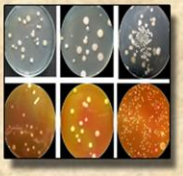
ANNUAL PROGRESS REPORT 2015-16










All India Co-ordinated Research Project
on Biological Control of Crop Pests

Compiled and edited by

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ICAR - National Bureau of Agricultural Insect Resources
Bengaluru 560 024

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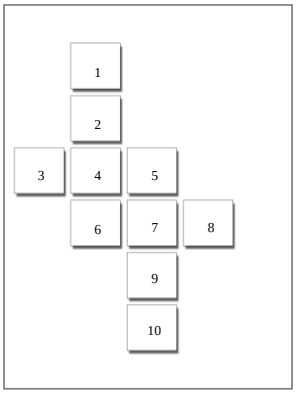


Cover page

1. Different *Bt* strains isolated from soil
2. Adult of *Pseudonemophas versteegi* (Ritsema) (Coleoptera: Cerambycidae)
3. Experimental plot on biological suppression of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in tomato
4. *Galleria mellonella* (Linnaeus) infected with *Heterorhabditis indica*
5. *Blaptostethus pallescens* Poppius (Hemiptera: Anthocoridae)
6. Large scale fields demonstration of bio-control technologies at farmer's field
7. *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) infested tomato
8. Pinapple plant infested with *Dysmicoccus neobrevipes* Beardsley (Hemiptera: Pseudococcidae)
9. Distribution of *Tuta absoluta* (Meyrick) pheromon traps to the farmers
10. Mass trapping of *Tuta absoluta* adults at farmer's field in Raichur

Photo credits: Photographs 1 & 7 – AAUA; 2 – CAU; 3 – MPKV; 4 – CPCRI; 5 – NCIPM; 6 – GBPUAT; 8 – KAU; 9 & 10 – UASR

Cover design: Sunil Joshi

Programme for 2015-16

1. Basic research

1. National Bureau of Agriculturally Important insects

1. Biodiversity of natural enemies of insect pests
2. Biodiversity of oophagous paraditoids with special reference to Scelionidae (Hymenoptera)
3. Biosystematics of Trichogrammatidae (Hymenoptera)
4. Biodiversity of aphids, coccids and their natural enemies
5. Documentation, production and utilisation of predatory anthocorids and mites
6. Molecular characterization and DNA barcoding of agriculturally important parasitoids and predators
7. Monitoring of invasive pests
8. Biosystematics and diversity of entomogenous nematodes in India
9. Mapping of the cry gene diversity in hot and humid regions of India
10. Exploitation of *Beauveria bassiana* for management of stem borer, *Chilo partellus* in maize and sorghum through endophytic establishment

2. Indian Agricultural Research Institute, New Delhi

1. Evaluation of *Trichogramma* strains for searching efficiency, temperature tolerance and fecundity and breeding of better performing strains *Trichogramma chilonis* under laboratory conditions
2. Screening for temperature tolerance in Cotton mealybug parasitoid, *Aenasius arizonensis* (Girault) (=*Aenasius bambawalei* Hayat) (IARI and PAU)

2.1.3. Biodiversity of biocontrol agents from various agro ecological zones

1. Survey, collection and diversity analysis of *Trichogramma*, *Chrysoperla*, Coccinelids, spiders, anthocorids and entomopathogens
2. Isolation of entomopathogens from soil samples collected from different districts of Punjab

2.2. Biological control of plant diseases using antagonistic organisms

1. Field evaluation of the promising *Trichoderma, Pseudomonas* and *Bacillus* isolates for the management of diseases and improved crop growth in rice, chickpea and pea (GBPUAT)
2. Evaluation of potential isolates of *Trichoderma, Pseudomonas* and *Bacillus* for the management of pre & post-emergence damping-off and improved growth in vegetable nursery beds of tomato onion and chilli (GBPUAT)
3. Evaluation of promising biological control agents against chilli anthracnose (AAU-A, GBPUAT and PAU)
4. Management of bacterial wilt an isolate of *Pseudomonas florescence* (CAU)

