirty four species of insects from six orders (Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, and Neuroptera) and eleven species of spiders (Arachnida) were grouped under four trophic levels into 11 guilds. The analysis of trophic guild structure and interaction indicated that many indigenous parasitoid species, which qualified to be placed under the fourth trophic level, actively parasitized the potential native predators of cassava mealybug (CMB) and thereby negatively impacted the natural biological control of CMB.

First record of a braconid solitary koinobiont endoparasitoid, *Meteorus pulchricornis* (Wesmael) (Hymenoptera: Braconidae: Euphorinae) which was found parasitizing *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) in maize. *Meteorus pulchricornis* is a new addition to the known and rapidly expanding parasitoid complex of FAW in India.

Overall, 80.46% FAW larval mortality by the natural enemy complex was observed in northern India. *Chelonus* nr. *blackburni* (Hymenoptera: Braconidae) was the predominant parasitoid in the study area causing 49.24% larval mortality followed by *Chelonus formosanus* Sonan.

4.1.2. Spider diversity in paddy ecosystem

Tetragnathid spider diversity in the paddy ecosystem from different agro-climatic zones of Tamil Nadu (14 locations) was documented. Collected specimens belonging to two genera, Tetragnatha Latreille and Leucauge White, and six species *viz. Tetragnatha javana* Thorell

(10.75%), *T. keyserlingi* Simon (58.78%), *T. mandibulata* Walckenaer, *T. nitens* Audouin (13.26%), *T. vermiformis* Emerton (5.81%) and *Leucauge decorata* Blackwall (0.71%) .

4.1.3. Development of mobile apps on non-chemical methods for management of important crop pests

A mobile app on management of the invasive pest, *S. frugiperda* in maize was developed. A mobile app BIPM on FAW was developed. This mobile app gives detailed information about the biology of FAW, damage symptoms in the field conditions, pest identification, and management through biological control, pheromone traps and chemical control. Attempts were also made to present the content in North Eastern languages of India, so as to benefit the farmers of North-Eastern region, where maize is grown widely. This mobile app was developed in several languages viz. English, Hindi, Marathi, Tamil, Telugu, and the North-Eastern languages like Assamese, Bengali, Khasi, Manipuri, Nagamese and Sikkimese.

4.1.4. Parasitisation potential of *Trichogramma chilonis* and *Telenomus remus* against fall armyworm, *Spodoptera frugiperda*

In a single release, the percent parasitism of *T. remus* was highest (92%) followed by *T. chilonis* (81%) and *T. pretiosum* (45%). In the simultaneous release of *T. remus* and *T. chilonis* per cent parasitism was 88.9 % and was on par with *T. remus* single release. Among all the duration-dependent treatments of sequential release, *T. chilonis* release post 24-48 hours of *T. remus* release provided the most satisfactory outcome.

4.1.5. Field evaluation of *Trichogramma chilonis* against *Spodoptera frugiperda*

Field evaluation of *T. chilonis* was carried out at Bagalur, Karnataka against *S. frugiperda* in the naturally infested maize crop. Four releases of *T. chilonis* at weekly intervals significantly ($P < 0.05$) increased the egg mass and egg parasitism of *S. frugiperda*. After four releases of *T. chilonis*, the egg mass parasitism was 66.25% and egg parasitism was 42.15% in maize field. The plant damage incidence (7.0%) and leaf damage score (1.15 on 0-9 Davis scale) was significantly ($P < 0.05$) less in *T. chilonis* plots.

4.1.6. Evaluation of *Blaptostethus pallescens* against thrips

The biocontrol potential of anthocorid predator, *B. pallescens* was evaluated against *Scirtothrips dorsalis* and *Thrips palmi* on capsicum grown in polyhouse at Doddabalapura. Weekly release of *B. pallescens* @ 20-30 per square meter (total 4-5 releases) with alternation of biopesticide *Bacillus subtilis* reduced the thrips population by 26.2%.

4.1.7. Geographical and host distribution of whiteflies

Surveys were conducted in Goa, Gujarat, Karnataka, Lakshadweep, Meghalaya and Odisha West Bengal to document the new geographical and host distribution record for whiteflies viz., rugose spiralling whitefly, *Aleurodicus rugioperculatus*. Woolly whitefly, *Aleurothrixus floccosus* was recorded in Karnataka, Lakshadweep and Tamil Nadu. Bondar's nesting whitefly, Paraleyrodes bondari and *A. floccosus* was recorded from Andhra Pradesh, Odisha and West Bengal. Besides, 45 host plants for rugose spiralling whitefly; 21 host plants for nesting whitefly, *Paraleyrodes minei*; 9 host plants for Bondar's nesting whitefly, *P. bondari*; 13 host plants for solanum whitefly, *Aleurothrixus trachoides* and 5 host plants for palm infesting whitefly, *A. atratus* was recorded for the first time in India.

4.1.8. Field efficacy of EPN formulations for the management of fall armyworm in maize

Field trials were repeated to study the comparative effect of WP and novel granular formulations of *H. indica* NBAII Hi101, *S. carpocapsae* NBAII Sc01 and *H. bacteriophora* NBAII Hb105 against fall armyworm, *Spodoptera frugiperda*. The results indicated that granular formulation of *H. indica* and *S. carpocapsae* were on par with respective WP formulations in reducing the populations of fall armyworm (FAW) (58-65%), however granular formulation of *H. bacteriophora* imparted only 24-28% control.

4.1.9. Evaluation of entomopathogenic nematode, *Heterorhabditis indica* against *Holotrichia* sp.

During 2020-2021 two field demonstrations were carried out at Bagalakote district of Karnataka to evaluate the efficacy of two species of entomopathogenic nematodes (EPN), *Steinernema carpocapsae* and *Heterorhabditis indica*, along with a commonly used insecticide (chlorpyrifos) against *Holotrichia* species. Field trial data showed that the reduction in *Holotrichia* grub population was significantly higher in field treated with *H. indica* at rate of 2.5×10^9 IJ ha^{-1} than *S. carpocapsae* and chlorpyrifos application. Chlorpyrifos application was more efficient in reducing the grub population than both nematode species at the lower application rate (1.25×10^9 IJ ha-1). These experiments suggest *H. indica* to be a promising biocontrol agent against *Holotrichi*a species.

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

Five field collected specimens of *Trichogramma chilonis* from Tamil Nadu were identified using morphological and molecular tools. Different populations of invasive cassava mealybug *Phenacoccus manihoti* was identified using cytochrome oxidase–I gene (CO-1) for the first time in India and DNA barcode was generated for the same. The parasitoid *Anagyrus lopezi* received from IITA, Republic of Benin was identified using molecular tools and GenBank Acc. No. (OK85480) and barcode was generated. Specimens of the invasive thrips in chilli were received from different parts of Andhra Pradesh, and it was identified as *Thrips parvispinus* (OM095426, OM095429, OM085663 and OM085664) employing morphological and molecular tools.

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-Anand

The egg parasitoids of fall armyworm viz., *Chelonus formosanus* and *Telenomus remus* were documented with Genbank accession No. OM422609 and OM424280, respectively. The predator *Mallada* sp. was collected in the coconut orchards infested with invasive rugose spiralling whitefly. The NPV infecting spotted pod borer, *Maruca vitrata* was recorded in cowpea fields of AAU, Anand campus.

CISH

The population dynamics of major insect pests infesting mango and natural enemies were monitored throughtout the year. Hoverfly activity was observed from 11th to 21 SMW. Peak activity of hoverflies was recorded during 14th SMW with 4.6/tree. The maximal population of spider as noted during 21st SMW as high as 3.2 individual/ tree. Chrysopids activity was recorded from 11th to 25th SMW and peak population was recorded during 21st SMW with population of 3.21 individuals/tree.The major species of Coccinellids viz., *Coccinella septempunctata* Linn. *C. transversalis*, *Menochilus sexmaculata* Fab. *Chilocorus rubidus* Hope and *Scymnus* sp. were observed feeding on mango hoppers; amongst most abundant and spectacular was *Coccinella septempunctata.*

PAU

Seventeen natural enemies including parasitoids (*Trichogramma chilonis*, *Chelonus formosanus*, *Campoletis flavicincta*, *Charops bicolor*, *Temelucha* sp., *Cotesia rufricus*, *Microplitis* sp., *Campoletis* sp. and unidentified Braconid) and seven predators (*Eocanthecona furcellata*, *Cheilomenes sexmaculata*, *Paederus* sp., *Neoscona theisi*, *Oxyopes* sp, unidentified Carabid beetle, unidentified Coccinellid beetle) were recorded to be associated with fall armyworm on maize/fodder maize. Among parasitoids, *Chelonus formosanus* was the predominant species. *Fulgoraecia melanoleuca* (nymphal and adult parasitoid) was recorded parasitizing *Pyrilla perpusilla* on sugarcane crop with peak activity in September month (30.6 % parasitism). Among predators, coccinellids, green lacewing, *Geocoris* sp. and spiders were prevalent on cotton crop. Out of these, spider species were predominant (68.4 % abundance) followed by *Chrysoperla* (21.4 % abundance).

TNAU

Encarsia guadeloupae and *Apertochyrsa astur* are the predominant natural enemies of coconut rugose spiralling whitefly. *Chrysoperla zastrowi silemmi* is feeding on soft bodied insects in Cotton, Cassava, Curryleaf, Cabbage and Ornamentals. *Cheilomenes sexmaculata* is seen in Chillies, Cassava, Brinjal, and Maize. In cassava, *Hyperaspis maindroni* was found to be the predominant coccinellid predator of the *Phenacoccus manihoti*. *Dipha aphidivora* and

Micromus igorotus were observed on sugarcane woolly aphid. *Nomuraea rileyi* caused epizootics on *Helicoverba armigera* in chickpea crop at Vellamadai. *Mallada desjardinsi* (Navas) eggs are parasitized by an encyrtid parasitoid, *Copidosomyia ambiguous*.

KAU - Thrissur

Spiders (22 nos.) were collected from rice ecosystem in Thrissur and Palakkad districts by pit fall trap and sweep net methods.

MPKV

The natural enemies' fauna inclusive of coccinellids, (*Coccinella septempunctata* L., *Menochilus sexmaculatus* F., *Scymnus* sp.), *Dipha aphidivora* Meyrick, *Micromus igorotus* Bank., syrphids, *Eupoderes confractor* and parasitoid, *Encarsia flavoscuttellum* were recorded in woolly aphid colonies in sugarcane. *Coccinella transversalis* F., *M. sexmaculata*, *Brumoides. suturalis* (F.), *Scymnus coccivora* Ayyar, *Triomata coccidivora* and *B. suturalis* were recorded in mealybug colonies on custard apple. *Nomuraea rileyi* infected cadavers of *S. litura* and fall armyworm (FAW) on maize crop were collected during the survey.

YSPUF&F

In tomato cropping system natural enemies like *Nesidiocoris tenuis, Encarsia formosa, Neochrysocharis formosa, Diglyphus horticola, Coccinella septempunctata, Hippodamia variegate* and *Chrysoperla z. sillemi* were found associated with pests .Cabbage and cauliflower ecosystem mainly harboured beetles like *Coccinella septempunctata, Hippodamia variegata* and *Cheilomenes sexmaculata,* and parasitoids like *Diaeretiella rapae, Cotesia glomerata* and *Diadegma* sp. In apple, *Chrysoperla z. sillemi, Coccinella septempunctata, Hippodamia variegata, Propylea lutiopustulata, Adalia tetraspilota, Chilocorus infernalis.*

UBKV

Six numbers of spiders were collected from rice field and were preserved and sent for identification to NBAIR. Apart from this, damselfly, dragonfly, lady beetle, mirid bug were also found in rice field in different growth stages of the crop. In 2021-22 Survey was conducted at Alipurduar, West Bengal. Soil samples were collected from potato field. One *Trichoderma* isolate was collected from rhizosphere of potato from Alipurduar.

SKAUST Srinagar

A total of five coccinellid predators including *Adalia tetraspolita*, *Calvia punctata*, *Chilocorus* sp., *Harmonia eucharis*, and *Oenopia conglobata* were found to be associated with different insect pests of apple, pear, nectarine and walnut. Association of *Calvia punctata*, *Oenopia conglobata* and *Chilocorus* sp. with pear psylla, *Cacopsylla pyricola* was recorded first time from Kashmir. Three variants of *Harmonia eucharis* were recorded on San Jose scale and green apple aphid on apple, and pear psylla on pear.

MPUAT

Several coccinellids, reduvids, green lacewings, spiders, predatory pentatomid bugs, *Campoletus chloridae, Cotesia flavipes* (Cameron) were collected from maize chickpea and tomato.

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

CPCRI, Regional Station, Kayamkulam

The population of *Aleurodicus rugioperculatus* and *Paraleyrodes bondari* are getting stabilized during the year ranging from 2.3 to 0.4 live colonies. The population of *P. bondari* was found to be relatively higher registering as high as 2.3 colonies per leafletin the month ofMarch 2021and got reduced subsequently reaching as low as 1.0 colonies on May 2021. Weather factors especially relative humidity and rainfall supplemented with parasitism by *Encarsia guadeloupae* on *A. rugioperculatus* played a crucial role in the whitefly dynamics. Percentage parasitism by *E. guadeloupae* on RSW colonies was found maximum during March-April 2021 and January-February 2022. Highest parasitism was observed in March 2021 (35%) and the lowest during October 2022 (14%).

DRYSRHU Ambajipeta

The mean adult population of rugose spiraling whitefly ranged between 0.00 to 31.09 adults/ four leaflets in the year 2021. The mean adult population of RSW was 1.00 adult/ four leaflets during January 2021 then its decreased to nil in April 2021, and thereafter there was a gradual build up in successive months with peak population observed during the month of December 2021 (31.09 adults/ four leaflets). A similar trend was also recorded in other life stages *viz.*, egg nymph, pupae. Among natural enemies, parasitoid *E. guadeloupae* had maximum (22.56 percent) parasitisation.

KAU Thrissur

The infestation remained low till November and was positively correlated with temperature. The degree of infestation gradually increased to high or severe towards March 2022. Mean parasitism by *Encarsia guadeloupae* during the study period ranged from 18.23 to 65.50 per cent at Thrissur and from 21.10 to 53.90 per cent at Palakkad.

OUAT

Survey on the Rugose spiraling whitefly, *Aleurodicus rugioperculatus* and its natural enemies in the coconut plantations of Bhubaneswar, Pipili and Nimapara areas of Khurda and Puri district of Odisha indicated the low incidence during June, July and Aug (1.0 to 1.5 colonies/leaflet) of *Kharif* season 2021 and rise gradually from October up to December (3.5colonies/leaflet}. No natural enemies have been reported reported so far.

RARS Kumarakom

In the surveys conducted to assess the infestation of Bondar’s white fly in coconut, percentage infestation ranged from 72.28 to 94.82 per cent at Kumarakom (Kottayam district) 70.57 to 98.33 per cent at Vyttila (Ernakulam district) and 71.56 to 91.33 per cent at Moncompu (Alappuzha district). Among the three locations, highest infestation was observed in Vytilla during September 2021.

COA Vellayani

Study on population build up of RSW in three different spots of Vellayani, revelaed that all the three locations followed a similar trend in the population patter, although the mean population recorded from the hot spot area near vellayani lake was high. The parasitism level noted varied from 66.08 to 76.94 in Location 1; 61.47 to 71.66 in Location 2 and 60.7 to 69.3 in Location 3. Highest parasitism was noted during the month of May 221 and March 2022.

ANGRAU

Rugose spirallying whitefly (RSW) incidence in coconut was low (<5%) in coconut during October, 2021 and severe (>50%) in march, 2022. Spread of RSW was noticed in mango, guava, sugarcane, maize, banana, papaya, sapota.

UBKV

It was found that the mean number of spirals per leaflet as well as mean percentage of leaflets infested per leaf by RSW population were minimum in the month of August, 2021 and expressed increasing trend upto January, 2022. But the data in both the parameters showed decreasing values in the month of February, 2022.

TNAU

The population of RSW ranged between 4.00 and 33.00/leaflet in various Districts in Tamil Nadu. The parasitisation by *Encarsia guadeloupae* ranged between 20.00 and 60.00 per cent on coconut gardens and a predator *Apertochrysa astur* was seen in all the coconut gardens. The population of bondar nesting whitefly ranged between 1.00 and 43.00/leaflet in various Districts in Tamil Nadu. Besides, *E. guadeloupae* and *A astur*, many predators *viz.*, *Cybocephalus* spp., *Chilocorus nigrita* (Fabricius), praying mantis, dragonflies and spiders (*Argiopes* sp) were also recorded as natural enemies of *A. rugioperculatus* in Tamil Nadu. In fixed plot survey, the population of RSW was maximum during second fortnight of August, 2021 while it was minimum during first fortnight of April, 2021. BNW population ranged between 4.0 and 39.0/leaflet. Parasitisation by *Encarsia* sp was 45 per cent during first fortnight of September, 2021.

4.4. Surveillance for pest outbreak and alien invasive pests

AAU-Anand

During the survey, incidence of fall armyworm in maize fields (20-25%, during June, July and August 2021) and invasive thrips, *Thrips parvispinus* in chilli fields (20-30%, January 2022) of Anand district was recorded.

ANGRAU

Collected invasive flower thrips/black thrips in chillies in Srikakulam, Vizianagaram, Visakhapatnam and Guntur districts during November, 2021, and identified at molecular level as *Thrips parvispinus* at NBAIR, Bengaluru. Flower thrips damage also observed in capsicum in January, 22. Monitored moderate to severe incidence of fall armyworm in maize in kharif, 21 (4-30%) and rabi, 21 (8-20%). Observed mixed populations of borers (*Chilo partellus, Seasamia inferens* and fall armyworm) in maize.

KAU Thrissur

Incidence of invasive alien pests, *Phenacoccus manihoti, Paracoccus marginatus, Phenacoccus solenopsis, Pseudococcus jackbeardsleyi* and *Icerya purchasi* was observed in cassava. In addition, incidence of wax scale on cassava and hard scale on mango was also reported. Incidence of *Pseudococcus jackbeardsleyi* was noticed in other plants like green manure crop, glyricidia. Some species of mealybugs were observed in weed plants. During survey, we could observe the mealybug, *Rastrococcus iceryoides* on the weed, *Triumfetta rhomboidea*. Two species of mealybugs were noticed in coconut and one of them was identified as *Pseudococcus longispinus.* Incidence of *P. mannihoti* was recorded from 105 locations (70.95%) out of a total of 148 locations/cassava plots covered during the roving surveys. A total of 162 samples were collected and sent to NBAIR for identification. Taxonomic identification of 89 samples completed so far revealed that the mealybugs coexisted as a complex on cassava and involved *Paracoccus marginatus* (40.66 %), *Ferrisia virgata* (30.77 %), *Phenacoccus manihoti* (20.88 %) and *Pseudococcus jackbeardsleyi* (7.69 %).

KAU Vellayani

Phenacoccus manihoti was observed in one location at Kottarakkara, Kollam district, during Sept- Oct 2020. However its presence could not be located in none of the tapioca fields of Trivandrum district.

MPKV

Nymphs and females of mealybug species, *Pseudococcus jackbeardsleyi* were recorded on custard apple in Pune and Ahmednagar region. The tea mosquito bug (*Helopeltis theivora*) was also recorded on custard apple in Pune district. The fall armyworm infestation was ranged between 11.40 to 38.28 per cent in maize crop in Pune, Solapur, Satara, Sangli and Ahmednagar districts. Fall armyworm was also found on sorghum in few fields with very low infestation of 1.00 to 2.00 per cent. Rugose spiralling whitefly first time observed on coconut palms in Western Maharashtra during the year 2021-22. Parasitoid, *Encarsia* sp. and predator, *Apertochrysa* sp. were seen in the colonies of rugose spiralling whitefly on coconut in all surveyed areas. *Encarsia* sp. and *Chrysoperla* sp. were also seen in the colonies of rugose spiralling whitefly on guava. The sugarcane woolly aphid incidence was relatively low and was observed in Pune, Satara, Sangli, Solapur and Ahmednagar districts.

YSPUH&F

During the survey two invasive pests namely *Tuta absoluta* and *Spodoptera frugiperda* were recorded infesting tomato and maize, respectively. Incidence of *T. absoluta* was recorded at Nauni, Deothi, Rajgarh, Naineti, Sarahan and Sundernagar areas of the state with pest incidence of 13 to 67 per cent infested plants. During the survey a mirid predatory bug, *Nesidiocoris tenuis* was recorded. *Spodoptera frugiperda* incidence on maize was recorded at Rohin, Kandraur, Sundernagar, Jahu, Una, Sarahan, Nauni and Nalagarh areas of the state with 20 to 70 per cent infested plants.

IIMR

Chilo partellus was predominant (8 - 10%) as compared to *Sesamia inferens* (< 5 %) in Sorghum. About 10% larval parasitization by *Cotesia flavipes* was observed. Surveys for incidence of *Spodoptera frugiperda* showed 5 – 6 % damage on Sorghum. About 2-3 % larval parasitization was observed by *Chelonus* sp. In Barnyard, Proso, Little, Kodo millets the incidence of shoot flies were recorded at seedling, panicle stages causing deadhearts (>30%) and white ears (20%), respectively.

PAU

The damage of fall armyworm, *Spodoptera frugiperda* was recorded to be 10-25 per cent on maize and fodder maize crops in various maize growing districts of Punjab. However, it was 40-50 per cent in late sown crop. No FAW incidence was recorded on any other crop.

In cotton, the incidence of pink bollworm, *Pectinophora gossypiella* was recorded in Bathinda and Mansa districts only during August-September (0-45 %). However, the incidence up to 90 per cent was also observed in few fields. Negligible damage due to pink bollworm was recorded in other cotton growing districts (Fazilka, Muktsar, Faridkot, Barnala) of Punjab.

SKAUST Srinagar

Survey conducted in five villages of district Ganderbal during May to August 2021 revealed per cent plant damage by *M. separata* ranging 1.11- 27.4 with overall damage of 7.08 to 14.4 per cent. Incidence of the pest was found negligible to moderate at all the locations during survey. Occurrence of *Spodoptera furgiperda* in the surveyed district was however not observed.

TNAU

In Coimbatore district the leaf damage due to *Tuta absoluta* was maximum (7.50%) in Thenkarai during second fortnight of February, 2021 while the fruit damage was 10.00 per cent. The leaf damage ranged between 3.30 and 5.00 per cent in other villages. Surveys were conducted to assess the mealybug damage in cassava fields in Erode, Namakkal Tirupur and Salem Districts. *Phenacoccus manihoti* infestation ranged between 15.00 and 35.00 per cent.

Among the predatory species, *Hyperaspis maindroni* was found to be the predominant coccinellid predator of the mealybug. Besides, *Hyperaspis maindroni*, *Mallada* sp, *Cryptolaemus* sp were seen on the colonies of *P. manihoti*.

4.5. Monitoring and record of incidence of papaya mealybug and its natural enemies on papaya and other alternate hosts

AAU - Anand

During the survey, incidence (<2-3%) of papaya mealybug was noticed in three orchards. The parasitoid, *Acerophagus papayae* was noticed parasitizing mealybug.

TNAU

The infestation of *Paracoccus marginatus* was noted in crops like papaya, tapioca, mulberry and guava. The incidence of papaya mealybug on papaya was recorded in Coimbatore and Tiruppur districts. Infestation of papaya mealybug ranged between 0.8 and 3.00 per cent in papaya fields. Papaya field in Thhetiplayam, Coimbtore Dt., was free from papaya mealy bug. Natural enemies of papaya mealybug *viz.*, *Acerophagus papayae*, *Spalgis epius* and *Cryptolaemus montrouzieri* were seen in papaya fields.

MPKV

Attack of mealybug, *Paracoccus marginatus* was not found on papaya and other host plants in Pune and Satara distrcits. It was recorded on one plant in Ahmednagar and Pune city during the survey with very low intensity.

4.6. Survey and surveillance of natural enemies of pinworm, *Tuta absoluta* in tomato

AAU - Anand

Adult moth catches (8-13/trap) of *T. absoluta* was recorded during the survey. However, no conspicuous infestation/damage symptoms caused by *T. absoluta* in tomato and other non-host crop plants was observed during the survey period.

4.7. Biological suppression of plant diseases

4.7.1. Field efficacy of different combinations of *Trichoderma harzianum* and *Pseudomonas fluorescens* against the early blight of tomato

AAU-Anand

Among the treatments where different combinations of *Trichoderma harzianum* and *Pseudomonas fluorescens* evaluated as soil application (SA), root dip (RD) and foliar spray (FS), the treatment T_6 - Th+ Pf (SA + RD) + Azoxystrobin 23% SC (FS) found effective in reducing the early blight disease intensity (5.08 %) and it was followed by the treatment T_5 - Pf (SA + RD) + Azoxystrobin 23% SC (FS) (7.40%). Among the treatments where the biopesticides were evaluated as foliar spray, the treatment T_3 - Th + Pf (SA + RD + FS) recorded the lowest disease intensity (13.05%).

4.7.2. Field efficacy of different combinations of *Trichoderma harzianum* and *Pseudomonas fluorescens* against the early blight of potato

AAU - Anand

Among the treatments where different combinations of *Trichoderma* and *Pseudomonas* evaluated as soil application (SA), seed treatment (ST) and foliar spray (FS), the treatment T_6- Th+ Pf (SA +ST) + Kresoxim-methyl 44.3% SC (FS) found effective in reducing the early blight disease intensity (6.47 %). Among the treatments where the biopesticides were evaluated as foliar spray, the treatment T_3 - Th + Pf (SA + ST + FS) recorded the lowest disease intensity (13.50 %).

4.7.3. Ecofriendly management of stem rot, *Macrophomina phaseolina* in sesame using biocontrol agents

ANGRAU

During 2021-22, December sown rabi crop, initial plant population recorded significantly high in T4- *P. fluorescens* ST + *T. asperillum* SD and was on par with other biopesticide treatments and low in untreated control . Sesame germination was significantly high in T4 - *P. fluorescens* ST + *T. asperillum* SD (93.28%), T2 –- *Pseudomonas fluorescens* ST + SD (91.11%) and was on par with other biocontrol agents and chemical whereas germination was low in control (70.56 %). Stem rot disease was noticed at 60 days crop age as high in control (24.07 %) and low in T4 - *P. fluorescens* ST + *T. asperillum* SD (5.49 %) followed by T3 -NBAIR *T. asperillum* ST + *P. fluorescens* SD (6.17 %) and T2- *Pseudomonas fluorescens* ST + SD (7.34%) compared to chemical treatment (11.225). Root length, shoot length and grain yield will be recorded after harvest in April, 2022.

4.7.4. Screening of promising isolates antagonistic fungi and bacteria against bacterial wilt of tomato

KAU Kumarakom

The results indicated that seed treatment, seedling dip and soil drenching with NBAIR-BATP isolate of *Bacillus albus* was highly effective in reducing wilt incidence which was on par with the effect of KAU strain PN026 of *P. fluorescens.* This was followed by the effect of NBAIR-PFDWD isolate of *P. fluorescens.* These three strains could also result in significant increase in plant height and fruit yield of tomato.

4.7.5. Management of Powdery mildew (*Uncinula necator*) of Grape by using biocontrol agents

MPKV

Powdery mildew (*Uncinula necator*) disease of grape was minimum in sprays with *Trichoderma harzianum* @ 5 g/l. + *Ampelomyces quisqualis* @ 5 ml/l. (6.67 PDI) with maximum fruit yield 18.667 mt/ha. *Bacillus subtilis* @ 5 g/ l + *Ampelomyces quisqualis* @ 5 ml /l sprays recorded 7.00 PDI with fruit yield 18.517 mt/ha. The chemical check Sulphur 80% WP @ 2g/litre of water recorded 8.67 PDI with fruit yield of 17.467 mt/ha.

4.7.6. Efficacy of Mechanized sett treatment with antagonistic microbes, fungicide and their integration against red rot in sugarcane

SBI Coimbatore

For fungicidal treatment, thiophanate methyl at 1000ppm was used in the STD either alone or in combination with bacterial antagonist indicated that treating setts in the Sett Treatment Device (STD) with the combination of thiophanate methyl and *P. alvei* was found to be significantly superior (0% PDI) as thiophanate methyl alone followed by combination of *P. alvei* and *T. harzianum* (10%PDI) as against 66.6% PDI in inoculated control. Further mechanized sett treatment with both the biocontrol agents and fungicide individually or in combination were found to be not deleterious and were effective in reducing the disease incidence, improving plant growth and yield attributes. The yield improvement by the combination of *P. alvei* and thiophanate methyl was found to be 1.74 fold over inoculated control and it was 15.5% increase over healthy control.

4.7.7 Field evaluation of ICAR-NBAIR antagonistic organisms against Maize Turcicum leaf blight (*Exserohilum turcicum)*

SKAUST Jammu

Among the various biopesticides assessed, NBAIR-TATP strain *T. asperellum* (Liquid formulation) T_4 - recorded lowest percent disease index (20.50%) and its talc formulation T_2 - (21.10%), followed by BC1 strain *Trichoderma asperellum* (Local strain, Jammu) (Talc formulation) T_5 (23.00%). Percent disease index in carbendazim spray T_7 - (19.10%) was comparable to that of T_4 -NBAIR-TATP strain *T. asperellum* (Liquid formulation). Grain yield was significantly highest in T_4 (32.05 q/ha) and T_2 (32.05 q/ha). The grain yield was lowest in T_8 – control (19.18 q/ha).

4.7.8. Evaluation of bio-agents against root-knot nematode and Fusarium wilt complex in guava under controlled conditions

CISH

These results indicated that T6 combination (*Purpureocillium lilacinum* + *Bacillus* spp.) is the most effective one in managing the disease and enhancing the growth of plants. *Purpureocillium lilacinum* and *Bacillus* spp with vermi compost reduced the *Fusarium oxysporum* and *Meloidogyne enterolobii* infection in guava plants with low root not index of 1.88 compared to the control root not index of 3.19.

4.7.9. Management of major diseases of rice with *Bacillus subtilis*

TNAU

Results revealed that T5 (T1-Soil application *Bacillus subtilis* (2.5kg/ha) + T2-Seed treatment *Bacillus subtilis* (10g/kg) + T3-Seedling dip *Bacillus subtilis* (2.5kg/ha) + T4-Foliar spray *Bacillus subtilis* (20g/lit)) was found to be the best in reducing the incidence of blast, brown spot, bacterial leaf blight, false smut to a considerable level . Yield was 3585Kg/ha in T5 and it was higher than the yield in T6-Azoxystrobin (1ml/lit) (3295Kg/ha).

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

NRRI

Among the tested strains, NBAIR-PFDWD (*Pseudomonas flourescens*) was the most effective isolate against sheath blight, brown spot and blast with lesser Percent Disease Index (PDI) of 17.58%, 20.72% and 11.43% respectively. The percent disease reduction over the control was highest for chemical fungicide against sheath blight (84.97%), brown spot (75.01%) and blast (81.57%) followed by NBAIR-PFDWD and NBAIR-TATP. The highest grain yield/plot (14.50 kg/plot) was recorded in chemical treatment followed by plants treated with NBAIR-PFDWD which had the 13.90 kg/plot. Similarly, NBAIR-TATP and NBAIR-BtoyPS enhanced growth and yield components but at a lower level of efficacy than NBAIR-PFDWD.

4.7.11. Evaluation of microbial antagonist for the management of ginger rot disease

AAU - Jorhat

Highest per cent germination (84.25) and highest number of tillers per plant (20.33) were recorded in T_5 (Seed treatment with *Pseudomonas fluorescens* (AAU Culture)@ 1x10^8 cfu/ml (5g/ltr) and spraying of *Trichoderma harzianum* (Commercial formulation)@ 1x10^8 cfu/ml (5g/ltr)) followed by T_3 (Seed treatment with *Pseudomonas fluorescens* (AAU Culture) @ 1x10^8 cfu/ml (5g/ltr) and spraying of *Trichoderma harzianum* (AAU Culture) @ 1x10^8 cfu/ml (5g/ltr)) with 81.42% and 18.67 nos., respectively. Similarly, in case of disease infected plant 14.67% was observed in T_5 followed T_3 with 17.67 % disease infection. The maximum disease severity (4) was recorded in T_7 which was untreated check. As regards to yield data, highest yield of ginger (18.00 t/ha) was recorded in T_5 followed by T_3 with 16.93 t/ha, where as in untreated control plot, it was only 12.33 t/ha.

4.7.12. Management of *Phytophthora* disease in black pepper nursery using biocontrol agents

KAU Thrissur

Among the different biocontrol agents, soil drenching of PGPR consortium at the time of planting + foliar application of PGPR at 15 days interval was found to be the best treatment against *Phytophthora* disease in black pepper. In addition, this treatment had positive influence on growth parameters of black pepper.

4.8. Biological suppression of pests

4.8.1. Biological suppression of sugarcane pests

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

MPKV

Highest (68.38%) white grub reduction was recorded in chemical control (Fipronil 40% + imidacloprid 40 WG @ 2.5ml/l). The next best treatments are *H. indica* @ 1.0 X10^5/ m^2 (59.18 %), *H. bacteriophora* @ 1.0 X 10^5/ m^2 *S. carpocapsae* @ 1.0 x10^5/ m^2, and *S. abbasi* @

$1.0x10^5$/ m^2 (54.04, 49.56 and 45.55 %), respectively. The highest cane yield of 145.65 Mt/ha was recorded in chemical check, the next best treatment was *H. indica* was at par with all the EPN treatments recording yield of 131.55 Mt/ha followed by *H. bacteriophora* with 126.72 Mt/ha, *S. abbasi* with 125.70 Mt/ha and *S. carpocapsae* with 124.48 Mt/ha.

4.8.1.2. Field evaluation of ICAR-NBAIR endophytic entomopathogenic strains against shoot borers (*Chilo infuscatellus* and *Chilo sacchariphagus indicus*) in sugarcane

ANGRAU

During 2021-22 kharif planted crop, Sett treatment at planting and spraying of endophytic entomopathogenic fungi three times at 14 days interval from 25 days after germination was effective in the management of shoot borers. Cumulative incidence of early shoot borer upto 120 days after planting was high in untreated control (31.99% DH) and low in Cholorantraniliprole treatment (7.8 % DH) and was on par with the entomopathogenic fungal treatments i.e., Bb23 (8.16% DH); Bb 45 (13.89% DH) ; Ma 4 (12.46% DH); Ma 35 (10.28% DH).

Internode borer incidence (%) and Internode borer intensity (%) was high in control (80% and 4.53%) and low in T6- Cholorantraniliprole treatment (45% and 2.95%) followed by T2-NBAIR - *Beauveria bassiana* Bb-45 (45 and 3.23%) and T4- NBAIR – *Metarhizium anisopliae* Ma-4 (50 % and 3.2 %). Cane yield recorded high in T6- Cholorantraniliprole treatment (90.74 t/ha) followed by T1 –Bb 23 (80.53 t/ha) and T4 –Ma 35 (78.84t/ha) and T3 –Ma4 (78.72 t /ha and low in control (63.92t/ha).

4.8.2. Biological suppression of cotton pests

4.8.2.1. Biointensive management of pink bollworm on *Bt* cotton

TNAU

Rosette flowers due to pink boll worm was 1.22 per cent in BIPM plots while it was 2.87 per cent in the control plot on 110 Days after Sowing (DAS). On 110 DAS, Green boll damage due to pink boll worm was 8.90 per cent in BIPM plots while it was 13.00 per cent in the control plot. There was 17.52 per cent reduction in the bad open bolls in BIPM module whereas 30.65 per cent reduction in bad open bolls was observed in insecticides treated plots. The yield was maximum in insecticide sprayed plots (2215Kg/ha) followed by 1890Kg/ha and 1598Kg/ha in BIPM and control plots respectively. CB ratio was higher in insecticide treated plots (1:2.57) than in BIPM plot (1:2.52).

4.8.2.2. Evaluation of entomopathogenic fungi, *Beauveria bassiana* (ICAR- NBAIR- Bb-5a) against sucking insect pests of cotton

UAS Raichur

Among the biocontrol agents, *B. bassiana* (ICAR- NBAIR-Bb-5a) 1×10^8 @ 5gm/l recorded highest reduction of leafhopper population over control (58.60 %) and it was at par with *L. leccani* (ICAR-NBAIR-VL-15) 1×10^8 @ 5gm/l which recorded 55.73 per cent. Reduction of thrips population over control was highest in *B. bassiana* (ICAR- NBAIR-Bb-5a) 1×10^8 @ 5gm/l (61.39 %) and it was at par with *L. leccani* (ICAR-NBAIR-VL-15) 1×10^8 @ 5gm/l which recorded 58.32 per cent. Per cent reduction of aphid population was highest in *L. leccani* (ICAR-NBAIR-VL-15) 1×10^8 @ 5gm/l and *I. fumosorosea* (ICAR-NBAIR strain) 1×10^8 @ 5gm/l which recorded 63.19 and 65.69 per cent, respectively. Highest seed cotton yield of 29.64 q/ha was noticed in *B. bassiana* (ICAR- NBAIR-Bb-5a) and it was at par with *L. leccani* (ICAR-NBAIR-VL-15) (29.64q/ha) and *I. fumosorosea* (ICAR-NBAIR strain) (28.54q/ha).

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

MPKV

Amongst the biopesticides, *Lecanicillium lecanii* (1 x 10^8conidia /g) @ 5 g/litre recorded lowest population of sucking pests *viz.*, aphids (3.83), jassids (2.67), and white flies (1.33) on 3 leaves per plant compared to the untreated control which recorded aphids (46.72), jassids (8.83), and white flies (6.05) on 3 leaves per plant. Chemical treatment recorded lowest population of aphid, jassid and whitefly pests and significantly superior over rest of the treatments. The *Lecanicillium lecanii* (1 x 10^8conidia/g) @ 5 g/litre recorded seed cotton yield of 12.38 q/ha and the next best treatment was Imidachloprid 17.8 % SL (14.01 q/ha), Whereas, untreated control recorded lowest seed cotton yield of 6.63 q/ha .

4.8.3. Biological suppression of rice pests

4.8.3.1. Management of rice stem borer and leaf-folder using entomopathogenic nematodes and entomopathogenic fungi

KAU Thrissur

Seven and fourteen days after second spray, stem borer infestation was the lowest in flubendiamide applied plots (35.75 and 31.25 number/m^2 respectively). Among entomopathogens, *B. thuringiensis* recorded the second best values of 42.75 and 37.50 number/m^2 for the corresponding period. For leaf folder, the lowest number of 5 leaf folds/ m^2 were recorded from flubendiamide treated plots, followed by *Beauveria bassiana* (6.25 no./m^2).

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

IIRR

At Navsari Gujarat, after first spray population of bugs was lowest in insecticide treatment plot (8.00/ 10 hills) but, *L saksanae* spray was on par (9.50/ 10 hills) with insecticide treatment. Similar trend was observed after second spray. The yield was highest in Thiamethoxam treated plots (8763.89 kg/ha) which was on par with yield projected from *L. saksanae* treated plots (8347.22 kg/ ha).

4.8.3.3. BIPM trial on paddy along with farmers practice and control

IGKV

Maximum percent of dead heart was recorded in control (9.11) and minimum (3.90) in BIPM treated (Vermicompost 100%) field. Similarly maximum white ear head was recorded in control (15.86) and minimum in BIPM treated (Vermicompost 100%) field (7.87). Maximum damage due to leaf folder in the form of percentage leaf folds was recorded in control (3.77) while it was minimum in BIPM treated (Vermicompost 100%) field.

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

NRRI

spray of NBAIR isolates i.e., NBAIR-PEOWN, NBAIR-BATP, NBAIR-BtoYPS, NBAIR-PFDWD and NBAIR-TATP shown less dead heart damage (9.11-12.42%) and white ear-head (2.48-4.29%) compared to untreated control which recorded maximum dead heart (20.73%) and white ear-head incidence (6.40%) caused by yellow stem borer. Least dead heart (1.77%) and white ear-head incidence (1.46%) was observed in the chlorantraniliprole insecticide application treatment. Similarly, with respect to leaf folder damage highest leaf damage (6.57%) was observed in untreated control and significantly less leaf damage (2.08-3.63%) was observed in all the NBAIR isolates sprayed plots.

4.8.3.5. Validation of BIPM practices against pest complex of organic Black rice

AAU Jorhat

At 65 days after transplanting, the mean dead heart and damaged leaves in case of leaf folder incidence in BIPM fields were 1.79 and 2.25%, respectively. The corresponding figures in farmers practice were 2.03 and 2.41 %. Similarly, WEH incidence in BIPM field was 2.25 % as compared to 2.41 % in farmers practice. As regards to grain yield, maximum yield of 3139.1 kg/ha in BIPM plot was significantly superior as compared to 2897.20 kg/ ha in farmers practice plots.

4.8.3.6. Development of biointensive IPM package and practices for pest management in basmati rice (Pusa basmati 1121)

GBPUA&T

In BIPM practices, Sheath blight disease reduction was found to be 53.28% while in farmer's practice it was 50.46%. In BIPM practices, Brown spot disease reduction was found to be 47.33% while in farmer's practice it was 24.26%. The incidence of leaf folder in BIPM practices was significantly lower (6.31%) than farmer's practice (9.08%). In BIPM practices, the mean dead heart damage owing to stem borer differed significantly (7.94%) from farmer's practice (9.12%) as compared to untreated control (20.25%). Similarly, the white earhead damage recorded in BIPM practices (7.62 %) was found to be non-significantly different from farmer's practice (8.18 %). The incidence of BPH per m^2 in the BIPM practices (1.39/m^2) differed substantially from the farmer's practice (1.70/m^2). In BIPM practices, the percentage of eggs parasitized by egg parasitoids on yellow stem borer was substantially higher (59.55%) than in farmer's practice (11.93%). The grain yield of rice obtained from the BIPM practice (48.00 q/ha) followed by grain yield of rice recorded from the farmer's practice (43.00 q/ha).