2.3. Biological suppression of Sugarcane pests

1. Monitoring the sugarcane woolly aphid (SWA) incidence and impact assessment of natural enemies on its biosuppression (MPKV, TNAU, PJTSAU and UAS-R)
2. Management of White grub, *Holotrichia consanguinea* Blanch in sugarcane using Bioagents (ANGRAU, Anakapalle)
3. Bioefficacy of entomopathogenic fungi and entomopathogenic nematodes in suppression of termite incidence in sugarcane (ANGRAU- Anakapalle)
4. IPM module for the sustainable management of early shoot borer (*Chilo infuscatellus*) and internode borer (*Chilo infuscatellus* and *Chilo sacchariphagus indicus*) in sugarcane (ANGRAU- Anakapalle)

2.4. Cotton

1. Monitoring biodiversity and outbreaks for invasive mealybugs on cotton, survey for incidence of mealybugs on cotton and collection of their natural enemies (MPKV, PAU, PJTSAU, TNAU, and UAS-R)
2. Monitoring biodiversity and outbreaks of sap sucking pests including mirids and their natural enemies in *Bt* cotton (MPKV, PJTSAU and UAS-R)
3. Diversity of sucking pests, bollworms and their natural enemies in transgenic *Bt* and non-*Bt* cotton (PAU-Ludhiana)
4. Bioefficacy of microbial insecticides against sucking pests in *Bt* cotton (AAU-A)
5. Biological suppression of sap sucking pests of *Bt* cotton (MPKV, PJTSAU and UAS-R)

2.5. Tobacco

1. Bio-intensive integrated management of tobacco aphid, *Myzus nicotianae* Blackman in central black soils of Andhra Pradesh (CTRI-Guntur)

2.6. Rice

1. Seasonal abundance of predatory spiders (PAU)

2. Diversity of insect pests and their natural enemies in organic and conventional rice (PAU)
3. Field evaluation of fungal pathogens on gundhi bug, *Leptocorisa oratorius* (KAU)

2.7. Maize

1. Bio suppression of *Chilo partellus* with *Trichogramma chilonis* on rabi maize (ANGRAU-Anakapalle)
2. Evaluation of NBAIR entomopathogenic strains against maize stem borer (ANGRAU-Anakapalle)

2.8. Sorghum

1. Field evaluation of NBAII entomopathogenic strains against sorghum stem borer, *Chilo partellus* (Swinhoe) in kharif sorghum (IIMR and UAS-R)

2.9. Pulses

1. Demonstration of NBAIR liquid formulation (PDBC BT1 AND NBAII BTG4) against pigeon pea pod borer (*Helicoverpa armigera*) (AAU and UAS-R)
2. Evaluation of microbial agents for management of Lepidopteran pests on Moong bean (*Spodoptera litura, Helicoverpa armigera*) (PAU)
3. Evaluation of IPM Modules of Green gram (MPUAT)
4. Evaluation of biocontrol agents against pod borers of cowpea (KAU)

2.10. Oil seeds

1. Biological suppression of mustard aphid, *Lipaphis erysimi* (MPKV)

2.11. Coconut

1. Bio-suppression of red palm weevil through entomopathogenic nematodes (CPCRI)

2.12. Tropical Fruits

1. Field evaluation of *Metarhizium anisopliae* formulations against mango hoppers (KAU and TNAU)
2. Survey, collection, Identification and Mass culturing of Trichogrammatids and Entomopathogenic nematodes from mango ecosystem in Uttar Pradesh and Uttarakhand for evaluation against mango leaf webber, *Orthaga euadrusalis* (CISH)
3. Monitor and record of incidence of papaya mealybug and its natural enemies on papaya and other alternate host (AAU, MPKV, KAU, TNAU and NBAIR)
4. Bio-efficacy of EPNs against Citrus trunk borer, Pseudonemophas (=Anoplophora) versteegi (CAU)
5. Field evaluation of Entomopathogens against banana pseudostem weevil, *Odoiporus longicollis* (KAU)

6. Field evaluation of entomopathogens against pineapple mealybug, *Dysmicoccus brevipes* (KAU)
7. Laboratory and field evaluation of entomopathogenic fungi against banana root mealybug, *Geococcus citrinus* (KAU)
8. Laboratory evaluation of entomopathogenic fungi against pepper root mealybug, Formicoccus *polysperes* (KAU)
9. Field evaluation of *Beauveria bassiana* liquid formulation against tea mosquito bug in Guava (TNAU)
10. Incidence of tamarind fruit and seed borer in Chhattisgarh state with their natural enemies.