4.8.4. Biological suppression of cereal pests

4.8.4.1. Biological suppression of fall armyworm *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) in maize

TNAU

Among the biocontrol agents, lowest plant damage of 39.67 per cent was observed in *Trichogramma chilonis* + NBAIR Bt 2% followed by *Trichogramma chilonis* + *Metarhizium anisopliae* Ma (41.52%), *Trichogramma chilonis* + *Beauveria bassiana* NBAIR -Bb 45 (43.27%), *Trichogramma chilonis* + Spfr NPV(NBAIR1) (43.31%) and *Trichogramma chilonis* + EPN *H. indica* NBAIR H38 (47.59%) on 7th day after first spraying of entomopahogens and insecticide, while in insecticide treated plots 38.62 per cent damage was observed. Similar trend was observed on 15th day after first spraying also. Yield was maximum (3563Kg/ha) in *Trichogramma chilonis* + NBAIR Bt 2% plots followed by *T. chilonis* + *Metarhizium anisopliae* Ma35(3420Kg/ha) and these two treatments statistically onpar with each other while in the insecticide treated plots the yield was 3883Kg/ha.

AAU-Jorhat

Larval count of *S. furgiperda*, a day after treatment varied from 1.87-1.93 per plant. However, at 7 days after treatment, a significant difference was observed where BIPM module recorded 1.74 larvae per plant as against 1.84 larvae in case of farmers practice (chemical plot).

Similar trend of result was also recorded at 10 days after treatment with 1.61 and 1.79 larvae per plant in BIPM module and farmers practice, respectively and both the treatments were significantly different with each other. In terms of per cent plant damage, BIPM module was significantly different (15.30%) after application of treatment as against farmers practice plot (22.83%). However, highest yield of 42.91 q/ha was recorded in BIPM module, which was significantly superior to farmers practice plot with 34.55 q/ha.

MPKV Pune

The lowest pooled mean per cent of plant damage/plot (13.47%) was observed in the chemical treatment (Emamectin benzoate 0.4g/l) which was significantly superior over rest of the treatments. The next promising treatment *Trichogramma pretiosum* 1 card (2 Rel) + EPN *Heterorhabditis indica* NBAIR H38 @ 4kg/acre recorded 25.79 per cent plant damage and it was at par with treatment *Trichogramma pretiosum* 1 card (2 Rel) + *Bt* 25 20 % @ 2.0 ml/l (28.20%), *Trichogramma pretiosum* 1 card (2 Rel) + *M. anisopliae* Ma 35, 0.5%@ 2.0 g/l (29.24%), (*Trichogramma pretiosum* 1 card (2 Rel) + *Spfr*NPV (NBAIR1) (29.86%), *T. pretiosum* 1 card (2 Rel) + *Beauveria bassiana* -Bb 45, 0.5% @ 2.0 g/l (31.86%) and Pheromones traps @15 /acre.

PAU

Among different biocontrol agents, lowest plant infestation due to fall armyworm, *S. frugiperda* was recorded in in *T. chilonis* + NBAIR-Bt 25 (11.26 %) followed by *T. chilonis* + NBAIR-SpfrNPV (14.68 %), *T. chilonis* + NBAIR-EPN (16.02 %), *T. chilonis* + NBAIR-Ma 35 (17.11 %) and *T. chilonis* + NBAIR-Bb 45 (17.82 %) as compared to untreated control (28.0 %). Likewise, larval population was also significantly lower in by *T. chilonis* + NBAIR-Bt 25 (4.83/ 10 plants), *T. chilonis* + NBAIR-SpfrNPV (6.00/ 10 plants), *T. chilonis* + NBAIR-EPN (6.67/ 10 plants), *T. chilonis* + NBAIR-Ma 35 (6.83/ 10 plants) and *T. chilonis* + NBAIR-Bb 45 (7.33/ 10 plants) as against untreated control (11.17/ 10 plants). However, chemical control was significantly better in reducing the plant infestation and larval population as compared to all treatments and also recorded highest grain yield.

SKAUST Jammu

Large plot trial (2.0 ha) on the effectiveness of BIPM module developed by NBAIR (Treatment 1) including installation of pheromone traps @ 10/acre, release of egg parasitoid (2 releases of *Trichogramma chilonis* @ 1,00,000 adults/ha at weekly interval when 1-2 adult moths are caught in pheromone trap, spray of azadirachtin 1500ppm @ 5ml/l water to kill eggs and neonates, one Spray of NBAIR Bt-25 @ 20 ml/litre one week of the neem spray (for early instars) and one spray of *Metarhizium anisopliae* (NBAIR Ma-35) (1×10^8 cfu/g) @ 5gm/litre (for 3rd instar and mature larvae); Chemical Control Treatment 2 - (Fipronil 0.6% GR @ 20 kg/ha) - Two applications at 15 days interval starting from the first appearance of FAW and untreated (Treatment 3) – was conducted at the farmer's field. Number of *S. frugiperda* larvae / 10 plants and plant damage (%) was significantly lowest in BIPM package (3.37 *S. frugiperda* larvae per 10 plants and 11.90% plant damage) followed by Treatment 2 (39.84% plant damage). Grain yield was accordingly highest in BIPM package (42.50 q/ha).

4.8.4.2. Field efficacy of *Metarhizium rileyi* (Anakapalle strain AKP-Nr-1 and *Metarhizium rileyi* (UASR strain KK-Nr-1).

UAS Raichur

Ten days after third spray lowest larval population of 0.18 larva per plant was noticed in the highest dosage of *Metarhizium rileyi* (KK-Nr-1) @ 1×10^{12} spores/ml (5g/L) and it was at par with *Metarhizium rileyi* (AKP-Nr-1) @ 1×10^{12} spores/ml (5g/L) which recorded 0.26 larva per plant. The highest per cent mycosis of 30.15 was noticed in the *Metarhizium rileyi* (KK-Nr-1) @ 1×10^{12} spores/ml (5g/L) and at par with *Metarhizium rileyi* (AKP-Nr-1) @ 1×10^{12} spores/ml (5g/L) which recorded 29.75 per cent. Untreated control recorded 3.75 per cent of mycosis. Highest grain yield of 60.25 q/ha was noticed in *Metarhizium rileyi* (KK-Nr-1) @ 1×10^{12} spores/ml (5g/L) and it was at par with *Metarhizium rileyi* (AKP-Nr-1) @ 1×10^{12} spores/ml (5g/L) which recorded 59.50 q/ha while in untreated control it was 48.75 q/ha grain yield

4.8.4.3. Evaluation of entomopathogenic fungi formulations against Pink borer (*Sesamia inferens*) in Finger millet, Kharif, 2021, (IIMR, Hyderabad)

IIMR, Hyderabad

Overall based upon the reduction in damage and increase in yield realized, the bio-control agents T5 (application of talc formulation of *Metarhizium anisopliae* (Ma 4) @10gml /lt at 20 & 40 DAE) and T6 (application of talc formulation of *Metarhizium anisopliae* (Ma 6 @10gml /lt) at 20 & 40 DAE) were the best and on par with T7 (application of Fipronil 3G @ 17.5 kg /ha) at sowing + whorlapplication of Fipronil 3G @ 7.5 kg at 30 DAE).

4.8.4.4. Management of FAW in Sorghum using biocontrol agents – Rabi 2021

IIMR Hyderabad

Release of *Trichogramma chilonis* @ one card/acre twice at weekly intervals commencing from 7 DAE, 14 DAE followed by spray of *Metarhizium anisopliae* (Ma 35) @ 0.5 % at 20, 35 DAE was found to decrease the egg patches, larvae numbers and whorl damage caused by *Spodoptera frugiperda*, significantly. There was11.8 and 19.2 % increase in the grain and fodder yield in comparison to control.

4.8.5. Biological suppression of pests of pulses

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

MPKV

The lowest larval population (0.34 larvae/mt) was observed in spinosad 45 SC @ 150 ml/ha, which was significantly superior over rest of the treatments. The lowest pod damage (3.55 %) was recorded in the treatment of spinosad 45 SC @ 150 ml/ha, which was at par with *Bacillus thuriengiensis* @ 1 Kg/ha and recorded 4.88 per cent pod damage of gram crop. Grain yield was recorded 17.83 and 16.03 q/ha, respectively.

MPUAT

The maximum reduction was recorded in quinalphos 25 EC @ 250g a.i/ha treatment (2.0 larvae per plant) and the minimum reduction was observed in *B. bassiana* @ $1x10^8$ conidia /gm @ 5 gm/l (3.0 larvae per plant) at ten days after spray; whereas, the untreated control recorded least reduction in larval population (5.5 larvae per plant) at ten days after spray. Minimum per cent pod damage was recorded in treatment of quinalphos 25 EC @ 250g a.i/ha (10.12%) and maximum was in *B. bassiana* @ $1x10^8$ conidia /gm @ 5 gm/l (16.22%).

4.8.5.2. Evaluation of oil formulation of *Lecanicillium* spp against sucking pests of cowpea

COA Vellayani

Seven days after first spraying, lowest population of bugs was noted in plots sprayed with oil formulation of *L. saksenae*, but was on par with the efficacy of *L. lecanii* oil formulation. Thereafter, the variation in population was not significantly different, though the lowest count was with *L. saksenae* oil (0.25 bugs per plant). The corresponding population in *L. lecanii* oil is 0.75 and those with spore suspensions it was 1.0 bug per plant, which was on par with thiamethoxam (1.0 bug).

4.8.5.3. Evaluation of entomopathogenic biopesticide against *Aphis craccivora* in cowpea (*Vigna unguiculata*)

AAU Jorhat

Minimum number of *A. craccivora* (10.83/ terminal shoots) was recorded in the treatment T_3 *Verticilium lecanii* 1×10^8 cfu/ml @5gm/lit followed by treatment T_4 (spinosad 45 SC @ 0.3 ml/lit) with 11.80/ terminal shoot) with a yield of 38.75 and 36.31 q/ha, respectively. Maximum infestation (22.14 aphids/ terminal shoot) was recorded at untreated control plot. However, it was observed that except *Metarhizium anisopliae* (T_2) all the tested biopesticides showed more or less equal effectiveness with the chemical treatment plot (malathion 50 EC @2ml/lit) in suppressing the *A. craccivora*.

4.8.5.4. BIPM module for management of *Helicoverpa armigera* on chickpea

NCIPM

BIPM module against pod borer in chickpea in Bundelkhand region was implemented at farmer's field in village Chokari (25°35'15.4"N 79°13'00.5"E) of district Jhansi (UP) with the help of district KVK during *Rabi* 2021 in five ha area in farmers participatory mode BIPM fields recorded significant per cent reduction in infestation of pod borer (70.52%) and disease incidence of collar rot (77.4%), *Fusarium* wilt (73.77%) and dry root rot (62.5%) over FP fields. Use of pheromone traps, installation of bird perches and foliar spray of *B. thuringiensis* and neem were found effective against pod borer and seed treatment with *T. harzianum* provided satisfactory management of wilt disease. Economic analysis indicated that BIPM field recorded average yield of 18.60 q/ha with B: C ratio 3.87 whereas, 14.40 q/ha yield was recorded in FP fields with B: C ratio of 3.06. Implementation of BIPM strategy provided >29 per cent increase in seed yield and >42 per cent increase in net return over FP consequently farmers earned >Rs 20000/ha extra net income over farmers practice. Farmer's field schools were organized in different villages to promote the use of biological control agents for pest management in chickpea and seed treatment by *T. harzianum* was also demonstrated.

4.8.5.5. Integration of botanicals, microbials and insecticide spray schedule for the management of pod borer complex in Green gram

ANGRAU

During 2021-22, Leaf webs caused by *Maruca virtata* per plant recorded was significantly low in T9-Spinosad two sprays (0.057) and on par with T8- Spinosad + Bt (0.143); T3 - Bt + Spinosad (0.113); T2 – Bt + Bt (0.125) and T1 – Bt + azadirachtin (0.152) and high in T10 - untreated control (0.277). Similarly, Pod damage was significantly low in T9-Spinosad two sprays (14.69%) and on par with treatments having *Bacillus thuringiensis* as first spray i.e., T3 - Bt+ spinosad (21.82%) T2 - Bt two sprays (22.76 %); T1 – Bt + Azadirachtin (24.68%) and T8 – spinosad + Bt (22.66 %). Pod damage was significantly high in untreated control (59.02%).

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

PDKV

Significantly minimum damage was recorded in insecticidal treatment (T2) with 3.85% pod damage due to lepidopteran pod borers. However, this treatment was found statistically at par with Bt treatment (T1) with 4.88 % pod damage. Both this treatments were significantly superior over untreated control (10.28 %). The grain damage due to pod fly was recorded by split opening the pods at harvest and it was found that treatment T2 with minimum grain damage (21.91%) followed by Bt treatment (T1) with 23.04 % grain damage and both the treatments were significantly superior over untreated control which recorded maximum per cent grain damage 36.27%.

4.8.6. Biological suppression of pests of tropical fruit crops

4.8.6.1. Field evaluation of microbial biocontrol agents for the management of mango thrips

CISH

Among the bio-pesticides, low incidence of thrips was observed in *B. bassiana* (CISH formulation) which registered 7.00 thrips/ tap at 14 days after spraying. Efficacy of *B. bassiana* (NBAIR formulation) also found effective in reducing the thrips population, 14 days after spray 8.00 thrips /tap was recorded.

4.8.6.2. Biological control of guava mealybug and scales using entomopathogens

SKAUST Jammu

Significantly highest percent reduction in mealybug population was recorded in *L. lecanii* spray (53.22% reduction) that was at par with that of *B. bassiana* spray (52.53%) and Azadirachtin spray (52.50%) at 7 DAS. At 3 DAS also mealybug population was significantly lowest in Azadirachtin spray (16.86 mealy bug nymphs or adults per 10 cm branch). Significantly highest mealybug population was recorded in untreated control.

UAS Raichur

Highest per cent reduction in mealybug population over control was noticed in *B. bassiana* (ICAR- NBAIR-Bb-5a) @ 1×10^8 @ 5 gm/l (81.72 %) and it was at par with *I. fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l which recorded 80.56 per cent. Among the biocontrol agents, *B. bassiana* (ICAR- NBAIR-Bb-5a) @ 1×10^8 @ 5 gm/l recorded highest fruit yield of 21.75 t/ha and it was at par with *I. fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l which recorded 21.50 t/ha. Untreated control recorded lowest fruit yield of 17.50 t/ha.

4.8.6.3. Biological control of anola mealybug and scales using entomopathogens

SKAUST Jammu

Entomopathogenic fungi *B. bassiana*, *M. anisopliae* and *L. lecanii* formulations, along with Azadirachtin 10000 ppm were assessed against Aonla mealybug. Significantly highest percent reduction in mealybug population was recorded in *M. anisopliae* and Azadirachtin spray (35.06 and 35.71% reduction) followed by *B. bassiana* spray (34.67% reduction) at 7 DAS. At 3 DAS mealy bug population was significantly lowest in Azadirachtin spray (5.20 mealybug / 10 cm twig). Significantly highest mealybug population was recorded in untreated control (8.14 mealybugs / 10 cm twig).

4.8.6.4. Evaluation of different isolates of entomopathogenic fungi against citrus thrips

CRS Tirupati

Among the three entomopathogens evaluated, *Lecanicilium lecanii* @5g/L was found effective with least infestation by thrips on fruits (11.78%) followed by acephate 75SP with 12.64% as compared to *Beauveria bassiana* @5g/L (16.09%) and *Metarhizium anisopliae* @ 5g/L (16.72%) where the latter two treatments were on par with each other and maximum infestation was recorded in control with 24.83% fruits infested. Though *Beauveria bassiana* produced higher fruit of 9.62t/h) but it was on par with T2 *(Metarhizium anisopliae* - 6.48t/ha) and T3 *Lecanicilium lecanii* (NBAIR Strain) (6.09t/ha) and lower yield was noticed in control (3.82t/ha)

4.8.6.5. Evaluation of different isolates of entomopathogenic fungi against citrus Rust and Green mites

CRS Tirupati

Among the three entomopathogens evaluated, *Beauveria bassiana* @5g/L (T1) was found effective with lower infestation by rust mites on fruits (19.46%) while least infestation was recorded in propargite 57EC with 13.44% whereas with respect to green mites infestation on fruits, *Lecanicilium lecanii* @5g/L (15.49%) showed lowest damage followed by T2 *(Metarhizium anisopliae* and maximum damage was noticed in control (31.59%). The yield data showed that though T1 produced higher yield of 10.67t/ha but it was on par with T2 and minimum yield was recorded in control (4.37t/ha).

4.8.6.6. Bio-intensive management of litchi fruit borer, *Conopomorpha sinensis* in litchi

PAU

BIPM practices involving ploughing in orchard during March-April, clean cultivation, regular collection and destruction of fallen infested fruits during May-June and releases of *T. embryophagum* @ 4000 parasitized eggs per tree 6 times at 7-10 days interval starting from flower initiation to colour break stage were significantly better in reducing the fruit borer damage (19.40 %) as compared to farmer's practice (26.80 %) and untreated control (60.60 %). The yield was also significantly more in BIPM (60.70 q/acre) as against farmer's practice (56.59 q/acre). However, lowest yield was recorded in untreated control (26.21 q/acre).

4.8.7. Biological suppression of pests of temperate fruit crops

4.8.7.1. Field evaluation of some bio pesticides against green apple aphid, *Aphis pomi* and mites infesting apple in Kashmir

SKAUST Srinagar

Average density of aphids / terminal shoot after three weekly treatments during June' 2021, was found considerably low (5.13) in case of Neem oil (Azadirachtin 10000 ppm @ 2.0 ml^{-1}) and was found statistically different from other bio pesticides used.

Two spotted spider mite: Similar treatments, except use of Fenazaquin 40 EC @ 0.4 ml^{-l} in place of dimethoate 30 EC also indicated efficacy of Neem oil (Azadirachtin 10000 ppm) as superior over other bio pesticides with mean population of 5.17 leaf at the end of experiment and was statistically different from all other treatments. Nevertheless, all the bio pesticides proved effective against two spotted spider mite. Neem oil also showed maximum percent reduction over pre treatment (77.14) as well as percent reduction over control (76.10).

4.8.7.2. Organic management of woolly apple aphid, *Eriosoma lanigerum* infesting apple in high density and traditional orchards

SKAUST Srinagar

After three sprays of treatments, aphid density declined from 1st to 3rd week and ranging 2.26 – 60.73. Among bio pesticides, Neem oil (Azadirachtin 10000 ppm) @ 2.0 ml^{-l} proved best in checking the WAA population up to $17.73^{-colony}$ and was statistically identical with Neem oil (Azadirachtin 10000 ppm) @ 1.0 ml^{-l} (35.66) and *M. anisopliae*@ 10. 0 ml^{-l} (44.86). Per cent reduction in aphid $density^{-colony}$ over pretreatment (88.06) and % reduction over control (87.75) was also found maximum in Neem oil (Azadirachtin 10000 ppm) @ 2.0 ml^{-l}.

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

YSPUH&F

The results revealed that chlorpyriphos (0.04%) was the most effective resulting in 100 per cent mortality of the pest. Among different biocontrol agents evaluated, *Heterorhabditis bacteriophora* (5000IJs/gallery) was the most effective resulting in 66.7 per cent mortality followed by *Heterorhabditi sbacteriophora* (2500 IJs/gallery) (60%), *Steinernemma feltiae* (5000IJs/gallery) and azadirachtin (2ml/L of 1500ppm; 10ml/gallery) (53.3% each). Other treatments resulted in 40 to 46.6 per cent pest mortality; in control no pest mortality was recorded.

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

SKAUST Kashmir

European red mite: As a result of two releases of anthocorid bugs @ 200 (T1) and 400 (T2) /plant during 2nd week of July' 2021, mean population of ERM$^{-\ leaf}$ after one week of treatment was recorded as 8.40 (T1), 6.06 (T2), 1.30 (T3, Fenazaquin) and 10.63 (T4, Untreated check). Per cent reduction in population of European red mite over untreated control was 21.21 and 42.89 per cent respectively.

Two spotted spider mite: The bug however was found more promising against two spotted spider mite than the ERM at similar treatments as mentioned above. Mean population of TSSM$^{-\ leaf}$ after one week of treatments was recorded as 3.23(T1, @ 200), 2.15(T2 @ 400), 1.16(T3, Fenazaquin) and 8.33 (T4, Untreated check) respectively. One spray of university recommended acaricide *i.e.*,Fenazaquin 40 EC @ 0.4 ml^{-l} however was found superior over all other treatments.

4.8.8. Biological suppression of pests in plantation crops

4.8.8.1. Efficacy of biorationals on the bio-suppression of rugose spiraling whitefly

CPCRI, regional station, Kayamkulam

Under good nutrition management, it was found that palms treated with neem oil (0.5%), water spray and *Isaria fumosorosea* could reduce the RSW population significantly ranging from 0.78 to 1.08 from the initial population of 1.51 to 3.01. Palms maintained under conservation biological control registered highest RSW population (1.51) after two-month of treatment. However, highest reduction of RSW population was recorded on neem oil treated palms followed by palms under conservation biological control and water spray. The least reduction was observed on palms exposed to *Isaria fumosorosea* (42.6%), whereas, neem oil treated palms registered highest pest reduction of 58.8%. Good health management practices are very much important in recouping palm health and thus to reduce the pest impact. After the receipt of monsoon showers all palms became free of pest infestation and BNW is overriding in certain leaflets.