2.13. Temperate Fruits

1. Evaluation of entomopathogenic fungi and EPNs for the suppression of Apple root borer, *Dorystheneshugelii* under field conditions (YSPUHF-Solan)
2. Survey for identification of suitable natural enemies of Codling moth, *Cydia pomonella* (SKUAST)
3. Field evaluation of *Trichogramma embryophagum* and *T. cacoeciae* against Codling moth, *Cydia pomonella* on apple (SKUAST)
4. Evaluation of predatory bug, *Blaptostethus pallescens* against European red mite, *Panonychus ulmi* on apple (SKUAST)
5. Field evaluation of anthocorid bug, *Blaptostethus pallescens* against Two spotted spider mite, *Tetranychus urticae* on apple (SKUAST)

2.14. Vegetables

1. Demonstration of BIPM package for management of key pests of tomato (AAU-J, MPUAT, TNAU and YSPUHF)
2. Survey and surveillance of pinworm, *Tuta absoluta* on tomato (AAU-A, AAU-J, KAU, MPKV, PAU, PJTSAU, SKUAST, YSPUHF, UAS-R, IIVR, TNAU and IGKV)
3. Biological suppression of American pinworm, *Tuta absoluta* on tomato (AAU-A, IIHR, MPKV, PJTSAU, UAS-R and YSPUHF-Solan)
4. Biological control of brinjal mealy bug, *Coccidohystrix insolitus* (TNAU)
5. Biological suppression of shoot and fruit borer, *Leucinodes orbonalis* in brinjal (MPKV)
6. Validation of different BIPM modules against shoot and fruit borer, *Leucinodes orbonalis* in brinjal (PAU)
7. Development of Biocontrol based IPM module against, *Leucinodes orbanalis* of Brinjal (AAU-J)
8. Bioefficacy evaluation of EPN formulations of NBAIR against ash weevil in brinjal (TNAU)
9. Bio-efficacy of microbial insecticides against *Spodoptera litura* in cabbage (AAU-A)
10. Role of habitat manipulation on natural enemies of cabbage pests (AAU-J)
11. Efficacy of *Bt* strains against Diamond back moth in Cauliflower (TNAU)
12. Field evaluation of biocontrol based IPM module against pests of cabbage (*Plutella xylostella*, *Spodoptera litura*, *Pieris brassicae*) (PAU)

13. Evaluation of fungal pathogens against sucking pest of hot chilli (*Capsicum sinensis*) (AAU-J and IIVR)
14. Development of bio-intensive IPM package for the suppression of insect pests of capsicum under field conditions (YSPUHF)
15. Biological suppression of fruit borer, *Earis vitella* in okra (MPKV)
16. BIPM in okra (OUAT)
17. Evaluation of Bio-intensive IPM module against, *Aleurodicus dispersus* on cassava (TNAU)
18. Evaluation of predatory bug, *Blaptostethus pallescens* against saffron thrips, *Haplothrips* sp. on saffron (SKUAST)
19. Biological Suppression of Bud Worm (*Hendecas*is *sp*) and Blossom Midge (*Contarinia sp*) in Jasmine (TNAU)
20. Effect of host plants on natural parasitism of *Diaphania indica* by the larval parasitoid, *Dolichogenidea stantoni* (IIHR)

2.15. Mealybugs

1. Monitoring the diversity and outbreaks for invasive mealy bug and other sap sucking pests on Cotton (TNAU, KAU, IIVR and OUAT)

2.16. Biological suppression of polyhouse crop pests

1. Monitoring the diversity of pests and natural enemies in chrysanthemum under polyhouse conditions (TNAU)
2. Evaluation of anthocorid predators against spider mites, *Tetranychus urticae* under insect net cage condition (PAU)
3. Evaluation of efficacy of predators against cabbage aphids in polyhouse (SKUAST)
4. Evaluation of entomopathogenic fungi against spider mite, *Tetranychus urticae* on capsicum /bell pepper under protected cultivation (PAU)
5. Biological management of red spider mite, *Tetranychus urticae* infesting rose in polyhouse conditions (MPKV)
6. Evaluation of biocontrol agents against sap sucking insect pests of ornamentals/ vegetables in polyhouses (YSPUHF)
7. Evaluation of predatory mite, *Neoseiulus longispinosus* against phytophagus mite in carnation under polyhouse conditions (YSPUHF)
8. Evaluation of Anthocorid predator, *Blapposthetes pallescens* against spider mites in polyhouse (NCIPM)

2.17. Biological suppression of storage pests

1. Evaluation of *Uscana* sp. (Trichogrammatidae) against *Callosobruchus* sp. on storability of pigeonpea seed (Dir.Seed.Res)

2.18. Enabling Large scale adoption of proven biocontrol technologies

CONTENTS

1. Rice (AAU-J. KAU, PAU, GBPUT and OUAT)

2. Sugarcane (OUAT and PAU)

i. Enabling large scale adoptation of proven biocontrol technologies against early shoot borer,Stalk borer and top borer of sugarcane (PAU)
ii. Enabling large scale adoptation of proven biocontrol technologies against early shoot borer and Internode borer of sugarcane (OUAT)

3. Maize

i. Demonstration of biological control of maize stem borer, C*hilo partellus* using *Trichogramma chilonis* (PAU)

4. Brinjal

i. BIPM in brinjal (OUAT)

2.19. Tribal sub plan programme (TSP)

1. AAU-Anand: Biocontrol technologies for the management of *Fusarium* wilt and pod bore (*H. armigera*) in pigeon pea
2. ANGRAU-Anakapalle: Organic Paddy cultivation
3. MPKV, Pune: Management of insect pests in fruit crops in tribal area
4. OUAT: Demonstration on biointensive pest management on brinjal at Kandhamal and Keonjhar districts.
5. TNAU-Coimbtore
6. YSPUHF: Use of eco-friendly methods of pest management for apple, apricot and vegetable crop pests.

2. Experimental Results

2.13 Temperate Fruits

2.14 Vegetables

2. EXPERIMENTAL RESULTS

2.1 Basic Research

2.1.1. National Bureau of Agricultural Insect Resources

Biosystematic studies on agricultural insects

i. Biodiversity of natural enemies of insect pests

Insect collections added from Rajasthan, Gujarat, Andamans & Nicobar islands, Mizoram and Karnataka: collected ~6000 specimens, >200 species during ~200 survey days. Described 3 new species, *Tetrastichus thetisae*, *Sympiesis thyrsisae* and *Halticoptera indica*. First phylogenetic study to resolve a diverse and geographically realistic subset of species within the genus *Glyptapanteles* (Hymenoptera: Braconidae) to correlate the host specialization in India was conducted. The genus *Glyptapanteles* is taxonomically challenging due to its highly speciose nature, morphological similarity amongst species and negligible host records. The present study was based on 60 populations reared from 35 host species, 100 + individual caterpillar rearings and from 12 different geographical locations of the country that represent 26

provisional *Glyptapanteles* species within 8 species-groups. Maximum likelihood and Bayesian inference methods displayed three and four major discrete *Glyptapanteles* clades, respectively. In clade A very few Indian species were grouped along with Neotropical and Thailand species. The other clades B and C grouped the majority of the Indian species and showed considerable host specificity in both the trees. Three different sets of data (morphology, host records, and COI) were integrated in order to generate accurate boundaries between species/species-groups. The present study, perhaps the most comprehensive done to date in India, suggests the presence of several additional *Glyptapanteles* species, which were previously unrecognized (Gupta *et al*., 2016). Images of life stages and damage of recent outbreak of *Hasora chromus* (Cramer) (Lepidoptera: Hesperiidae) in March 2016, Bangalore was uploaded in NBAIR website.

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

Surveys were conducted for Platygastroidea in eight states *viz*., Tripura, Andaman and Nicobar Islands, Tamil Nadu, Kerala and Karnataka. A total of 1150 parasitoids were collected, curated and preserved for future studies. So far 52 genera under four families of Platygastroidea were recorded from India under this project and an additional four genera are added raising the total to 66 genera. The four genera are *Pardoteleia, Pleistopleura, Ptiostenius, Titta* and *Nyleta.*

A new species group and fifteen new species has been described. The new species group *Idris adikeshavus* group has been proposed with five new species – *Idris adikeshavus, I. brevicornis, I. deergakombus, I. teestai* and *I. lopamudra.* Two new species, *Ptilostenius griffithi* and *P. nicevillei*, are described from both female and male specimens. A new species of Trimorus - *T. leptoclava* - with an unusual female antenna (the distal segments of the clava are not incrassate) is described. A new species of an unusual, sexually dimorphic species of *Gryon* – *Gryon ingens* has been described. This was reared from the eggs of *Isyndus heros* Fab (Hemiptera: Reduviidae) laid on leaves of mango. Six new species of platygastridae from India: *Amblyaspis khasiana* (Meghalaya), *A. kurinji* (Tamil Nadu, Shenbaganur), *Gastrotrypes longicaudatus* (Bengaluru), *G. manii* (Andaman Islands), *Isolia kalingi* (Orissa) and *Synopeas* (*Sactogaster*) *ribhoiense* (Meghalaya) are described and illustrated.