ANGRAU

During 2021-22, Per cent reduction in whitefly intensity was observed high in T1- *Isaria* sprays + *Encarsia* release (56.35%) after two sprays than one spray (27.36%) due to parasitization by *Encarsia* released after first spraying of *Isaria* fungus and in T2 –*Isaria* sprays + *Dichocrysa* release (51.72%) after two sprays than one spray (24.38%) due to *Dichocrysa* predation released after first spraying of *Isaria* fungus. Reduction in whitefly intensity was low in T3 - Neem formulation 10000 ppm sprays (16.22%) after two sprays than one spray (7.32%).

DRYSRHU Ambajipeta

After two sprays at 15 days interval the incidence, along with lowest number of egg spirals (1.05 per leaflet) were recorded in neem oil 5% spray followed by *I. fumosorosea* (1.57 spirals per leaflet) treatments. The highest number (18.92) of parasitized nymphs (live & blackened) and nymphs with parasitoid emergence holes/leaflet was recorded in natural conservation of *E. guadeloupae* treatment.

KAU Thrissur

The treatments neem oil and water spray registered the lowest number of 3.32 and 4.23 colonies respectively, both being on par with each other. The entomopathogen *I. fumosorosea* recorded significantly higher number of 5.53 live colonies, which was on par with the value of 5.10 on untreated palms. Fourty five days after second spray, the highest number of parasitized colonies were observed in *I. fumosorosea* (12.53 no.), which was on par with untreated palms (10.10 no.). Water spray and neem oil had the lowest number of parasitized colonies at 6.47 and 8.09 respectively.

TNAU

Population of RSW nymphs was minimum (12.25Nos.) in the coconut trees sprayed with neem oil 0.5% followed by foliar application of *Isaria fumosorosea* (pfu-5) @ $1x10^8$ cfu/ml (13.33 nos.), Foliar water spray (15.25Nos.) and *Encarsia guadeloupae* (natural conservation) (18.13Nos.) on 15th day after 2nd spraying. Parasitised nymphs were significantly more in *Encarsia guadeloupae* (natural conservation) (37.09%) than in foliar application of *Isaria fumosorosea* (pfu-5) @ 1x10^{8} cfu/ml (26.24%), foliar application of neem oil 0.5% (24.84%) and foliar water spray (30.22%) on 15th day after 2nd spraying. There was reduction in nymphal population in *Encarsia guadeloupae* (natural conservation) (12.50Nos.) on 60th day after 2nd spraying, when compared with foliar application of *Isaria fumosorosea* (pfu-5) @ 1x10^{8} cfu/ml, foliar water spray and foliar application of neem oil 0.5%.

4.8.8.2. Biological suppression of Bondar's nesting whitefly in coconut

KAU Kumarakom

Efficacy of entomopathogenic fungi, *Isaria fumosorosea* (Pfu-5) @ 1x10^{8} cfu/ml and neem oil @ 0.5 % against nesting whitefly, *Paraleurodes bondari* was tested under field conditions. Significant low mean number of healthy nymphs per leaflet (3.48 and 2.95) were observed on palms sprayed with water at 10 and 50 days after spraying. At 50 days after spraying neem oil spray could also give significant reduction in healthy nymphs per leaflet. There was no significant difference in the number of healthy nymphs among the other three treatments.

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

DRYSRHU Ambajipeta

After 45 days of second treatment imposition, it was found that there was a significant reduction in the mean disease incidence 27.34% in the treatment spraying of *T. reesei* @ 2 $\times 10^{6}$ cfu/ml followed by spraying of copper oxychloride (3g/litre of water) (17.49 %) while there was an increase in mean disease incidence in control and soil application of 50g *T. reesei* along with 5 kg neem cake treatments.

4.8.8.3. Area-wide demonstration of biological suppression of black headed caterpillar (BHC) using *Goniozus nephantidis* and *Bracon brevicornis*

CPCRI: Regular monitoring on the incidence of black headed caterpillar, *Opisina arenosella* was undertaken at Kottayam, Alappuzha and Kasaragod districts of Kerala. To combat the pest incidence, pruning and destruction of infested frond sat lower whorls as well as timely augmentative release of *Goniozus nephantidis* and *Bracon brevicornis* @ 20 parasitoid/palm was undertaken during November 2019. Pest population was gradually reduced and in August 2021 it was found to be 0.8% with pest reduction exceeding 98%. This validates further the biological control success story in the bio-suppression of the black headed caterpillar using augmentative release of stage-specific parasitoids. Laboratory maintenance of parasitoids *viz*., *Goniozus nephantidis* and *Bracon brevicornis* was continued and these parasitoids were supplied to State Parasite Breeding Stations and farmers as per demand.

4.8.8.4. Converging biological suppression approaches for area-wide management of coconut rhinoceros beetle.

CPCRI

As part of "Convergence of bio-control technologies for area-wide management of coconut rhinoceros beetle", more than 200 kg of *Metarhizium majus* mass multiplied in semi-cooked rice was distributed to dairy farmers in Vallikunnam panchayat since April 2021. The application procedure of the entomopathogenic fungus on the breeding sites was demonstrated by ICAR-CPCRI Crop Protection Scientists through sensitization programmes covering all the wards in the village at a regular time period under the co-ordination of the Agricultural Officer/Dairy Society. The farmers were empowered on the technical know-how, famer-participatory technology dissemination as well as sustainable impact of the technology. A group of women farmers were also trained on the mass production of green muscardine fungus at farm level and inoculation in the breeding zones of the bio-village.

4.8.9. Biological suppression of pests in Vegetables

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

YSPUH&F

Bio-intensive Integrated Pest Management (BIPM) module, targeting mainly *Tuta absoluta,* comprised of pheromone trap (PCI), marigold as trap crop, six releases of *Trichogramma achaeae* @ 50000/ha, two sprays of azadirachtin 1500ppm @ 2ml/L, one spray of *Lecanicillium lecanii* (5g/L of 10^8 conidia/g). For comparison, chemical plots where the crop was sprayed with chlorantraniliprole 18.5EC and indoxacarb 14.5 EC alternatively at 15 days interval were also maintained. Seasonally the mine density remained nearly same in both the plots and varied from 0.24 to 0.41 mines per leaf in BIPM plots and 0.26 to 0.38 mines per leaf in chemical plots. Similarly, the fruit infestation in the two plots remained almost same throughout the season and varied from 2.18 to 3.19 per cent in BIPM plots and 1.59 to 4.43 per cent in chemical plots. The yield recorded in BIPM plots (33.8t/ha) was also statistically on par with that recorded in chemical treated plots (31.9t/ha). The incidence of *Helicoverpa armigera* remained very low throughout the cropping season.

4.8.9.2. Bio-intensive insect management in brinjal

AAU-A

The significantly lowest shoot damage was recorded in BIPM module (2.27 %) followed by chemical module (3.31 %). With regard to the data on fruit damage recorded on number and weight basis depicts the significantly lowest fruit damage in BIPM module (2.50 % on number basis, 3.24 % on weight basis) than the fruit damage recorded in chemical module (3.84 % on number basis, 4.81 % on weight basis). The BIPM module recorded the highest fruit yield of 374.31 q/ha and it was statistically at par with the yield recorded in chemical module (346.78 q/ha).

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

IIHR

Treatments *Heterorhabditis indica* @ 2.5 10^9 IJs ha^{-1} and*M. anisopliae*NBAIR followed by *B. bassiana* NBAIR and *B. bassiana* AAU strains. They were significantly different from the control check, but not superior over chemical control. Similarly, the leaf damage scoring by ash weevil in different treatments were recorded. The *B. bassiana* NBAIR and *M. anispoliae* AAU strains were showing significantly lower leaf damage scoring compared to other treatments.

4.8.9.4. Evaluation of biointensive IPM module against key pests of okra

AAU-Jorhat

In chemical control plot, six numbers of alternate spray of insecticides at fortnightly intervals contributed maximum protection from infestation of larvae per five plant and per cent fruit damage of 1.68 and 7.33 %, respectively as against 2.02 and 8.15 % in BIPM plot. However, highest marketable fruit yield of 76.49 q/ha was recorded in BIPM plot, whereas in chemical control plot, the yield was 69.10 q/ha. The per cent parasitisation on *Corcyra* sentinel cards by *Trichogrammatids* in BIPM plot was 9.4 per cent as against 1.7% in chemical control plot.

4.8.9.5. Efficacy biocontrol agents for management of fruit borer, *Earias vittella* on bhendi

IIVR

Amongst the tested biopesticides, treatment 4 *i.e.*, spraying of *Bacillus thuringiensis* @ 1 kg/ha was found most promising against okra fruit borer (*Earias vittella*) with maximum (70.07) per cent reduction over control (PROC). In case of okra jassids (*Amrasca biguttula biguttula*), spraying of *Metarhizium anisopliae* (NBAIR) 1×10^8 spores/ g @ 5 g/lit and Azadirachtin 1500 ppm @ 2 ml/lit were found superior with 45.69 and 39.52 PROC, respectively, over other biopesticides and untreated control. However, in case of whitefly (*Bemisia tabaci*), Azadirachtin 1500 ppm @ 2 ml/lit was found most effective followed by *Metarhizium anisopliae* (NBAIR) 1×10^8 spores/ g @ 5 g/lit.

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

AAU-Jorhat

Among the different biopesticides *L. lecanii* (V1-8 isolate) @ 5 ml/litre was the best treatment in reducing the mean population of aphid, *B. brassicae* (3.38/plant) and *P. xyllostella* (4.20/plant), with 65.51 and 56.92 per cent reduction over control followed by the next best treatment of ICAR- NBAIR strains of *B. bassiana* (Bb-45 isolate) with 65.31 and 50.46 per cent reduction over control of aphid (3.40/plant) and DBM (4.83/plant), respectively. In case of yield, maximum of 215.25 q/ha was obtained in *L. lecanii* (V1-8 isolate) treated plot. However, amongst the all treatments, four alternate sprays of chemical insecticides could significantly reduce the mean population of aphid (3.05/plant) and DBM (4.95/plant) in cabbage.

MPKV

The VI-8 isolates of *Lecanicillium leccanii* @ 5.00 gm/liter was superior in controlling aphid population (28.45 number of aphids/3 leaves/head) while Bb-5a isolate of *Beauveria bassiana* @ 5.00 gm/liter was superior with 0.91 larvae of diamond back moth/head and at par with Bb-45 isolate of *Beauveria bassiana* @ 5.00 gm/liter with 0.95 larvae of diamond back moth/head. Highest yield (149.98 q/ha) was recorded in the treatment Cynantraniliprol 10.26% OD while 129.59, 129.09 and 125.89 q/ha was recodered in VI-8 isolates of *Lecanicillium leccanii*, Bb-5a isolate of *Beauveria bassiana*, and Bb-45 isolate of *Beauveria bassiana*, respectively.

4.8.9.7. Influence of habitat manipulation on incidence and severity of pest damage in cabbage

AAU A

Intercropping of cabbage crop with mustard and cowpea has significant influence on incidence of aphid infesting cabbage. The treatment T_1 – cabbage intercropped with mustard and cowpea recorded the lowest aphid population (8.68/ plant) with highest coccinellids population (3.42/plant). Whereas, the lowest larval population of DBM was recorded in the treatment T_3 – cabbage intercropped with cowpea and oats as border crop (1.32/ plant), followed by the treatment T_1- cabbage intercropped with mustard and cowpea (2.92 /plant). The influence of intercrops and border crops in reducing the pest incidence was reflected in yield of the crop. The highest yield of 24.98 tonnes/ha was recorded in the treatment T_3- cabbage intercropped with cowpea and oats as border crop followed by the treatment T_1 – cabbage intercropped with mustard and cowpea (20.78 tonnes/ha). The lowest yield of cabbage was recorded in the treatment T_5 – cabbage as sole crop (9.45 tonnes/ha).

4.8.9.8. Management of hoppers, aphids and Whitefly on Okra by oil based formulation of *Metarhizium anisopliae* (IIHR Strain)

IIHR

All the entomopathogenic treatments are not statistically significant with each other. There was no significant difference observed among the treatments except chemical control. Among the entomopathogens treatment *Beauveria bassiana* (NBAIR Bb5a) @ 5g/L followed by *Lecanicilium lecanii* (NBAIR Vl8) @ 5g/L was found significant against thrips on capsicum under polyhouse conditions. But not significant reduction of thrips was observed.

4.8.9.9. Efficacy of capsule formulations of *Beauveria bassiana* in managing amaranthus leaf webber *Hymenia recurvalis*

KAU Vellayani

Seven days after second spraying all the treatments were effective in reducing the pest. Spraying *Beauveria bassiana* Bb (KAU) capsules @ 3ml/ L or its spore suspension 20 ml /L was the best treatment which was closely followed by the effect of capsules and spore suspension of Bb5 (NBAIR). Yield data recorded from the experimental plots revelaed that, there was a significant increase in yield in plots treated with capsulses of *B.bassiana* compared to the talc formulations and spore suspensions

4.8.9.10. Evaluation of BIPM against fruit flies *Deccaus bactrocera* sp. in cucumber

AAU-Jorhat

BIPM package revealed minimum per cent damaged fruits (16.18%) which were significantly different from chemical control where the per cent damaged fruit was 28.41% after 65 Days after treatment (DAT). The marketable fruit yield obtained in BIPM field was 86.46 q/ha as against 58.74 q/ha in conventional package. The maximum damaged fruits (35.20 %) caused by *Deccaus bactrocera* was recorded in untreated control plot with minimum yield of 44.96 q/ha.

4.8.9.11. Management of *Fusarium* wilts in vegetable cowpea using microbial agents

COA Vellayani

Results revealed that seed treatment with *P. flourescence* (KAU strain) followed by fortnightly soil drenching and foliar spraying with *P. flourescence* (T1); combined application of *P. fluorescence* (fortnightly) + *Trichoderma* sp. as basal (T3) as well as need based CoC (T4) are equally good in managing fusarium wilt in cowpea. None of the plants show wilting symptom in these plots. The yield recorded was highest *P. flourescence* treated plots and lowest in untreated plots

4.8.9.12. Efficacy of different biocontrol agents against onion thrips, *Thrips tabaci* L.

AAU-Anand

Among different bio-pesticides/biocontrol agents evaluated, T_3 – *Metarhizium anisopliae* AAU strain Ma1 (2.36 thrips/plant) was the first effective treatment with lowest number of thrips/plant followed by T_6 – Azadirachtin10000 ppm (2.63 thrips/ plant). The untreated control treatment recorded the highest thrips population of 12.24 thrips/ plant.

4.8.9.13. Evaluation of BIPM against fruit flies *Zeugodacus cucurbitae* against bitter gourd

IIVR

Lowest fruit fly damage (7.46%) was recorded in Module 1 comprising good agricultural practices like raking the soil and removal of weeds, installation of cue lure traps @ 15/ha for monitoring, collection and destruction of damaged fruits; spraying of neem based insecticides (Azadirachtin 300 ppm @ 5 ml/lit of water) and spraying of Spinosad 45 SC @ 0.3 ml/lit followed by module 2 (16.67%) i.e., conventional practice with Jaggary 1% + Malathion 50 EC @ 2 ml per litre of water. Interestingly, module 1 also recorded lowest whitefly (0.74/leaf), jassid (0.59/leaf), cucumber moth (3.35 larvae/plant) whereas maximum fruit damage (23.45%) by *Z. cucurbitae* was observed in untreated control plots.

4.8.9.14. Field evaluation of ICAR-NBAIR strains of entomopathogenic fungi against cowpea aphid (*Aphis craccivora*)

KAU Thrissur

Five days after the first spray, imidacloprid, with a mean number of 7.50 aphids, was significantly superior to the remaining treatments (*Beauveria bassiana*, *Metarhizium anisopliae* and *Lecanicillium lecanii*) which were on par with each other as well as untreated control.

MPKV Pune

The post count pooled data of two sprays showed that the treatment T4: Imidacloprid 17.8 SL significantly suppressed the population of cowpea aphids (18.80 aphids /3 leaves) over rest of the treatments. The treatment T3: Vl-8 isolate of *Lecanicillium lecanii* @ 1×10^8 cfu/ml @ 5.00 gm/ liter was second superior with 29.84 aphids/3 leaves. Highest mean populations of aphids (54.17 aphids/3 leaves) were recorded in untreated control. The significant highest yield was recorded from the treatment Imidacloprid 17.8 SL @ 0.40 ml/l of water (13.76 q/ha) which was followed by 12.58 q /ha in the treatment, Vl-8 isolate of *Lecanicillium lecanii* @ 1×10^8 cfu/ml @ 5.00 gm per litre.

4.8.9.15. 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 during 2021-22

UAS Raichur

Highest per cent reduction of thrips population over control was noticed in *L. leccani* @ 1×10^8 (ICAR-NBAIR-VL-15) @ 5.0 g/l (69.65 %) followed by *I. fumosorosea* (ICAR-NBAIR strain) @ 1×10^8 @ 5.0 g/l (67.50 %). Per cent reduction of mite population over control was highest in *L. leccani* (ICAR-NBAIR-VL-15) (67.77 %) and it was at par with *I. fumosorosea* (ICAR-NBAIR strain) (64.17%). Highest fruit yield of 25.28 q/ha was noticed in *L. leccani* and it was at par with *I. fumosorosea* which recorded 24.62 q/ha while untreated control recorded lowest fruit yield of 16.04 q/ha.

4.8.10. Biological suppression of oilseed crop pests

4.8.10.1. Field evaluation of bio-pesticides against mustard aphid

UBKV

Imidacloprid 17.8 SL @ 0.4ml/lit was found to be the best treatment resulting the lowest number of aphids per shoot (2.17 aphid per at 15DAS). Among the selected bio-pesticides, Azadirachtin 3000 ppm @ 2.5 ml/lit treated plots showed the lowest number of aphids per shoot followed by *Beauveria bassiana.*

4.8.10.2. Evaluation of locally isolated potential entomopathogenic fungi, *Metarhizium rileyi (KK-Nr-1)* against groundnut leaf miner and tobacco caterpillar in ground nut ecosystem during 2021-22

UAS Raichur

Among the biocontrol agents highest per cent reduction of leafminer over control was noticed in *M. rileyi* (KK-Nr-1) @ 1×10^8 spores/ml (5g/L) which recorded 69.57 per cent and it was at par with *M. rileyi* @ 1×10^8 @ 5 gm/l (UAS- Dharwad) which recorded 68.64 per cent. The highest per cent reduction of *Spodoptera* population was noticed in *M. rileyi* (KK-Nr-1) @

1×10^8 spores/ml (5g/L) (67.45 %) and at par with *M. rileyi* @ 1×10^8 @ 5 gm/l (UAS- Dharwad) 63.75 %). Among the biocontrol agents highest pod and halum yield of 24.68 q/ha and 33.52 q/ha was noticed in *M. rileyi* (KK-Nr-1) @ 1×10^8 spores/ml (5g/L) which was at par with *M. rileyi* @ 1×10^8 @ 5 gm/l (UAS- Dharwad) which recorded 22.54 q/ha and 30.84 q/ha pod and halum yield.

4.8.11. Biological suppression of polyhouse and flower crop pests

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

KAU Thrissur

Nine days after treatment, both acaricide (0.04 mites / cm^2) and *B. pallescens* @ 20 m/row plots (0.32 mites / cm^2) recorded the lowest count of mites and they were on par with each other. Difference was also observed in terms of yield per plant. *B. pallescens* released @ 20 /m row recorded the highest mean yield of 2.73 kg per plant, followed by acaricide treated plot at 2.70 kg/plant, both being on par with each other.

4.8.11. 2. Evaluation of biocontrol agents for the control of sucking pests in capsicum under polyhouse

IIHR

All the entomopathogenictreatments are not statistically significant with each other. There was no significant difference observed among the treatments except chemical control. Among the entomopathogens treatment *Beauveria bassiana* (NBAIR Bb5a) @ 5g/L followed by *Lecanicilium lecanii* (NBAIR Vl8) @ 5g/L was significant efficacy against thrips on capsicum under polyhouse conditions. But not significant reduction of thrips was observed.

4.8.11. 3. Management of phytophagous mites on cucumber using *Blaptostethus pallescens* and *Neoseiulus longispinosus* under polyhouse condition

YSPUH&F

After 14 days of the second treatment, the mite population was the lowest in spiromesifen (100g a.i./ha) treated plants, however, the mite population was on par in plants where *N. longispinosus* (1:20), *N. longispinosus* (1:30) or *B. pallescens* (20 nymphs/m row) was released. The highest yield (6.8kg/plant) was recorded in plants treated with spiromesifen (100g a.i./ha) followed by *N. longispinosus* (1:20) (5.5kg/plant), *N. longispinosus* (1:30) (4.6Kg/plant), *B. pallescens* (20nymphs/m row) (3.9Kg/plant) and *B. pallescens* (10nymphs/m row) (3.4Kg/plant). In untreated control plants the yield was 2.0Kg/plant.

4.8.12. Large scale adoption of proven biocontrol technologies

4.8.12.1. Rice

GBPUAT

Large scale field demonstrations of bio-control were conducted at the end of 135 farmers of 25 villages of District Nainital and U S nagar, covering an area of 200 ha. The farmer's acreage ranged was from 0.2 – 7.0 ha. Twelve quintals PBAT-3 (*Trichoderma harzianum*Th14 + *Pseudomonas fluorescens* Psf 173) was distributed to the farmers to conduct to popularize use of biocontrol agents in place of chemical pesticides amongst farmers. Polysheet (2x10m to each farmer) was distributed for nursery soil solarization. Neem oil was distributed for the control of stem borer in rice. Pheramone traps were placed @ 20/ha to control rice stem borer. A total of twenty five visits at different locations were made to provide inputs, technical knowledge and collection of data.

AAU-Jorhat

The per cent dead heart and damaged leaf caused by *Scirpophaga* sp and *Cnaphalocrocis* sp. were 3.85 and 2.45 in BIPM package as against 4.26 and 2.72 in farmer's practice after 60 DAT, respectively. In case of WEH, the per cent incidence was 3.15 in BIPM plots which were slightly higher than farmer's practice plots (3.12) at 100 DAT without any significant difference in between the treatments. Maximum yield of 4963.5 Kg/ha was registered in BIPM plots which was significantly higher compared to farmer's practice plot with 4637.5 Kg/ha. Minimum yield of 3357.10 Kg/ha was recorded in Untreated control plot. The net returns over control in BIPM package were Rs. 61291.90 as compared to Rs. 49967.50 in farmers practice plot with cost: benefit ratio of 1:1.751 and 1:1.249, respectively.

IIRR

The demonstrations were taken up in Manchal, Ibrahimpatnam, Rangareddy, Telangana. The results indicated there was reduction in the incidence of stem borer (0.2 to 20 %), sheath blight (20 to 36%) and bacterial leaf blight (18 to 35%). The white ear damage by stem borers ranged from 6.41 % in BIPM 2 to 10.31 % in *Psuedomonas* treated plots. Overall the farmer was able get increased returns (28 to 35%) due to reduced pesticide (insecticide and fungicide) applications and increase in the yields.

KAU Thrissur

Large scale validation of BIPM in rice was carried out over a total area of 240 ha with 220 ha in Alathur grama panchayat in Palakkad and 20 ha in Thekkinkara panchayat in Thrissur district from November 2021 to March 2022. The dead heart as well as white ear head symptoms in BIPM plots was approximately 50 per cent lower than in non BIPM plots. Similarly, leaf folder damage was approximately 75 per cent lower than in conventionally managed plots. The yield obtained from BIPM plots, at 8340 kg/ha was approximately 27 per cent more than that obtained from non BIPM plots (6100 kg/ha). The cost of cultivation also was nearly three per cent lower in the former. The increased yield as well as reduced cost resulted in an increase in profit by Rs. 65245/ha. The cost benefit ratio, at 1.80 for BIPM fields compared quite favorably with 0.99 for non BIPM fields.

OUAT

Large scale demonstration was carried over 5 ha area. The dead heart (DH), white ear head (WEH) and leaf folder (LF), incidence in BIPM demonstrated plots were 4.00, 3.04 and 4.10%, respectively as compared to 3.60, 2.40 and 3.45% infestation in farmers practice (FP) with the use of chemical pesticides. Significantly higher DH (8.80%), WEH (9.00%) and LF

(10.32%) infestation was noticed in untreated control. Highest yield (39.71q/ha) was recorded in FP. But the yield (38.47 q/ha) in BIPM package was at par with FP. Lowest yield (30.96 q/ha) was recorded in untreated control. The benefit cost ratio in BIPM treated plots was found (1.35) as against 1.39 in FP and 1.13 and untreated control, respectively.

PAU

Large scale demonstrations of biocontrol based IPM (mechanical control by passing the 20-30 m long coir/jute rope before flowering, forwards and then backwards, both ways while touching the crop canopy for leaf folder and 5-6 releases of *T. chilonis* and *T. japonicum* each @ 1,00,000 parasitoids/ha) conducted at famers' fields in Ludhiana, Amritsar, Patiala, Gurdaspur, Jalandhar and Faridkot districts in organic *basmati* rice over an area of 347 acres rendered lower incidence of dead hearts in biocontrol fields (1.78 %) as against untreated control (3.89 %) resulting in a reduction of 54.34 per cent. Similarly, leaf folder damage in release field was significantly lower in biocontrol fields (2.42 %) as compared to untreated control (6.18 %) with a mean reduction of 60.48 per cent. The mean incidence of white ears was significantly lower in biocontrol field (2.66 %) as against untreated control (5.20 %) resulting in a reduction of 48.85 per cent. The additional benefit in biocontrol practices was Rs 7580/- per ha over untreated control.

4.8.12.2. Chickpea

UAS Raichur

One day before spray, larval population ranged from 4.50 to 5.25 per plant. Ten days after spray lowest of 0.45 larva per plant was noticed in FP followed by HaNPV (2.12 larvae/plant). FP recorded lowest pod damage (5.04 %) followed by HaNPV (15.52 %). Highest grain yield of 16.25 q/ha was recorded in FP followed by HaNPV (14.54 q/ha) while untreated control recorded 10.58 q/ha.

4.8.12.3. Cotton

TNAU

Large scale demonstration was carried over 10 acre area. In BIPM module pink bollworm incidence bad open boll was 22.00 per cent while it was 32 per cent in control. The yield increase in BIPM plots was 20.00 per cent over control plots.

4.8.12.4. Okra

AAU-Anand

Between the two modules demonstrated for pest management in okra, significantly the lowest *E. vittella* larval population was recorded in BIPM module (1.11/ plant) as compared to the chemical module (2.89/plant). The population of *H. armigera* recorded in BIPM module (2.63/ plant) and chemical module (4.47/plant) found non-significant. The lowest population of jassid was documented in chemical module (2.26/ leaf) which as statistically at par with the population recorded in BIPM module (3.34/ leaf) and in case of whitefly BIPM module witnessed significantly lowest whitefly population (2.19/leaf) as compared to chemical module (4.21/leaf). The BIPM module has witnessed significantly the highest population of coccinellids (2.60/ plant). The fruit damage was significantly lower in BIPM module (3.50 % - number basis, 3.16 %– weight basis) as compared to chemical module (4.65 % - number basis, 4.02 %– weight basis). The BIPM module recorded the significantly higher yield (127.82 q/ha) as compared to chemical module (117.26 q/ha). This result demonstrates the successful bio-intensive module, which helps in reducing the pest incidence in okra crop with higher yield.

4.8.12.5. Tomato

GBPUAT

Field demonstrations were laid at 68 farmer's field at Golapar area of district Nainital covering an area of 25 ha. Fifteen quintals PBAT-3 (*Trichoderma harzianum*Th14 + *Pseudomonas fluorescens* Psf 173) was distributed to the farmers for soil, seed, root dip treatment and foliar spray through biocontrol agents to counter soil borne diseases. An average yield of 70.0 q/ha was recorded with bio-control technologies as compared to 55.0 q/ha with conventional farmers practices.

MPUAT

No significant difference was observed between BIPM package and chemical control with regard to the parameters *viz*., number of *H. armigera* larvae/plant and fruit damage. BIPM package was equally effective as chemical control against *H. armigera*. Chemical control module recorded the highest yield (13.75 t/ha) which was at par with the yield recorded in BIPM package (12.10 t/ha). Significantly, low yield was recorded in untreated control (7.92 t/ha). It could be concluded that BIPM package had promising results in minimizing the pest damage with higher yield.

4.8.12.6. Cabbage

AAU-Anand

Between the two modules demonstrated for bio-intensive pest management in cabbage, the lowest larval population of diamond back moth was recorded in BIPM module (2.09/plant) as compared to chemical module (3.03/plant). With regard to aphid population, the BIPM module recorded significantly lowest population (13.64/plant) than chemical module (17.65/plant). With respect to the population of natural enemies, BIPM module witnessed highest coccinellids population (2.53/ plant) which was significantly higher than the population observed in chemical module (0.69/plant). Further, BIPM module recorded the significantly lowest fruit damage (3.09 %) as compared to chemical module (4.41 %). Due to significant low fruit damage in BIPM module, highest yield (29.63 t/ha) was recorded and it was statistically at par with the yield documented in chemical module (23.50 t/ha).

4.8.12.7. Coconut

TNAU

Large scale demonstration was carried over 25 acre area. BIPM module *ie., Encarsia guadeloupae* natural conservation + Release of *Apertochyrsa astur* eggs @1000/ha + Yellow sticky traps @20/ha was demonstrated in Chinnappampalayam, Anaimalai Block, Coimbatore

Dt. In BIPM field, there was 80 per cent reduction in the population of Rugose spiralling whiteflies (RSW) while in control plot there was 60 per cent reduction in RSW population. Similar trend was observed in the population of Bondars Nesting Whiteflies also.

4.8.12.8. Maize

MPUAT

The demonstrations on the releases of *Trichogramma chilonis* against *Chilo partellus* were conducted at farmer's fields in an area covering 10 hectares in Udaipur district of Rajasthan. The dead heart incidence in fields with the releases of *T. chilonis* was 13.42 per cent and in chemical control, it was 10.12 per cent. The reduction in incidence over control was 44.95 and 58.49 per cent in T_1 and T_2, respectively. The yield in *T. chilonis* (T_1) (29.10q/ha) and Spinosad 45 SC (T_2) (32.45 q/ha) fields were significantly more than in untreated control (22.70 q/ha).

PAU

The demonstrations on the biological control of maize stem borer, *Chilo partellus* using *T. chilonis* were carried out at farmer's fields on an area of 5 acres in collaboration with KVKs in Hoshiarpur, Kapurthala, Roop Nagar and Gurdaspur districts of Punjab. Two releases of *T. chilonis* @ 1,00,000/ ha at 10 and 17 days old crop resulted in 56.67 per cent reduction in dead hearts incidence over control as compared to 85.25 in chemical control. The additional benefit over untreated control in biocontrol package was Rs 6530/- per ha as compared to Rs 12885/- per ha in chemical control

4.8.12.9. Apple

YSPUHF

A large scale demonstration on the management of apple root borer, *Dorysthenes hugelii* by using *Metarhizium anisopliae* was laid in 11 apple (cv Royal Delicious) orchards in Shimla, and Kinnaur districts covering an area of 5h (Table 4). *Metarhizium anisopliae* (10^8 conidia/g) was applied @ 30g/ tree basin mixed in well rotten farm yard manure (FYM). Chemical treatment comprising of chlorpyriphos (0.06%) was also maintained for comparison.

Metarhizium anisopliae treatment resulted in 69.6 per cent mortality of the apple root borer grubs in different orchards, while in chlorpyriphos (0.06%) treated plants the grub mortality was 79.7 per cent. Farmers saved about Rs 12000/- per hectare by avoiding/reducing pesticide applications.

4.8.12.10. Mango

AAU Anand

The large-scale demonstration of bio-intensive management of mango hopper had taken at five locations (Location 1 -, Pinsad, Navsari district, Location 2 – Talala, Dist. SasanGir, Location 3 - Kharad, Surat district, Location 4 - Dhrangadhra, Surendranagar district and Location 5 - Nakhatrana, Kutch district). The BIPM module comprising microbial biopesticide *Metarhizium anisopliae* was found effective in reducing the mango hopper population. The significantly lower population was recorded in BIPM module in the location 1 (7.62/twig), location 2 (5.26/twig) and location 3 (5.16/twig), whereas the population recorded in the location 4and 5were statistically at par with population recorded in chemical module. The results of the large-scale demonstration clearly highlight the successful biointensive management of mango hopper with microbial biopesticide *Metarhizium anisopliae* (NBAIR Ma-4) 1% WP.

4.8.12.11. Sugarcane

OUAT

Demonstration was carried over 5 ha area. Release of *T. chilonis* and *T. japonicum* were carried out as per treatment schedule and compared with farmers practice and untreated control. Maximum infestation due to ESB, and TSB in BIPM package were 10.86% and 2.04% as against 11.20% and 2.10% in FP indicating comparable level of infestation. But, much higher levels of infestation due to ESB (11.08%) and TSB (2.20%) were recorded in untreated control in pre release condition. Both the BIPM package and FP were at par in Post release observations. Highest cane yield (78.94 t/ha) and B: C ratio (1.68) were recorded in BIPM package which is comparable to FP(73.80 t/ha) with B: C ratio (1.61). Lowest yield (58.22 t/ha) and B: C ratio (1.38) were noted in untreated control.

PAU

Large-scale demonstrations on the effectiveness of *Trichogramma chilonis* @ 50,000 per ha at 10 days interval during July to October, 2019 (10-12 releases) over an area of 5989 acres conducted at farmers' fields in collaboration with Krishi Vigyan Kendras (KVKs), Regional Station (Gurdaspur) and four sugar mills of the state reduced the incidence of stalk borer, *Chilo auricilius* by 56.21 per cent over untreated control with higher additional returns of Rs. 19774/- per ha.

Large-scale demonstrations on the effectiveness of *T. chilonis* @ 50,000 per ha at 10 days interval during mid - April to June, 2019 (eight releases) over an area 839 acres conducted against early shoot borer, *C. infuscatellus* at farmers' fields in collaboration with Krishi Vigyan Kendras (KVKs) and Regional Station (Gurdaspur) Hoshiarpur, Jalandhar, Gurdaspur, Patiala, Kapurthala and Muktsar districts reduced its incidence by 55.0 per cent as against 81.79 per cent in chemical control (chlorantraniliprole 18.5 SC @ 375 ml/ ha). However, the cost: benefit ratio (1: 19.23) was higher in biocontrol as compared to chemical control (1: 10.51).

Large-scale demonstrations on effectiveness of *T. japonicum* against top borer, *Scirpophaga excerptalis* carried out at farmer's fields over an area of 460 acres in collaboration with KVKs in Hoshiarpur, Jalandhar, Patiala, Kapurthala and Muktsar districts reduced its incidence by 52.40 per cent as compared to 80.82 per cent in chemical control (chlorantraniliprole 0.4 GR @ 25 kg/ha). The cost benefit ratio was higher in biocontrol (1: 18.08) as against chemical control (1: 12.47)

UAS Raichur

Two months after treatment imposition minimum of 1.51 per cent dead hearts were noticed in farmers practice which was followed by release of *T. chilonis* (TTS) recorded 2.75 per cent while untreated control recorded 12.50 per cent dead hearts. The highest cane yield of 121.75 t/ha was recorded in farmers practice and it was followed by *T. chilonis* (TTS) release plot 118.50 t/ha while untreated control recorded 105.50 t/ha.

MPKV

The results of shoot borer infestation indicated that six releases of *T. chilonis* TTS @ 50,000 parasitoids/ha at 10 days interval starting from 40 days after emergence of shoots found significantly superior to untreated control in reducing the ESB infestation (from 15.90 to 8.01 % dead hearts) and cane yield 144.37 MT/ha.

4.8.12.12. Soybean

UAS Raichur

Ten days after spray, *M. rileyi* (KK-*Nr-1*)1×10^8 spores/g @ 5.0 g/l recorded 1.84 larvae per mrl while in untreated control it was 7.38 larvae per meter row length. *M. rileyi (*KK-*Nr-1)*1×10^8 spores/g @ 5.0 g/l recorded 7.26 per cent foliage damage while untreated control recorded 25.75 per cent. *M. rileyi* (KK-*Nr-1*)1×10^8 spores/g @ 5.0 g/l recorded 16.50 q/ha grain yield which was superior over untreated control which recorded 12.50 q/ha grain yield.

4.8.12.13. Pea

GBPUAT

Large scale field demonstrations of bio-control technologies on pea were conducted at 65 different farmers of district Nainital covering an area of 25 ha. Four quintals PBAT-3 (*Trichoderma harzianum*Th14 + *Pseudomonas fluorescens* Psf 173) was distributed to the farmers for seed treatment through biocontrol agents to counter soil borne diseases. An average green pod yield of 85.0 q/ha was recorded with bio-control technologies as compared to 58.0 q/ha with conventional farmers practices.

4.9. Tribal Sub plan programme (TSP)

AAU-Anand

In the year 2021-22, Fifty tribal farmers were selected from different villages of Dediapada taluka of Narmada district and twenty five farmers from different villages of Dahod district were selected. In association with Krishi Vigyan Kendra (KVK), Dediapada, Navsari Agricultural University, khedutshibir and training programme was organized in the month of

October 2021 and February 2022. Further, in association with KVK, Dahod, Anand Agricultural University, Anand khedutshibir and training programme was organized in the month of March 2022 to train the farmers on use of biocontrol inputs and strategies to tackle key pests and diseases to achieve sustainable crop production. Biocontrol inputs were distributed to the farmers. Significant reduction (25-30%) in use of chemical pesticides was documented with the use of bio-inputs provided.

AAU-Jorhat

A total of 350 farmers from (Baghmora, Charighoria, Kasreng Chapori, Sadiyal and Na-chelauria have been selected under the programme and provided with trainings and materials viz. Japi, Biopesticides, water cane, neem oil, Falcon kit etc.

ANGRAU

150 Tribal farmers of Arakuvalley division, Visakhapatnam district, Andhra Pradesh were selected. Exposure visit for creating awareness on Biological control agents and Biopesticides for 40 tribal farmers practicing Biointensive pest management in rice, turmeric, ginger and vegetables from Kollaput, Kothavalasa, Demudulavalsa, Killoguda, Dumbrigudamandal, Arakuvalley division, Visakhapatnam district and felicitated one tribal farmer for adopting and promoting biological control in rice organic cultivation at RARS, Anakapalle.

YSPUH&F

160 farmers from Tandi, Udaipur, Poorbani and Roghi from Himachal Pradesh were provided training and inputs like yellow sticky traps, neem baan, Trichoderma, Pseudomonas etc. were distributed.

IGKV

Three tribal centres (Ambagarh Chowki (Rajnandgaon), Kondagaon and Jagdalpur (Bastar)) were selected. Live demonstrations of the various bioagents such as, Trichocards, Bracocards, reduviid bigs, Coccinellid beetles and *Zygogramma* beetles were conducted and 253 farmers were benefitted.

OUAT

TSP programme also conducted in tribal village of Dhenkanala district where trichocards were distributed among farmers for sugarcane crop and One booklet also released on sugarcane bio agents

UBKV

Under TSP programme, total five training programmes were conducted. Among these, three training programmes were conducted in Nurpur and Baniagaon villages under GP Shamuktala, Dist. Alipurduar-II. Here, total 120 tribal farmers (40 farmers at each training programme) were involved. On the other hand, total 88 tribal farmers were present in the two training programmes at Singimari village of Coochbehar district. Distribution of mustard seed, *Trichoderma viridae*, neem oil, litchi saplings were done at the training programmes in Nurpur villages. Whereas in Baniagaon and Singimari, Trichocards, neem oils and fruit fly traps were handed over to the beneficiaries. The objective of both the training programmes and input distribution was to make the farmers aware as well as to make them interested about the different aspects of biological control.

UAS Raichur

Thirty six farmers from Buddinni, Sirwar taluk, Raichur were provided with various inputs including seeds and bio-inputs were distributed to farmers and they were trained about integrated crop management in Rabi crops. Training programme on integrated pest management in chickpea was also organised to train these farmers about pest management using bio-inputs and agronomic practices for enhancing crop production.