iii. Biosystematics of Trichogrammatidae (Hymenoptera)

Eight states were surveyed for Trichogrammatidae. These included island ecosystems like the Andamans and the Nicobars; lowland rainforests and cultivated areas in Tripura in NE India; cultivated and natural ecosystems in eastern India *viz*., Odisha; and Kerala, Tamil Nadu and Karnataka in S.India which included parts of the W.Ghats and other cultivated and non-cultivated areas.

The relatively recently described *T. rabindrai*, a species so far known only from S. India was discovered in S. Andaman. It is being bar coded to determine whether it is a cryptic species. A species of *Mirufens* was for the first time collected from the Nicobar islands. It was collected from leaf galls of *Dipterocarpus* sp. Additional species of trichogrammatids collected from the

Nicobars are being sorted for further studies. These are the first species of trichogrammatids to be collected from these islands.

A species of *Trichogrammatoidea* similar *T. tenuigonadium* in habitus but with genitalia in males resembling other *Trichogrammatoidea* has been discovered from Karnataka. The barcode generated for this species is distinct unlike any other species in the genus thus validating its status as a new species.

iv. Biodiversity of aphids, coccids and their natural enemies

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

v. Documentation, production and utilisation of predatory anthocorids and mites

Anthocorid predators such as *Montandoniola bellatula* Yamada 2007 and *Xylocoris cerealis* Yamada and Yasunaga 2006 (from Karnataka) were new records for India. Two new species of *Orius* were recorded, one from coconut and rose and another from *Clerodendrum infortunatum*, all from Karnataka. Four anthocorid predators, *viz*., *Cardiastethus exiguus, Bilia castanea, Orius maxidentex* and *Buchananiella pseudococci pseudococci* were recorded on thrips infested mulberry in Salem (Tamil Nadu) and *O. maxidentex* from Karnataka. A new species of *Orius* was recorded on *Clerodendrum infortunatum*. Though the population of aphids and broad mites was low, there seemed to be a close correlation between the populations of the pests and the anthocorid. It was interesting to observe that this anthocorid could survive the harsh summer months. The fertility parameters of two litter inhabiting anthocorids *Amphiareus constrictus* and *Buchananiella indica* were studied, of which *A. constrictus* had a higher reproductive rate than *B. indica*, while the finite rate of increase was comparable for the two species.

Four to six releases of *Blaptostethus pallescens* against broad mites (*Polyphagotarsonemus* latus) infesting capsicum could significantly reduce the pest incidence and curling symptoms and improve the plant height in comparison to control where no releases were made.

EM and LM images of eggs of *Blaptostethus pallescens* and *Blaptostethoides pacificus* were examined to identify characters, which can be utilised to separate them. The follicular pits on the surface of the operculum form different patterns, which aid as identification characters.

Xylocoris flavipes and *Blaptostethus pallescens* were evaluated against *Sitophilus oryzae* infested maize seeds. The treatments where 20 and 30 *X. flavipes* nymphs and 40 *X. flavipes* adults were released and where 20, 30 and 40 *B. pallescens* nymphs were released after seven days of egg laying by *S. oryzae*, were significantly superior to control. In another experiment

where anthocorid predators were released along with the pests, pest emergence was significantly reduced in the treatments with 10 *B. pallescens* nymphs, and 10 and 30 *B. pallescens* adults and 10 to 30 *X. flavipes* adults. This experiment indicates that anthocorid predators are potential bio-agents of *Sitophilus oryzae* and would be very effective if introduced as soon as seeds are stored as they would deter adult oviposition.

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

T. chilonis was exposed in large 3 ft cages @ of 8 tricho cards / per one nucleus card and maximum of 104 cards could be exposed at a time and parasitism reached up to 99.0%. By adopting a similar method, *T. japonicum* was exposed @ of 4 tricho cards / per one nucleus card and maximum of 97 cards could be exposed at a time and up to 85.0% parasitism could be recorded.

The interaction between two parasitoids of litchi stink bug *Anastatus acherontiae* and *Anastatus bangalorensis* was studied. In sequential and simultaneous exposures, overall parasitism (26.7 to 90.0%) was significantly higher than or on par with the parasitism by individual species indicating that the parasitoids are complementary to each other.