5. Publications

During the year 2021-22, a total of 274 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	21	15	28	64
AAU, Anand	4	2	39	45
AAU, Jorhat	1	-	8	9
ANGRAU	2	3	10	15
KAU, Thrissur	3	-	-	3
KAU, Vellayani	2	-	2	4
KAU, Kumarakom	1	-	-	1
MPUAT, Udaipur	3	-	-	3
PAU, Ludhiana	6	1	2	9
UAS Raichur	1	-	3	4
TNAU, Coimbatore	6	-	1	7
SKUAST, Srinagar	5	-	1	6
SKAUST Jammu	5	-	13	18

DRYSRUH	1	3	5	9
YSPUHF, Solan	7	4	-	11
IGKV	14	-	3	17
CPCRI	5	7	10	22
UBKV	3	-	2	5
PJTSAU	4	-	1	5
GBPUAT	6	3	8	17
Total	100	38	136	274

6. Profile of experiments and demonstrations carried out during 2021-22

Crop/Insect	**Experiments**	**Large Scale Demonstrations**
Biodiversity of biocontrol agents	7	-
Antagonists of crop disease management	20	1
Sugarcane	4	3
Cotton	4	-
Rice	5	3
Cereals	6	3
Plantation crops	3	-
Pulses	12	1

Oilseeds	2	-
Tropical and temperate fruits	11	1
Vegetables	14	1
Polyhouse crops	3	-
TSP	10	-
Total	101	13

7. Budget of AICRP on Bio control for 2021-22

Details of Expenditure	Sanctioned and allotted grants (Rs. In lakhs)	Grants released during 2021-22 from ICAR (Rs. In lakhs)	Total expenditure
Pay and allowances	217.08	217.08	217.08
Capital	6.10	6.10	6.10
Recurring contingency	429.67	429.67	429.67
TA	25.33	25.33	25.33
Total	678.18	678.18	678.18

8. Experiments conducted by centres

Experiment allotted	Centres identified	Centres conducted the experiment
Biodiversity of biocontrol agents from various agro-ecological zones	All Centres	All Centres
Surveillance for pest outbreak and alien invasive pests	All Centres	All Centres
Evaluation of fungal and bacterial isolates for crop health management in rice	GBPUA&T	GBPUA&T
The bio-control efficacy of identified biocontrol agents towards rice sheath blight (*Rhizoctonia solani*) disease under potted plants	ICAR-NRRI, Cuttack	ICAR-NRRI, Cuttack
Management of major diseases of rice with *Bacillus subtilis*	TNAU, Coimbatore	TNAU, Coimbatore
Field evaluation of ICAR-NBAIR antagonistic organisms against wheat yellow rust (*Puccinia striiformis* f. sp. *tritici*)	SKUAST, Jammu	SKUAST, Jammu
Field evaluation of ICAR-NBAIR antagonistic organisms against Maize Turcicum leaf blight (*Exserohilum turcicum*)	SKUAST, Jammu	SKUAST, Jammu
Demonstration of *Trichoderma* sp. for the management of *Fusarium* wilt in pigeon pea	AAU, Anand	AAU, Anand
Title : Management of Fusarium wilt in vegetable cowpea using microbial agents	KAU, vellayani	KAU, Vellayani

Evaluation of bio-agent consortium in glasshouse (pot experiments) and in field for crop health management in chickpea	GBPUAT, Pantnagar	GBPUAT, Pantnagar
Field evaluation of ICAR-NBAIR antagonistic organisms against Chickpea Fusarium wilt (*Fusarium oxysporum* f. sp. *ciceris)*	SKUAST, Jammu	SKUAST, Jammu
Field evaluation of ICAR-NBAIR antagonistic organisms against Mustard White rust (*Albugo candida)*	SKUAST, Jammu	SKUAST, Jammu
Ecofriendly management of stem rot, *Macrophomina phaseolina* in sesame using biocontrol agents	ANGRAU at RARS, Anakapalle	ANGRAU at RARS, Anakapalle
Evaluation of bio-agents against root-knot nematode and Fusarium wilt complex in guava under controlled conditions	CISH, Lucknow	CISH, Lucknow
Evaluation of microbial antagonists for the management of foot rot of citrus (kinnow) caused by Phytophthora spp.	PAU, Ludhiana	PAU, Ludhiana
Management of Powdery mildew (*Uncinula necator*) of Grape by using biocontrol agents	MPKV, Pune	MPKV, Pune
Bio-efficacy of different bio-agents against the early blight of tomato	AAU, Anand	AAU, Anand
Screening of promising isolates antagonistic fungi and bacteria against bacterial wilt of Tomato (*Ralstonia solanacearum*)	RARS, kumarakom	RARS, Kumarakom

Bio-efficacy of different bio-agents against the early blight of potato	AAU, Anand	AAU, Anand
Field evaluation of ICAR-NBAIR antagonistic organisms against Pea Rust (Uromyces fabae)	SKUAST, Jammu	SKUAST, Jammu
Management of Fusarium wilt/ root rot of pea through biological control agents	Dr YS PUHF, Solan	Dr YS PUHF, Solan
Efficacy of Mechanized sett treatment with antagonistic microbes, fungicide and their integration against red rot in sugarcane	SBI, Coimbatore	SBI, Coimbatore
In vivo evaluation of effective bio control agents against Phytophthora Pod rot management in cocoa	DRYSRHU, AMBAJIPETA, A.P	DRYSRHU, AMBAJIPETA, A.P
Management of *Phytophthora* disease in black pepper nursery using biocontrol agents	KAU, Thrissur	KAU, Thrissur
Field evaluation of ICAR-NBAIR entomopathogenic strains against Rice stem borer (*Scirpophaga incertulas*), leaf folder (*Cnaphalocrocis medinalis*), Brown planthopper (*Nilaparvata lugens*)	ICAR-NRRI, Cuttack	ICAR-NRRI, Cuttack
Management of rice stem borer and leaf-folder using entomopathogenic nematodes and entomopathogenic fungi	KAU, Thrissur	KAU, Thrissur
Large scale bio-intensive pest management on rice	PAU, KAU-Vellayani, KAU-Thrissur, AAU-J, OUAT, IGKV	PAU, KAU-Vellayani, KAU-Thrissur, AAU-J, OUAT, IGKV

Large scale demonstrations on bio-intensive pest management in organic *basmati* rice	PAU, Ludhiana	PAU, Ludhiana
Management of rice stem borer and leaf-folder using entomopathogenic microorganisms	KAU, Thrissur	KAU, Thrissur
Enabling large scale adoption of proven bio control technologies	AAU, Jorhat	AAU, Jorhat
Large scale bio-intensive pest management in rice	OUAT, Bhubaneswar	OUAT, Bhubaneswar
Large scale bio-intensive pest management on rice	ICAR-IIRR, Hyderabad	ICAR-IIRR, Hyderabad
Biointensive pest management in rice	KAU-Vellayani	KAU-Vellayani
Validation of BIPM practices against pest complex of organic Black rice	AAU-Jorhat	AAU-Jorhat
Comparative efficacy of entomopathogenic fungi against sucking pests of rice, Leptocorisa acuta	ICAR-IIRR, Hyderabad	ICAR-IIRR, Hyderabad
Laboratory bioassay of *Metarhizium rileyi* (Anakapalle strain AKP-Nr-1) against Fall armyworm, Spodoptera frugiperda	ANGRAU-Anakapalle	ANGRAU-Anakapalle
Field efficacy of *Metarhizium rileyi* (Anakapalle strain AKP-Nr-1) against fall armyworm, Spodoptera frugiperda in maize	ANGRAU, Anakapalle; UAS, Raichur	ANGRAU, Anakapalle; UAS, Raichur
Evaluation of entomopathogenic fungi and *Bt* against maize stem borer	PAU, Ludhiana	PAU, Ludhiana

Biological control of maize stem borer, *Chilo partellus* using *Trichogramma chilonis*	PAU, Ludhiana; MPUAT, Udaipur	PAU, Ludhiana; MPUAT Udaipur
Biological Control of Maize Stem Borer, *Chilo partellus* using *Trichogramma chilonis.*	MPUAT, Udaipur	MPUAT, Udaipur
Bio-ecological engineering for the management of major insect pests of maize and benefit of their natural enemies	SKSUAT-Jammu	SKSUAT-Jammu
Demonstration of BIPM module against fall army worm, *Spodoptera furgiperda* on *rabi* maize	AAU, Jorhat	AAU, Jorhat
Field trial against Fall armyworm in maize at AICRP-BC centres	IIMR, Maize Hyderabad, PAU, PJTSAU, AAU-Anand, OUAT, MPKV, CAU and TNAU	IIMR, Maize Hyderabad, PAU, PJTSAU, AAU-Anand, OUAT, MPKV, CAU and TNAU
Large scale demonstration of proven biocontrol technologies against maize stem borer, *Chilo partellus* using *Trichogramma chilonis*	PAU, Ludhiana	PAU, Ludhiana
Field trial against fall armyworm in maize	PJTSAU, Hyderabad	PJTSAU, Hyderabad
Field trial against Fall armyworm in *Rabi* maize	OUAT, Bhubaneswar	OUAT, Bhubaneswar
Field trial against Fall armyworm in maize	CAU, Imphal	CAU, Imphal
Biological suppression of fall armyworm,	AAU-Anand	AAU-Anand

***Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) in maize**		
Trial on maize fall armyworm	TNAU, Coimbatore	TNAU, Coimbatore
Evaluation of BIPM module for fall armyworm, *Spodoptera frugiperda* in maize ecosystem	UAS, Raichur	UAS, Raichur
Large scale demonstration of management of fall armyworm using biological control agents and biopesticides	ANGRAU, Anakapalle	ANGRAU, Anakapalle
Evaluation of BIPM module for fall armyworm, Spodoptera frugiperda in maize ecosystem	MPKV, Pune	MPKV, Pune
Evaluation of NIPHM white media for production of *Nomuraea rileyi* (*Metarhizium rileyi*) NIPHM MRF-1 strain for management of maize fall armyworm (Spodoptera frugiperda)	NIPHM, Hyderabad	NIPHM, Hyderabad
Evaluation of entomopathogenic fungi formulations against millet borers in finger millet, kharif2020	IIMR, Hyderabad	IIMR, Hyderabad
Integration of botanicals, microbials and insecticide spray schedule for the management of pod borer complex in Greengram	ANGRAU, Anakapalle	ANGRAU, Anakapalle
Evaluation of entomopathogenic biopesticide against Aphis craccivora in cowpea (*Vigna unguiculata*).	AAU, Jorhat	AAU, Jorhat

Evaluation of oil formulation of *Lecanicillium* spp against sucking pests of cowpea	KAU, Vellayani	KAU, Vellayani
Biological suppression of pod borer, *Helicoverpa armigera* (Hubner) infesting chickpea	MPKV, Pune	MPKV, Pune
BIPM module for management of *Helicoverpa armigera* on chickpea	PAU, Ludhiana	PAU, Ludhiana
Two BIPM modules were evaluated for the management of *Helicoverpa armigera*	TNAU, Coimbatore	TNAU, Coimbatore
Large Scale Demonstration of Ha NPV Kalaburgi strain against chickpea pod borer during 2020-21	UAS, Raichur	UAS, Raichur
Habitat manipulation / Bio-ecological engineering for the management of *Helicoverpa armigera* in chickpea	SKUAST, Jammu	SKUAST, Jammu
Evaluation of Biointensive Integrated Pest Management against pod borer in chickpea In Bundelkhand region	ICAR, NCIPM	ICAR, NCIPM
"Evaluation of NBAIR Bt formulation on pigeon pea against pod borer complex	PDKV, Akola	PDKV, Akola
Evaluation of microbial antagonists for the management of diseases (Powdery mildew/Ascochyta blight/Rust) in pea	PAU, Ludhiana	PAU, Ludhiana
Evaluation of entomofungal agents and botanicals for the management of sucking	MPKV, Pune, PJTSAU, Rajendranagar,	MPKV, Pune, PJTSAU, Rajendranagar, UAS,

pests in cotton	UAS, Raichur	Raichur
Evaluation of entomofungal agents and botanicals for the management of sucking pests in cotton	PJTSAU	PJTSAU
Evaluation of entompthogenic fungi, Beauveria bassiana (ICAR- NBAIR- Bb-5a) against sucking insect pests of cotton	UAS, Raichur	UAS, Raichur
Biointensive management of pink bollworm in Bt cotton	PJTSAU Hyderabad, TNAU, Coimbatore	PJTSAU, Hyderabad, TNAU, Coimbatore
Field efficacy of EPN strains against white grubs in sugarcane	MPKV Pune	MPKV, Pune
Large scale demonstration of *Trichogramma* species against sugarcane borer	MPKV Pune, OUAT Bhuvaneswar	MPKV, Pune, OUAT, Bhuvaneswar
Large Scale Demonstration of *Trichogramma chilonis* (TTS) against sugarcane early shoot borer	UAS, Raichur	UAS, Raichur
Large scale demonstrations of proven biocontrol technologies against sugarcane stalk borer, *Chilo auricilius*	PAU, Ludhiana	PAU, Ludhiana
Efficacy of *Aschersonia placenta* for the management of whitefly in sugarcane ecosystem	ICAR, SBI	ICAR, SBI
Efficacy of entomopathogenic fungi for the	ICAR, SBI	ICAR, SBI

management of white grub in sugarcane ecosystem		
Evaluation of locally isolated potential entomopathogenic fungi, *Metarhizium rileyi (KK-Nr-1)* against groundnut leaf miner and tobacco caterpillar in ground nut ecosystem	UAS, Raichur	UAS, Raichur
Frontline demonstration on biological control of insect pests of mustard	CAU, Pasighat	CAU, Pasighat
Field evaluation of bio-pesticides against mustard aphid	UBKV, Pundibari	UBKV, Pundibari
Bio-efficacy of entomopathogens against Banana fruit and leaf scarring beetles, *Nodostoma subcostatum*	AAU, Jorhat	AAU, Jorhat
Monitoring and record of the incidence of papaya mealybug and its natural enemies on papaya and other alternate hosts	AAU, Anand	AAU, Anand
Large scale demonstration on bio-intensive management of mango hopper	AAU, Anand	AAU, Anand
Management studies for inflorescence thrips on mango with bio-pesticides in field conditions.	DRYSRHU, Ambajipeta	DRYSRHU, Ambajipeta
Habitat manipulation for conservation of bio-agents for management of mango insect pests	CISH, Lucknow	CISH, Lucknow
Biological control of guava mealybug using entomopathogens	SKUAST, Jammu	SKUAST, Jammu
Development of biocontrol based IPM module	CISH, Lucknow	CISH, Lucknow

for the management of guava fruit borer.		
Biological control of root-knot nematode in guava	UAHS, Shimogga	UAHS, Shivamogga
Evaluation of entompthogenic fungi, Beauveria bassiana (ICAR-NBAIR-Bb-5a) against mealy bug in guava ecosystem	UAS, Raichur	UAS, Raichur
Management of apple root borer using *Metarhizium anisopliae*	Dr YSPUHF, Solan	Dr YSPUHF, Solan
Field evaluation of some bio pesticides against green apple aphid, *Aphis pomi* and mites infesting apple in Kashmir.	SKUAST, Srinagar	SKUAST, Srinagar
Evaluation of different isolates of entomopathogenic fungi against citrus thrips	Dr.Y.S.R. Horticultural University	Dr.Y.S.R. Horticultural University
Biological control of anola mealy bug using entomopathogens	SKUAST, Jammu	SKUAST, Jammu
Bio-intensive management of litchi fruit borer, *Conopomorpha sinensis* (Bradley) in litchi	PAU, Ludhiana	PAU, Ludhiana
Surveillance of rugose spiralling whitefly in coconut and population of natural biocontrol agents	ICAR-NBAIR, Bengaluru	ICAR-NBAIR, Bengaluru
Surveillance of Rugose white fly in coconut and population of natural biocontrolagents	KAU, Vellayani	KAU, Vellayani
Surveillance of rugose whitefly *Aleurodicus rugioperculatus* in coconut and assessing the	DRYSRHU, Ambajipeta	DRYSRHU, Ambajipeta

population of natural bio control agents		
Surveillance of rugose whitefly in coconut and assessing the population of natural biocontrol agents	KAU, Thrissur	KAU, Thrissur
Surveillance of rugose whitefly in coconut and assessing the population of natural biocontrol agents	RARS, Kumarakum	RARS, Kumarakum
Biological suppression of rugose spiralling whitefly in coconut	RARS, Anakapalle	RARS, Anakapalle
Biological control of rugose spiralling whitefly in coconut	CPCRI, Kayamkulam	CPCRI, Kayamkulam
Surveillance of rugose whitefly *Aleurodicus rugioperculatus* in coconut and assessing the population of natural bio control agents	DRYSRHU, Ambajipeta	DRYSRHU, Ambajipeta
Surveillance of rugose whitefly in coconut and assessing the population of natural biocontrol agents	KAU, Thrissur	KAU, Thrissur
Biological suppression of rugose spiralling whitefly in coconut	TNAU, Coimbatore	TNAU, Coimbatore
Field evaluation of bioagents against rugose spiralling whitefly on coconut	UAHS, Shivamogga	UAHS, Shivamogga
Converging biological suppression approaches for area-wide management of coconut rhinoceros beetle	CPCRI, Kayamkulam	CPCRI, Kayamkulam
In vivo evaluation of effective biocontrol agents	DRYSRHU,	DRYSRHU,

against Phytophthora pod rot management in cocoa	Ambajipeta	Ambajipeta
Survey and surveillance of natural enemies of pinworm, *Tuta absoluta* on tomato	AAU, Anand	AAU, Anand
Role of Habitat manipulation for pest management in Tomato	CAU (Imphal)	CAU (Imphal)
Demonstration on bio-intensive management of insect pests of tomato	Dr YS PUHF, Solan	Dr YS PUHF, Solan
Bio-intensive pest management of *Helicoverpa armigera*, *Tuta absoluta* and sucking pests of tomato	IIHR, Bengaluru	IIHR, Bengaluru
Large Scale Field Trials for the Management of *Helicoverpa armigera* (Hubner) on Tomato	MPUAT, Udaipur	MPUAT, Udaipur
Management of sucking pests in tomato under polyhouse condition	PAU, Ludhiana	PAU, Ludhiana
Survey and surveillance of natural enemies of pin worm, *Tuta absoluta* on tomato	PJTSAU, Hyderabad	PJTSAU, Hyderabad
Development of bio-intensive pest management (BIPM) module for the management of shoot and fruit borer, *Leucinodes orbonalis* (Guenee) in brinjal	AAU, Anand	AAU, Anand
2Bio-efficacy of microbial agents against *Myllocerous subfasciatus* on brinjal	IIHR	IIHR
Bio-intensive insect pest management in brinjal	KAU, Thrissur	KAU, Thrissur

Evaluation of biointensive IPM module against key pests of okra	AAU, Jorhat	AAU, Jorhat
Large scale demonstration on bio-intensive pest management in okra	AAU, Anand	AAU, Anand
Management of hoppers, aphids and Whitefly on Okra by oilbased formulation of *Metarhizium anisopliae* (IIHR Strain)	IIHR	IIHR
Efficacy biocontrol agents for management of fruit borer, *Earias vittella* on bhendi	IIVR, Varanasi	IIVR, Varanasi
Evaluation of *Neoseiulus indicus* for the management of spider mites on okra	KAU, Thrissur	KAU, Thrissur
Field evaluation of ICAR-NBAIR entomopathogenic strains against cabbage aphid (Brevicoryne/Myzus) and *Plutella xylostella* (DBM)	CAU, Imphal	CAU, Imphal
Field evaluation of ICAR-NBAIR entomopathogenic strains against cabbage aphid (Myzus persicae) and *Plutella xylostella* (DBM)	IIVR, Varanasi	IIVR, Varanasi
Field evaluation of ICAR-NBAIR entomopathogenic strains against cabbage aphid, *Brevicoryne brassicae* (L.) and *Plutella xylostella* (L.).	MPKV, Pune	MPKV, Pune
Field evaluation of ICAR-NBAIR entomopathogenic strains against cabbage aphid, *Brevicoryne brassicae* and dimond back	AAU, Jorhat	AAU, Jorhat

moth, *Plutella xyllostella*		
Influence of habitat manipulation on incidence and severity of pest damage in cabbage	AAU, Anand	AAU, Anand
Management of thrips, aphids and whitefly on chilli by oil based formulation of *Metarhizium anisopliae* (IIHR Strain)	IIHR	IIHR
Screening of promising isolates of entomopathogenic fungi for management of mites in chilli	RARS, Kumarakom	RARS, Kumarakom
Survey for incidence of *Phenacoccus manihoti*- the recent invasive mealybug on cassavaHost range of *P. manihoti* across agricultural and horticultural crops	TNAU, Coimbatore	TNAU, Coimbatore
Evaluation of BIPM against fruit flies *Deccaus bactrocera* sp. against cucumber	AAU, Jorhat	AAU, Jorhat
Management of phytophagous mites on cucumber using *Blaptostethus pallescens* and *Neoseiulus longispinosus* under polyhouse	Dr YS PUHF, Solan	Dr YS PUHF, Solan
Management of spider mite in cucumber using anthocorid predator, *Blaptostethus pallescens* under polyhouse condition	KAU, Thrissur	KAU, Thrissur
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	UAS, Raichur

Efficacy of capsule formulations of *Beauveria bassiana* for the management of amaranthus leaf webber, *Hymenia recurvalis*	KAU, vellayani	KAU, vellayani
Large scale demonstration of entomopathogenic fungi, *Metarhizium rileyi* (KK-Nr-1) against soybean defoliators in Bidar district.	UAS, Raichur	UAS, Raichur
Survey for incidence of *Phenacoccus manihoti*- the recent invasive mealybug on cassava. Host range of *P. manihoti* across agricultural and horticultural crops	TNAU, Coimbatore	TNAU, Coimbatore
Efficacy of different biocontrol agents against onion thrips, *Thrips tabaci* L.	AAU, Anand	AAU, Anand
Management of spider mite in cucumber using anthocorid predator, *Blaptostethus pallescens* under polyhouse condition	KAU, Thrissur	KAU, Thrissur
Management of sucking pests in tomato under polyhouse condition	PAU, Ludhiana	PAU, Ludhiana
Evaluation of biocontrol agents for the control of sucking pests in capsicum under polyhouse	IIHR, Bengaluru	IIHR, Bengaluru
Management of phytophagous mites on cucumber using *Blaptostethus pallescens* and *Neoseiulus longispinosus* under polyhouse	YSPUHF, Solan	YSPUHF, Solan
TRIBAL SUB PLAN	All Centres	All Centres