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

Different parasitoids, predators and other insects were collected from Andaman & Nicobar Islands, Srinagar, Pune, Anand, Varanasi, Dharmapuri and Bangalore and were used for DNA barcoding studies. Parasitoids belong to Braconidae *viz*., *Glyptapanteles* sp. (Barcode: ACZ3549) (Genbank Acc. No. KR260984), *Glyptapanteles* sp *(***AAI5405) (**KT284335), *Glyptapanteles* sp (ACZ3433) (KT25318), *Microplitis maculipennis* (ACV9232) (KP759295), *Glyptapanteles creatonoti* (AAH1199) (KR021154), *Glyptapanteles* sp (ACZ3493) (KT254316), *Glyptapanteles obliquae* (Wilkinson) (ACS3730) (KR021152), *Glyptapanteles aristolochiae* (Wilkinson) (ACZ3726) (KR021156), *Glyptapanteles cf. Spodopterae Ahamad (*ACS3730) (KR260983), *Glyptapanteles spodopterae* (ACS3730) (KR260976), *Glyptapanteles* sp (AAH1199) (KT284334), *Glyptapanteles* sp (ACZ3303) (KT254319), *Glyptapanteles bliquae* (Wilkinson) (AAH1199) (KR021152),*Glyptapanteles cf. amprosemae* Ahmad (ACZ3016) (KT284342) were characterized and barcodes generated. Phylogenetic analyses were performed on 38 based on mitochondrial cytochrome oxidase subunit I (COI) nucleotide sequences. Maximum likelihood and Bayesian inference methods displayed three and four major discrete **Glyptapanteles** clades, respectively. Furthermore, molecular characterization and DNA barcodes were generated for 103 agriculturally important parasitoids, predators and other insects based on COI gene & ITS-2 and deposited in GenBank and BOLD and obtained accession numbers.

A study was conducted to identify and differentiate *Trichogramma* species and infer their evolutionary relationship based on internal transcribed spacer-2 (ITS-2) and cytochrome oxidase I (COI). With available related species sequences of COI and ITS-2 loci, Bayesian phylogenetic trees for total 84 and 76 Trichogrammatids sequences were considered to understand evolutionary relationship among the different species and their identification. Performed comparative assessment of mean intra- and inter- specific evolutionary distances of using COI and ITS-2. In case of ITS-2 locus, the low intra- and high inter-specific distances was estimated for the different groups in trichogrammatids. Overall, ITS-2 is appropriate molecular marker identification in Trichogrammatids, at both species and genera level.

vii. Monitoring of invasive pests

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

Tuta absoluta (Meyrick 1917), a lepidopteran tomato leaf miner also called as pin borer belongs to the family Gelichiidae. It is considered as one of the most devastating tomato pests in the countries it has invaded so far. It has originated from Peru (South America) and then invaded many other countries in South America, Europe, Africa and Asia. *T. absoluta* larvae can completely destroy the tomato leaves by mining leaves, stems and buds and burrowing tunnels in the fruits, causing the unmarketability of fresh tomatoes and yield losses up to 100%. The pest was detected and identified in October 2014 from Pune, Maharashtra in India by the Scientists of ICAR and now poses most serious threat to tomato cultivation in the country. The damage of this pest on tomato crops has been reported from Gujarat, Maharashtra, Telangana, Andhra Pradesh, Karnataka and Tamil Nadu.

1. Diagnostic features of *T. absoluta* damage on tomato

Feeding damage is caused by all the larval instars. Larva attacks all the parts of tomato except roots throughout the crop stage *i.e.*, from seedling to harvest and can cause up to 100% crop damage mainly the leaves and green fruits. *T. absoluta* can be easily recognized on tomato plants by the presence of large blotch or mine on the leaves with dark frass inside and pinhead size holes on the developing fruits. On the leaves, the larvae feed on the mesophyll tissue, forming large mines or extensive galleries. In case of serious infestation, leaves die completely. The larval entry and exit holes on the fruits are small and pin-head sized. Sometimes the entry and exit holes are used by secondary pathogens, leading to fruit rot. Multiple holes and presence of many larvae in a fruit can be noticed **(Table 1)**. The other potential host plants for *T. absoluta* in India are brinjal and potato apart from other solanaceous weed hosts.