9. Experiments concluded (only experiments with two or more years)

Experiment allotted	No of years	Remarks based on the results from various centres	Status of the experiment
Evaluation of oil formulation of *Lecanicillium spp* against sucking pests of cowpea	2	**Recommendation** Chtin enriched oil formulations of *L. saksenae* (KAU) and *L. lecanii* (NBAIR) were effective in managing aphids when sprayed twice one at vegetative and the other at the reproductive phase of the crop. Though *L. saksenae* was inferior to thiamethoxam in the initial days after treatment, at the final stage it was superior to *L. lecanii* and thiamethoxam. 32.79 per cent increase in yield was noted in oil formuation treated plots.	Completed
Management of *Fusarium* wilt in vegetable cowpea using microbial agents	2	**Recommendation** Seed treatment with *P. flourescens* (KAU isolate) @ 10 g/L as seed treatment + fortnightly soil drenching + foliar spraying was effective in managing fusarium wilt of cowpea.	Completed
BIPM in rice	2	**Recommendation** BIPM comprising seed treatment with (*B. bassiana* NBAIR Bb5a) + foliar spray at vegetative phase + Tricho cards (6 times at weekly intervals from 30 days) + foliar spray of *L.saksenae* (KAU) twice at reproductive phase was as effective as spraying quinalhos	Completed

		four times in managing leaf roller, stem borer and rice bug. BIPM plots recorded higher yield than Farmers practice. BC ratio was 1.5 in BIPM while it was 1.4 in farmers practice.	
capsule formulations of *Beauveria bassiana* in managing amaranthus leaf webber *Hymenia recurvalis*	2	**Recommendation** Spraying Bb (KAU) capsules @ 3/ L or its spore suspension 20 ml /L was the best treatment which was closely followed by the effect of capsules and spore suspension of Bb NBAIR 5a	Completed
Management of pink bollworm by using *Trichogrmmatoidea bactrae* on *Bt* cotton'	3	**Recommendation** Six releases of *Trichogrammatoidea bactrae* @ 1 lakh eggs/hectare at an interval of 10 days, starting from 55 days of crop germination is recommended for effective management of pink bollworm on cotton with higher economic returns,	Concluded with recommendation
Evaluation of NBAIR Bt formulation on pigeon pea against pod borer complex	4	**Recommendation** Three sprays of *Bacillus thuringiensis*)NBAIR-BTG4 1%(@ 10 ml/L starting at 50 % flowering and subsequent sprays at 15 days interval is recommended for the management of pigeon pea pod borer.	Concluded with recommendation
Development of biointensive pest	2	**Recommendation** The BIPM module comprising *Trichogramma*	Carried forward for further large-

management (BIPM) module for the management of shoot and fruit borer, *Leucinodes orbonalis* (Guenee) in brinjal		*chilonis*, *Bacillus thuringiensis* (AAU-*Bt*1) and EPN *Steinernema carpocapsae* was found equally effective for the management of shoot and fruit borer, *Leucinodes orbonalis* in brinjal.	scale demonstration
Efficacy of different biocontrol agents against onion thrips, *Thrips tabaci* L.	2	**Recommendation** Microbial biopesticide *Metarhizium anisopliae* AAU strain Ma1 was foundeffective in reducing the thrips menace in onion. The treatment *Metarhizium anisopliae (*AAU strain Ma1) recorded the lowest thrips population/plant with the highest bulb yield (B:C ratio 1:1.78).	Carried forward for further large-scale demonstration
Field efficacy of *Trichoderma harzianum* and *Pseudomonas fluorescens* against the early blight of tomato	2	**Recommendation** Different combinations of *Trichoderma harzianum* (Th) and *Pseudomonas fluorescens* (Pf) were evaluated through soil application (SA), root dip (RD) and foliar spray (FS). The treatment Th+ Pf (SA + RD) + Azoxystrobin 23% SC (FS) was found effective in reducing the early blight of tomato.	Concluded with recommendation
Field efficacy of *Trichoderma harzianum* and	2	**Recommendation** Different combinations of *Trichoderma*	Carried forward for further large-scale

Pseudomonas fluorescens **against the early blight of potato**		*harzianum* (Th) and *Pseudomonas fluorescens* (Pf) were evaluated through soil application (SA), seed treatment (ST) and foliar spray (FS). The treatment Th+ Pf (SA + RD) + Kresoxim-methyl 44.3% SC (FS) was found effective in reducing the early blight of potato.	demonstration
Field evaluation of entomopathogenic strains against Rice stem borer (*Scirpophaga incertulas*), leaf folder (*Cnaphalocrocis medinalis*), Brown planthopper (*Nilaparvata lugens*).	2	**Recommendation** NBAIR isolates i.e., NBAIR-PEOWN, NBAIR-BATP, NBAIR-BtoYPS, NBAIR-PFDWD and NBAIR-TATP shown lesser dead heart and white ear-head damage caused by rice yellow stem borer, leaf damage caused by rice leaf folder but increased plant height and grain yield than the untreated control but next to insecticide check under field conditions.	Carried forward for multi-location trails
Field evaluation of microbial strains against Rice Blast (*Magnaporthe oryzae*), Brown spot (*Bipolaris oryzae*) and sheath blight (*Rhizoctoniasolan*	2	**Recommendation** NBAIR-PFDWD (*Pseudomonas flourescens*) was the most effective isolate against rice diseases *viz.*, sheath blight, brown spot and blast with lesser Percent Disease Index (PDI) followed by NBAIR-TATP (*Trichoderma asperellum*) under field conditions. Field results revealed that NBAIR-PFDWD treatment enhanced the plant growth of rice plants in terms of plant height, fresh	Carried forward for multi-location trails

***i*).**		shoot weight, fresh root weight, dry shoot weight, dry root weight and yield as compared with control plants.	
Evaluation of Biointensive Integrated Pest Management against pod borer in chickpea in Bundelkhand region (ICAR-NCIPM)	2	**Recommendation** BIPM module consist ofseed treatment with *T. harzianum*, installation of pheromone traps @5/ha and erection of bird perches 20/ha, need based foliar spray of *B. thuringiensis* and application of neem oil were found effective against pod borer and wilt disease complex at farmers field. BIPM provided 20 to 29 % higher yield over FPwith BC ratio of 2.9 to 3.87.	Concluded
Evaluation of biocontrol agents against leopard moth, *Zeuzer amultistrigata* in apple	2	**Recommendation** EPN *Heterorhabditis bacteriophora* (5000IJs/gallery) can be used for the management of leopard moth, ***Zeuzera***	Concluded with the recommendation
Management of phytophagous mites on cucumber using *Blaptostethus pallescens* and *Neoseiulus longispinosus* under polyhouse	2	**Recommendation** Predatory mite, *Neoseiulus longispinosus* at 1:20 predator: prey ratio was as effective as spiromesifen (100g a.i./ha).	Carried forward for large scale demonstration

Management of *Fusarium* wilt/ root rot of pea through biological control agents	2	**Recommendation** Seed treatment with *Trichoderma asperellum* @10g/kg seed + soil application of *T. asperellum* after mixing with FYM (10g/Kg FYM) @40g/m^2) was the most effective treatment for the control of *Fusarium* wilt/ root rot of pea.	Carried forward for large scale demonstration.
Field evaluation of biocontrol agents against fall armyworm in maize	2	**Recommendation** Four releases of *T. chilonis* cards @ 1cc/acre + 2 Foliar sprays of *Bacillus thuringiensis* formulation @ 10ml/L starting from a week after sowing at 10 days interval recorded higher yield and Benefit cost ratio compared to other biologicals used to manage Fall Armyworm.	The trial is carried forward for large scale demonstrations in farmer's fields
Evaluation of entomofungal agents and botanicals for the management of sucking pests in cotton	3	**Recommendation** Four sprays of *Lecanicillium lecanii* 1 X 10^8 CFU/g or ml @ 5g/L or Azadirachtin 1500 ppm recorded higher yield 11.37 and 11.62 q/acre resp. compared to other biologicals tested.	The trial is carried forward for large scale demonstrations in farmer's fields.
Biological suppression of Bondar's nesting whitefly in coconut	3	**Recommendation** Application of *Isaria fumosorosea* followed by neem oil spray could bring about reduction in live colonies and nymphs of Bondars nesting whitefly.	Concluded with recommendation

Field evaluation of ICAR-NBAIR entomopathogens against cabbage aphid (*Brevicoryne/Myzus*) and *Plutella xylostella* (DBM)	2	**Recommendation** Three rounds of foliar spray of *Lecanicillium lecanii* Vl8 @ 5ml/l can be used for the management of DBM and Aphids in Cabbage	Carried forward for further large scale demonstration

10. Technologies identified for large plot multilocational trials

Details of technologies	Centres which conducted the trials	Proposed centres to take up the trial
Large scale demonstration of Management of fall armyworm using biological control agents and Biopesticides	ANGRAU, Anakapalle	UAS, Raichur
Large scale bio-intensive pest management in rice	KAU, Thrissur	OAUT, Bhubaneswar
Biological control of rugose spiralling whitefly in coconut	CPCRI, Kayankulam	DRYSRUH, Ambajipetta
Converging biological suppression approaches for area-wide management of coconut rhinoceros beetle.	CPCRI, Kayankulam	DRYSRUH, Ambajipetta
large scale demonstrations of natural enemies for the management of coconut rugose spiraling	DRYSRHU, Ambajipetta	CPCRI, Kayankulam

whitefly		
Large scale field demonstrations of bio-control technologies for the management of rice diseases	GBPUAT, Pantnagar	KAU. Thrissur,
Large scale field demonstrations of bio-control technologies for the management of chick pea wilt	GBPUAT, Pantnagar	UAS, Raichur
Bio-intensive management of insect pests of tomato	DYSPUHF, Solan	IIVR, Varanasi
Management of apple root borer using *Metarhizium anisopliae*	DYSPUHF, Solan	SKUAST, Srinagar
Demonstration of *Trichoderma* sp. for the management of Fusarium wilt in pigeon pea	AAU, Anand	UAS, Raichur
Large scale demonstration on bio-intensive pest management in okra	AAU, Anand	IIHR, Hessaraghata
Large scale demonstration on bio-intensive pest management in cabbage	AAU, Anand	IIHR, Hessaraghatta
Large scale demonstration on bio-intensive management of mango hopper	AAU, Anand	CISH, Lucknow, IIHR Hassaraghatta
Large scale demonstrations of proven biocontrol technologies against sugarcane stalk borer, *Chilo auricilius*	PAU, Ludhiana	ANGRAU, Anakapalle
Large scale demonstrations on bio-intensive pest management in organic *basmati* rice **Mechanical control for leaf folder by passing the 20-30 m long coir/jute rope before flowering,**	PAU, Ludhiana	AAU, Jorhat

forwards and then backwards, both ways while touching the crop canopy **Biocontrol (5 releases of *T. chilonis and T. japonicum* @ 1 lakh/ha each at weekly interval starting from 30 days after transplanting) for stem borer and leaf folder**		
Large scale demonstration of proven biocontrol technologies against maize stem borer, *Chilo partellus* using *Trichogramma chilonis*	PAU, Ludhiana	ANGRAU, Anakapalle

11. Technologies identified for commercialization/POP practices

- Two sprays of NSKE (5%) @4 ml/l at 30 and 55 days after transplanting followed by six releases of egg parasitoid *Trichogramma chilonis*. @ 50,000/ha at 10 days interval starting from 25 days after transplanting were found effective against rice insect pests.

- Spraying of Azadirachtin 1500 ppm @ 2ml/L followed by spraying of *Lecanicillium lecanii* $1x10^8$ spores/ml @ 5g/L and eight releases of *Trichogramma chilonis* (MITS) @ 1,00,000/ha at weekly interval starting from initiation of flowering was found effective against brinjal pests.

- Six releases of *T. chilonis, T. priteosum* @ 1,00,000/ha with weekly intervals helps in controlling DBM and other lepidopteran pests of cabbage and cauliflower.

- Three releases of *Trichogramma pretiosum* @ 1 card/acre at weekly interval followed by the spray of *Bacillus thuringiensis* NBAIR *Bt*G4 1% WP @ 50 g/ 10 lit. for three times at ten days interval with the initiation of pest was effective for the management of fall armyworm, *Spodoptera frugiperda* in maize

- The bio pesticide *Metarhizium anisopliae* NBAIR Ma4 @ 5 ml/litre was effective in reducing mango inflorescence thrips population under field conditions

- Foliar application of entomopathogenic fungus *Isaria fumosorosea* @ $1x10^8$ spores/ml (5 gm /L along with sticker 2 ml/L) followed by release of parasitiod *Encarsia guadeloupae* at 15 days after *Isaria fumosorosea* first spraying was found effcetive for the managemnt of rugose spiralling whitefly.

- Soil solarisation of nursery beds followed by Seed treatment with PBAT-3 bioagent @10 g/kg seed and Seedling root dip @10 g/L for 30 min prior to transplanting and four foliar sprays @10 g/L at 15 days interval was found effective for the management of sheath blight of rice

- Soil solarisation of nursery beds followed by soil application with value added compost (enriched with biocontrol agent PBAT-3 @1 kg /q compost), seed treatment with Bioagent @10 g/kg seed, seedling root dip @10 g/L for 30 min. prior to transplanting and five foliar sprays with PBAT-3 @10 g/lit water at 15 days interval was found effective against soil borne pathogens of tomato.

- Soil application of value added compost (enriched with biocontrol agent PBAT-3 @1 kg /q compost) followed by seed treatment with Bioagent @10 g/kg seed and four foliar sprays with PBAT-3 @10 g/L at 15 days interval was found effective against chick pea wilt.

12. Action taken report on recommendations of XXX AICRP BC Annual review meeting

DDG/ADG/ Director/Project coordinators	Comments/ Suggestions	Action taken against the Comments/ Suggestions
Technical session : Panel Discussion for collaboration between institutes and AICRPs		
Dr. Tilak Raj Sharma, Deputy Director General (Crop science),	Dr T R Sharma insisted to develop more three minutes video on various aspects of biological control.	The following are the 3 to 5 minutes videos prepared by various centres of AICRP on Biological Control 1. Management of mango hoppers using *Metarhizium anisopliae* NBAIR Ma4 2. Management of Sugarcane white grub using *Metarhizium anisopliae* NBAIR Ma4 3. Management of Coconut Rugose Spiralling whitefly 4. Management of cassava mealybug using parasitiod *Apoanagyrus lopezi* 5. NBAIR –activities

	Dr T R Sharma requested to release the package of practices of recommendations and validated biocontrol technologies along with the technical bulletin in the next annual review meeting.	The following validated technologies have gone to the packages of practices recommendations of the university. Seed treatment of paddy with PBAT 3 (Pant Bioagent 3) @ 10 g/kg of seed followed by seedling root dip with PBAT 3 @ 10 g/L for 30 min. prior to transplanting, soil application with PBAT 3 @ 5kg/ha and four foliar sprays with PBAT- 3 @ 10 g/lit water at 15 days interval effectively managed the sheath blight disease of rice (GBPUAT, Pantnagar) Three releases of *Trichogramma pretiosum* @ 100000 eggs/ha at weekly interval followed by the spray of *Bacillus thuringiensis* NBAIR BtG4 1% WP @ 50 g/ 10 lit. for three times at ten days interval with the initiation of pest will be effective for the management of fall armyworm, *Spodoptera frugiperda* in maize

		Foliar application of entomopathogenic fungus *Isaria fumosorosea* NBAIR Pfu5 @ $1x10^8$ spores/ml (5 gm /L along with sticker 2 ml/litre) was found effective against Rugose spiraling whitefly in coconut and oil palm. Release of predator *Pseudomallada astur* at 15 days interval @ 1000 eggs/acre (low infestation level) and up to 2000 eggs/acre (high level of infestation) of Rugose spiralling whitefly of infested palms Integrated pest management of sugarcane stalk borer, *Chilo auricilius* using pheromone traps @ 25 per ha from July to October along with already recommended 10-12 releases of *Trichogramma chilonis* @ 50,000 per ha at 10 days interval from July to October. The pheromone lures are to be replaced at monthly interval. Soil application of *Metarhizium anisopliae* NBAIR Ma4 ($1x10^8$ spores/ ml) @ 5 ml/L twice during July and September was found effective against sugarcane white grub.

	Dr T R Sharma urged the centres to evaluate the validated technologies for management of plant diseases.	Centres are evaluating the efficacy of validated Biocontrol agents i.e PBAT (*P. fluorescens* + *T. harzianum*), *Bacillus megaterium* NBAIR 63, *Pseudomonas fluorescens* NBAIR-PFDWD, *Trichoderma harzianum* NBAII GJI16B, *Trchoderma asperullum* NBAIR-TATP against the soil borne diseases of crop plants
	Dr T R Sharma advised the AICRP BC to collaborate with NIBSM and NCIPM	NIBSM is having collaboration with AICRP BC for the evaluation of its *Bacillus thringiensis* NIBSM Bt 18 strain against chick pea pod borer. NIBSM Bt 18 strain has been included in the AICRP BC technical programme to evaluate against the chickpea pod borer at four AICRP Biocontrol centres (MPUAT-Udaipur; PAU Ludhiana; IGKV Raipur; AAU Jorhat). NCIPM is a contingency centre of AICRP Biological Control and had been evaluating the efficacy of NBAIR Bicontrol agents especially for the management of maize fall armyworm chickpea pod borer and Rice soil borne disease.

		Beyond research collaboration AICRP BC is sharing the crop pest out break data of all centres along with the advisory services to NCIPM.
	Conducting meeting involving the NBAIR, NBAIM, NCIPM and NIBSM for future collaborations and exchange of materials	Meeting was conducted at ICAR NBAIR on 8-03-2022 involving Dr. S. C. Dubey, Assistant Director General (PP & Biosafety), ICAR, Dr. Harsh Vardhan Singh, Director, NBAIM, Dr. Subash Chander, Director, NCIPM, New Delhi. Discussions were held on exchange of materials and future collaborations. NBAIM is certifying the finger print data of all microbial resources of NBAIR.
	Dr. T R Sharma highlighted the branding of the biocontrol products for further promotion.	Biocontrol technologies are being popularised and promoted through mass media, exhibitions, high level meetings, national and international conferences etc
	Finger print data have to be generated for all new strains.	Finger print data have been generated for all major biocontrol agents such as *Beauveria bassiana* NBAIRBb-23, *Beauveria bassiana*

		NBAIRBb-45, *Beauveria bassiana* NBAIR Bb-5a *Metarhizium anisopliae* NBAIR Ma-35, *Metarhizium anisopliae* NBAIR Ma-4, *Lecanicillium lecanii* NBAIR Vl8, *Bacillus thuringiensis* NBAIR BtG4, *Bacillus thuringiensis* NBAIR Bt25, *Bacillus thuringiensis* NRRI BtBiocb 8,*Spilosoma obliqua* NPV, *Spodoptera frugiperda* NPV, *Bacillus megaterium* NBAIR 63, *Pseudomonas fluorescens* NBAIR-PFDWD, *Trichoderma harzianum* NBAII GJI16B, *Trichoderma asperullum* NBAIR-TATP, *Bacillus albus* NBAIR-BATP
Dr. S. C. Dubey, Assistant Director General (PP&Biosafety)	Dr. S. C. Dubey emphasized to prepare distribution maps to assess the spread and establishment of various natural enemies of pests and plantpathogens.	Exclusive one institute project is in progress at NBAIR to develop distribution maps to assess the spread and establishment of various natural enemies of pests. Crops and pests / diseases have been prioritised while preparing the technical programme for all the centres for 2022 to 25.

	Crops and pests / diseases have to be prioritised to have the intervention of microbial biocontrol agents.	Microbes with multiples traits like *Pseudomonas* spp, *Bacillus* spp. etc have been evaluated at various centres against diseases of crops.
	Microbes with multiple traits have to be focussed and validated in the future programmes	1. *Pseudomonas fluorescens* NBAIR-PFDWD- Abiotic stress tolerant strain with high antagonistic potential, high DAPG and siderophore producing capacity. Induces growth of plants. 2. *Trichoderma harzianum* NBAII GJI16B- carbendazim and salinity tolerant strain with high antagonistic potential. 3. *Bacillus megaterium* NBAII 63–Strain with high phosphate solubilization ability, growth promoting ability and high antagonistic potential.
	The severity of rugose spiralling whitefly of coconut has to be indicated.	Data on severity of rugose spiralling whitefly coconut have been recorded by the centres working on coconut RSW

	Data on multilocational trails of the organisms should be used for final registration. The details of the technical programme should be clearly mentioned and all the centres should follow the technical programme without any deviation.	Data on multilocational trails of the organisms have been used for generating dossiers for the purpose of registration of the following organisms 1) *Beauveria bassiana* NBAIR Bb5a 2)*Metarhizium anisopliae* NBAIR Ma35, 3) *Metarhiziumanisopliae*NBAIRMa4, 4) *Lecanicillium lecanii* NBAIR Vl8, 5) *Bacillus thuringiensis* NBAIR BtG4, 6) *Bacillus thuringiensis* NBAIR Bt25, 7) *Helicoverpa armigera* NPV, 8) *Spodoptera litura* NPV, 9) *Spodoptera frugiperda* NPV, 10) *Bacillus megaterium NBAIR 63,* 11) *Pseudomonas fluorescens* NBAIR-PFDWD, 12) *Trichoderma harzianum* NBAII GJI16B,
Dr. A K Saxena, Director, ICAR-	Authenticated cultures of NBAIR/NBAIM may be provided to	NBAIR Cultures/Technologies are being validated by AICRP Chick pea, maize, rice,

NBAIM, Mau	other crop based AICRPs for evaluation.	coconut, vegetables and fruits. 1. ICAR-IIMR (Winter Nursery) Hyderabad is a voluntary centre of AICRP on Biological Control and is evaluating all natural enemies of against maize fall armyworm. 2. NBAIR's organisms such as *Bacillus thuringiensis*, *Metarhizium anisipliae* and *Helicoverpa armigera* nucleopolyhedrovirus (HearNPV), EPN *Heterorhabditis indica* and Nanogel slow-release pheromone formulations are being evaluated against chickpea pop borer (*Helicoverpa armigera*) at 13 centres of AICRP on Chickpea. 3. Entomopathogens such as *Beauveria bassiana* NBAIR Bb 5a, *Metarhizium anisopliae* NBAIR Ma4, *Bacillus thuringiensis* NBAIR BtG4 are currently being evaluated at ICAR IIVR, ICAR IIHR under AICRP vegetables against insect pests. 4. Entomopathogenic fungus *Isaria*

		fumosorosea NBAIR Pfu5 is being evaluated against coconut Rugose Spiralling Whitefly under AICRP palms. 5. *Metarhizium ansiopliae* NBAIR Ma 4 was included under AICRP fruits technical programmes for evaluation against mango hopper.
	Collaboration needed to further evaluate the technologies in large scale.	Discussions are being held among the Directors of the plant protection institutes on mutual exchange of organisms/bioagents and collaborations Director NBAIR participated Annual meeting of AICRP on Rice 26.04.2022. Discussions were held on the validation of NBAIR's biocontrol agents in the AICRP on Rice against pest and diseases of rice.
Dr Y.G Prasad, Director, ICAR-CICR, Nagpur	Major problem in cotton is root knot nematode, root rot, sucking pests and pink bollworm.	Experiments on the management of sucking pests and pink bollworm of cotton are progressing at UAS Raichur, TNAU Coimbatore; ANGRAU Anakapalle, PJTSAU Hyderabad, AAU Anand, PAU Ludhiana, PDKV Akola.

		1. Evaluation of efficacy of entomofungal pathogens for the management of sucking pests in cotton (UAS Raichur; TNAU Coimbatore; AAU Anand ANGRAU Anakapalle; PJTSAU Hyderabad; PDKV Akola) Treatments T1: Powder formulation *Lecanicillium lecanii* NBAIR Vl 8 (1x10^8 spores /g) @ 5 g/l T2: POP Recommendation (Spiromesifen 240 SC @ 7 ml/10 L) T3: Control Two sprays will be given at 15 days interval soon after the incidence starts **2. Large scale evaluation of biointensive management of pink bollworm on *Bt* cotton (UAS Raichur; TNAU Coimbatore; AAU Anand, ANGRAU Anakapalle; PJTSAU Hyderabad; PAU Ludhiana, PDKV Akola)** **Treatment details** T1: Standard practice of plant protection till 55th

		day or appearance of PBW. The following inputs to be provided for PBW. • Timely sowing (up to Mid-May) • Erection of pheromone traps (Funnel type) @ 2 trap/ acre for Monitoring and 20 trap/acre for Mass trapping • Releases of *Trichogrammatoidea bactrae* 100,000/ha, five releases starting from 55 days after germination (Two release at flowering time and Three release at boll formation stage • Application of azadirachtin 1500 ppm @ 2ml/L of water T2: POP recommendation (Lambda-Cyhalothrin / Profenophos 50 EC 2ml) T3:Control
	Biocontrol technologies should be evolved for the management of above pests through fruitful collaboration. The Biocontrol based IPM evolved for pink bollworm may be tested in Maharastra	Validated cotton biocontrol technologies are being evaluated at Maharashtra (PDKV Akola) and Gujarat (AAU Anand)

	and Gujarat centres of AICRP-Cotton. More studies on the mass rearing field release techniques of *Bracon hebetor* and *Bracon lefroyi* which are recorded as important parasitoids on cotton pests.	Mass rearing and field release techniques of *Bracon hebetor* have been standardized by NBAIR. Collection and exploration of parasitoid *Bracon lefroyi* has been initiated
Dr. R. Meenakshi Sundaram, Director, ICAR-IIRR, Hyderabad	A meeting to be conducted between IIRR, NBAIR and NBAIM for the biocontrol technologies for the management of rice pests and diseases by IIRR.	Director NBAIR participated the Annual Review meeting of AICRP on Rice on 26.04.2022. In the meeting it was decided to include NBAIR's entomopathogens under AICRP on Rice programmes to evaluate against rice pests.
Dr. Sujay	Availability of quality	Advisories were given to all AICRP Biocontrol

Rakshit, ICAR-IIMR	biocontrol agents especially parasitoids and predators is a major constraint for the uptake of biocontrol technologies. Officials of Department Agriculture, cooperation and farmers welfare may be informed about the mass rearing technologies of bioagents.	centres to produce the quality biocontrol agents in large scale and supply to farmers. Trainings are being imparted regularly to Officials of Department Agriculture, cooperation and farmers on mass rearing technologies of bioagents
Dr. G.P. Dixit, Project Co-ordinator (Chick pea)	ICAR-NBAIR technologies such as *Bacillus thuringiensis*, *Metarhizium* and NPV strains to be evaluated in large scale on chick	NBAIR's organisms such as *Bacillus thuringiensis*, *Metarhizium anisipliae* and *Helicoverpa armigera* nucleopolyhedrovirus (HearNPV), EPN *Heterorhabditis indica* and Nanogel slow-release pheromone formulations are being validated against chickpea pod borer

	pea for the suppression of *Helicoverpa armigera*.	(*Helicoverpa armigera*) at 13 centres of AICRP on Chickpea.
	Fusarium wilt and root rot diseases are another problem in chick pea. We are ready to collaborate with ICAR-NBAIR for the management of this diseases with the available technologies.	Experiments on the management of chick pea wilt and root rot using bioagents are progressing under AICRP on Biological control. The promising bioagents will be shared after the completion of evaluation of evaluation trials.
	Looking for collaboration with ICAR-NBAIR for Nanogel slow-release pheromone formulations for	Nanogel slow-release pheromone formulation is being validated against chickpea pop borer (*Helicoverpa armigera*) at 13 centres of AICRP on Chickpea.

	management of *Helicoverpa armigera* and *Spodoptera litura*	
Dr. Pankaj Kaushal, Joint Director (Research), ICAR-NIBSM, Raipur	ICAR-NIBSM is ready to collaborate with ICAR-NBAIR on the basic research and strategies for the management of pests and diseases. It was suggested to Dr Dubey to arrange a meeting between Directors of NIBSM, NBAIR and NCIPM to study strategies to avoid overlapping in the programs between these institutions. ICAR-NIBSM was	*Bacillus thringiensis* NIBSM Bt 18 strain has been accepted and included in the technical programme 2022 to 25 of AICRP BC to evaluate against the chickpea pod borer at four AICRP Biocontrol centres (MPUAT-Udaipur; PAU Ludhiana; IGKV Raipur; AAU Jorhat). ICAR NIBSM invited Dr Dubey, ADG (PP&BS), ICAR and the Directors of NBAIM, NBAIR and NCIPM to its RAC meeting held on 8.06.2022 to avoid overlapping in the programs between these institutions.

	requested to invite all the Plant Protection institutions to its RAC meeting.	
Dr. I P Singh, Project Co-ordinator (AICRP-Pigeon pea)	In pigeon pea, pod borer and pod fly are the major problem and technologies for the production of *Bacillus thuringiensis* formulations may be passed to AICRP-Pigeon pea for the management of pigeon pod borer.	Programmes will be chalked out to validate the NBAIR's organisms in AICRP (Pigeon pea) against pigeon pea pod borer. Attempts will be made to explore the biocontrol agents for the management of pod fly.
Dr. Rajesh Kumar, Project Co-ordinator (AICRP-Vegetables)	*Fusarium* wilt, Sclerotium rot in vegetables are major challenging diseases along with diamond back moth in cabbage and root knot	Experiments on validation of various biocontrol agents against cabbage diamond back moth and soil borne diseases of vegetables are being continued under AICRP on Biocontrol.

	nematode in tomato as serious pests and diseases. Syrphid flies are very important insects as pollinators and biocontrol agents under protected cultivation and technologies if any for their use need to be disseminated to the AICRP on vegetable.	Utilisation of Syrphid, *Ischiodon scutellaris* as a pollinator and Aphidopagous predator is under progress at NBAIR. The Bureau will share the details after completion of the studies.
Dr. Prakash Patil, ICAR-IIHR, Project Co-ordinator (AICRP-Fruits)	Biocontrol technologies using for the management of papaya mealybugs by ICAR-NBAIR may be demonstrated at relevant centres of	The incidence levels of papaya mealy bug has drastically come down below the pest status due to the continuous supply and distribution of parasitoid, *Acerophagus papayae.* However need based parasitoid *Acerophagus papayae* is being distributed in the papaya growing areas.

	AICRP Fruits.	
	Large scale demonstration of ICAR-NBAIR *Metarhizium ansiopliae* strain against mango leaf hopper along with IIHR *Metarhizium ansiopliae* strain will be undertaken.	*Metarhizium ansiopliae* NBAIR Ma 4 was included under AICRP fruits technical programmes for validation against mango hopper.
	Efficient biocontrol technologies for management of mango thrips, citrus fruit sucking moth and citrus thrips are very much needed.	*Beauveria bassiana* NBAIR Bb5a is being evaluated under AICRP BC against mango inflorescence thrips and citrus thrips
Dr.	Rugose spiralling	The following NBAIR technologies have been

Maheshwarappa, Project Co-ordinator (AICRP-Palms)	whitefly is a serious insect pest in coconut and oil palm besides, tea mosquito bug is another serious pest on cocoa and cashew	validated for the management of coconut rugose spiralling whiteflies. • Foliar application of entomopathogenic fungus *Isaria fumosorosea* @ $1x10^8$ spores/ml (5 gm /L) along with sticker 2 ml/litre) was found effective against Rugose Spiralling Whitefly in coconut and oil palm. • Release of predator and parasitoid, *Encarsia guadeloupae* in coconut ecosystem will greatly reduce the Rugose Spiralling Whitefly populations.
	Technologies on mass production protocol for *Encarsia guadeloupae* for management of Rugose Spiralling Whitefly may be shared with AICRP-Palms	Mass production protocols of *Encarsia guadeloupae* have been shared with AICRP Palms.
	Pheromone technology developed for red palm weevil may be demonstrated	Pheromone technology developed at NBAIR had been demonstrated against red palm weevil under AICRP Palms

	at AICRP-Palm centres	
Dr. Balraj Singh, Project Co-ordinator (Pollinators)	NBAIR can share its expertise on biosystematics for the taxonomic identification of honey bees and pollinators. ICAR-NBAIR technologies on Stingless bees and syrphid mass production protocols if any may be passed on to AINP-Pollination.	NBAIR expertise is being shared for the taxonomic identification of honey bees and pollinators. Mass production protocols of stingless bees and syrphid are being standardized at NBAIR and the protocols will be passed on to the AINP-Pollinators & Honeybees after completion of the study.
Dr. Srinivasa, Project Coordinator (AINP on Acarology)	Yellow mite in mulberry is a serious pest and any biocontrol technologies for the management of yellow	Biocontrol technologies including acaropathogen *Hirsutella thompsonii* and predatory mites *Neoseiulus longispinosus* and *Phytoseiulus* spp. are available with ICAR NBAIR for the management of mulberry yellow mite and same information has been communicated to Network

	mite can be evaluated by AICRP-acarology.	Coordinator, AINP on Agril. Acarology for further collaborations.
Dr. Uma Rao, Project Coordinator (AICRP-Nematodes) & Head, Division of Nematology, IARI	In polyhouse root knot nematodes management is a challenging problem. • Compatibility of biocontrol agents for the management of nematodes is urgently needed. • A meeting with all stakeholders including NBAIR, NBAIM, NCIPM and PC, AICRP-fruits should be arranged in 15 days time.	An interaction meeting was held involving Dr. Anil Sirohi, PC AICRP on Nematodes and Dr Prakash Patil, AICRP on fruits at NBAIR on 30 May 2022. Ongoing experiments of AICRP on Nematodes were reviewed. During discussions it was identified that one trial on guava *Fusarial* wilt complex is currently addressed by AICRP on nematodes and AICRP on Biological Control in collaboration with AICRP on fruits. Three centres (TNAU Coimbatore, Kalyani and Pantnagar) of AICRP Nematodes and one centre (CISH Lucknow) of AICRP BC are currently involved with AICRP fruits. It was decided to shift this experiment exclusively under AICRP Nematodes with more number of centres for better validation. Under AICRP nematodes, entomopathogenic nematodes (EPNs) are collected and catalogued with a difficulty of

		correct identification and maintenance, As AICRP BC is under Bureau, it was decided that such EPN cultures shall be deposited with AICRP BC which in turn shall provide identification and maintenance and retrieval services with proper record and posterity.
Specific recommendations of the technical sessions	Uniformity in treatments, number of treatments and replications should be followed for each experimental trial across the locations for better statistical analysis and interpretation of data (All centres) While recording pest incidence, instead of mentioning as low,	Uniformity in treatments, number of treatments and replications was followed by all centres for each experimental trial across the locations for better statistical analysis and interpretation of data All centres have been instructed to present the quantified data of pest incidence instead of mentioning as low, moderate and severe

	moderate and severe incidence, quantified data has to be presented (All centres)	incidence.
	For the survey programme, the PC cell has to fix the standard methodology, which has to be followed by centres.	PC cell has developed a standard methodology which was circulated to all centres and all centres are following the methodology for their survey programmes.
	Future surveys should cover unexplored areas in collaboration with the centres of AICRP-BC or other crop AICRP centres which are located in that region (All centres).	Surveys covering unexplored areas are being undertaken with the collaborations AICRP-BC centres or other crop AICRP centres which are located in that region

	Formulation of microbials can be used instead of using pure culture in the experiments (All centres)	All centres using formulation of microbials for their experiments instead of pure cultures.
	The accession number of microbial agents, based on cataloguing at the institute level, to be mentioned in the experiments; and the same isolates must be submitted to ICAR-NBAIM, Mau, to get the national accession number. Both the local accession numbers to be mentioned (All	Strain number/ local accession numbers of all bioagents are mentioned in the technical programme of the experiments. Many bioagents have been submitted to the Microbial repository of ICAR-NBAIM, Mau

	centres)	
	Centres can try to develop mass production protocols for the promising natural enemies recorded on specific crops and pests (All centres)	Centres have developed the mass production protocols for their cultures/ bioagents. 1. KAU Vellayani – *Lecanicillium saksenae* KAU ITCC7714 for the management of rice and cowpea bugs. 2. ANGRAU Anakapalle - *Bacillus thuringiensis* RARS TPT-C33 and *Metarhizium rileyi* AKP Nr-1 for the management of Maize FAW 3. UAS Raichur- *Metarhizium rileyi* KK Nr-1 for the management of Maize FAW 4. TNAU Coimbatore *Bacillus subtilis* TNAU BS1 for the management of rice diseases. 5. Dr. YSPUHF Solan- Predatory mite *Neoseiulus longispinosus* for the management of spider mite in tomato 6. TNAU Coimbatore and HRS Ambajipetta – Predator *Apertochrysa astur* for the management of coconut Rugose Spiralling Whitefly.
	The data on whitefly species distribution should include information on thenatural enemy in those regions. (CPCRI Kayankulam, HRS Ambajipetta)	Centres working on coconut whitefly are recording the observations on natural enemies population along with the pest incidence. An experiment was conducted by HRS Ambajipetta using *Isaria fumosorosea* against

	Isaria fumosorosea can be tested against RSW infesting banana (HRS, Ambajipetta) Information should be presented on the cultures maintained and supplied by the centres (All centres). In the experiments where BIPM module is compared with farmers practice, recommended package of practice by respective university has to be included instead of farmers practice as a check	RSW in banana and the results will be presented in the annual meeting. Information will be presented on the cultures maintained and supplied by the centres In BIPM experiments where ever applicable university package of practice recommendation is included as a check instead of farmers practice.

	(All centres) In case of coconut rugose spiralling whitefly (RSW) experiments, neem oil is proved to be very effective, therefore, it may be included as one of the components in large scale demonstration trial (Coconut centres). Since *Isaria fumosorosea* has been observed to be compatible with parasitoid *Encarsia*, further observation of emergence holes of the parasitoid can be examined for	 Neem oil has been included as one of the components in the evaluation trials. Observation on emergence holes of the parasitoid *Encarsia* has been recorded in the plots where *Isaria fumosorosea* was applied along with the release of parasitoid, *Encarsia*.

	confirmation of any mitigation effect of fungus (Coconut centres)	
General Recommendations of the technical sessions	GB Pant University should supply their promising isolates / formulations to be tested in other centres facing disease problems (GBPANT) If a centre is presenting information on occurrence of the invasive papaya mealybug, it should accompany information on parasitism by *Acerophagus papayae.*	GBPUAT's product PBAT3 (*T. harzianum* 14 and *P. fluorescens*17) has been validated at AAU Jorhat and PAU Ludiana against sheath blight of rice. Centres working on papaya mealy bug will provide the information on parasitism by *Acerophagus papayae.*

	Centres should aim to cover larger areas in their biocontrol trials (All centres).	Large scale demonstration experiments have been undertaken by the centres

Sl.No	Technology Demonstrated	Name of the Centres	State	Area (ha)
1.	Management of fall armyworm using biological control agents	TNAU Coimbatore, PJTSAU Hyderabad, UAS Raichur, ANGRAU Anakapalle, MPUAT Udaipur	Tamilnadu, Telangana, Andrapradesh, Karnataka, Rajasthan,	300
2.	Biological control of rugose spiralling whitefly in coconut	DRYSRUH, Ambajipetta	Andrapradesh, Tamilnadu, Kerala, Karnataka	350
3.	Bio-control technologies for the management of rice diseases	GBPUAT, Pantnagar, KAU Thrissur	Uttarkhand, Kerala	400
4.	Bio-control technologies for the management of chick pea wilt	GBPUAT, Pantnagar, UAS, Raichur	Uttarkhand, Karnataka	200
5.	Bio-intensive management of	DYSPUHF, Solan,	Himachal Pradesh,	250

	insect pests of tomato	IIVR,Varanasi, IIHR Bangalore, AAU Anand	Uttarpradesh, Karnataka, Gujarat	
6.	Management of apple root borer using *Metarhizium anisopliae*	DYSPUHF Solan	Himachal Pradesh	40
7.	Bio-intensive pest management in organic *basmati* rice	PAU, Ludhiana	Punjab	1000
8.	Demonstration of *Trichogramma* spp. (ICAR-NBAIR HTTS) against borers in sugarcane	PAU Ludhiana, OAUT - Bhubaneswar, UAS Raichur	Punjab, Karnataka, Odisha	500
9.	Demonstration of Plant Bioagent for the management of root rot complex of tomato	GBPUAT Pantnagar,	Uttarkhand,	400

	While reporting *Fusarium* species as pathogenic to insect	All centres have noted the information and will test the pathogenicity of *Fusarium* on plants

	pests, proper care has to be taken to study pathogenic effect of crops as majority of *Fusarium* species are plant pathogenic in nature (All centres)	before confirming *Fusarium* spp. as a entomopathogen.
	Adequate pest/disease incidence to be ensured before imposing treatments for optimal results (All centres)	Complied by the centres.
	The production protocol for production of *Metarhizium rileyi* be shared with the other AICRP Centres for the production of the	UAS Raichur centre is ready to share the production protocol of *Metarhizium rileyi* to any other centre.

	inoculum (Action: UAS, Raichur)	
	Evaluation of biopesticides for pest management under poly-house conditions should be intensified with more experiments and generate adequate data (YSPUHF, Solan).	More experiments have been planned for the period 2022 to 2024 to the bioagents against mites of cumber, tomato and aphids of capsicum
	A standard isolate (s) should be included as standard check in evaluation trials with any new/local isolate (s) for comparative performance.	Standard isolate is being included in all the evaluation experiments

	Research works should be concentrated on development of more robust strains of biocontrol agents with additional attributes.	NBAIR had developed multiple trait robust stress tolerant natural enemies such as Temperature tolerant *Trichogramma chilonis,* Insecticide tolerant *Trichogramma chilonis*, Multiple insecticide tolerant *Chrysoperla zastrowi sillemi* and carbendazim tolerant *Trichoderma harzianum,* salinity tolerant *T. harzianum* and abiotic stress tolerant *P. fluorescens* for the management of crop pests and diseases. Further research works are in progress to develop the bioagents with additional traits.
	All the institutes and AICRPs/AINPs should contact NBAIR/NBAIM/NCIPM for the biocontrol technologies/cultures and other technologies with prior intimation to ADG PP within 15 days.	All AICRPs / AINPs have been requested to follow the procedure to obtain biocontrol technologies/cultures from NBAIR/ NBAIM/ NCIPM

	Partnership research involving private firms to be promoted to scale up the validated biocontrol agents. Funding from private organizations has to be explored to carry out more research to develop smart biocontrol agents with longer shelf life	Interested firm will be identified for public - private partnership research to improve the shelf life and to scale up the validated bicontrol agents.