Table 1. Extent of damage on tomato crop by *T. absoluta* in different states during March 2015 to February 2016

State / District	Place / village	% leaf miner (Blotch)	% Fruit damage
Tamil Nadu: Dharmapuri	Palakodu	5.7-55.5%	3.5-43.4 %

Krishnagiri	Rayakottai, Kelamangalam, Ulimaranapalli, Binnamangalam Hosur, Soolagiri, Bagalur	11.8-46.2%	7.5-52.4%
Coimbatore	Iruttupallam, Alandurai, Thondamuthur	Nil	Nil
Dindugal	Moolanur, Kaveriammapatti, Oddanchathiram	Nil	Nil
Karnataka: Chintamanai	Doddaulluru, Nandagudi Kadagaskanahalli, Kuruhatti	1.5-41.7%	5.0-32.5%
Kolar	Malur	3.5-64.3%	0.0-41.8%
Bengaluru Rural	Devanahalli, Doddaballapur Hessarghatta, Rajanukunte, Hoskote	5.5-33.5%	11-28.5%
Bengaluru Urban	Anekal, Jigini, Halehalli	4.5-45.5%	2-32.7.0%
Raichur (North Karnataka)	Kadagammadoddi, Kapur, Katlekur, Singandoddi and Hosur	10.2 – 60.3%	2.6 – 35.8%
Andhra Pradesh	Madanapalli, Kuppam	13.0-36.7%	0.0-21.8%
Telangana	Warangal, Adilabad	0.0-2.8%	>1.0%
Gujarat: Surendranagar	Sayala, Limbudi	1-4.5%	Nil
Rajkot	Dhoraji, Gondal, Jetpur	2-3%	Nil
Junagadh	Vadal, Choki	5.5-17.0%	5-12.5%
Jamnagar	Jalansar	1-4%	Nil
Anand	Anand	>2%	Nil

2. Natural enemies of *Tuta absoluta*

Cage studies were conducted to evaluate *Trichogramma* species against eggs of *Tuta absoluta* infesting tomato plant. Three species of *Trichogramma* could successfully parasitize *T. absoluta*. Parasitism by *Trichogramma achaeae* was 28.8% followed by *T. pretiosum* (thelytokous) (22.7%) and *Trichogrammatoidea bactrae* (12.5%). No parasitism was recorded in the cages where *T. chilonis* was released.

Anthocorid predators, *Amphiareus constrictus* and *Blaptostethus pallescens* were observed to be efficient predators of *Tuta absoluta* eggs, feeding on 90 to 100% of the eggs when released in a ratio of 1 predator: 10 eggs.

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

Four NBAIR Bt isolates along with standard MTCC-8997 expressing the coleopteran specific proteins were tested against early second instar larvae of *Tuta absoluta* by tomato leaf dip methodology. The most toxic was NBAIR-4 isolate with LC_{50} of 301.3 ppm, followed by NBAIR-1, which showed LC_{50} as 373.7 ppm. The formulations are being tested for field efficacy **(Table 2)**.

Table 2. Bioassay of NBAIR *Bt* isolates against *Tuta absoluta*

Bt Isolate	LC_{50} (48h) in ppm	Slope ± SE	F-Limits		χ^2 (DF)
			L	U	
NBAIR-1	373.7	3.74 ± 0.72	286.2	486.8	1.1 (3)
NBAIR-3	413.7	2.8 ± 0.93	301.9	569.3	1.9 (3)
NBAIR-4	301.3	4.5 ± 0.92	234.3	382.5	1.7 (3)
NBAIR-6	860.3	2.3 ± 0.51	603.3	1492.4	1.2 (3)
MTCC-8997	999.0	2.83 ± 0.51	408.6	767.9	1.9 (3)

Laboratory bioassay with three isolates each of *B. bassiana* (Bb-5a, Bb-19 and Bb-23) and *M. anisopliae* (Ma-4, Ma-6 and Ma-35) against *Tuta absoluta* was carried out and the results indicated very low mycosis (6.7 to 26.7%) with these isolates.

4. Rapid action management plan advocated to farmers

i. Destruction of infested tomato plants and fruits by burying deep inside the soil or by burning.
ii. Crop rotation with non solanaceous crops.
iii. Nursery with pest proof net covering and use of pest free seedlings for transplantation
iv. Preservation / augmentation of natural enemies like *Nesidiocoris tenuis*, *Necremnus* sp., *Orius* sp., and *Trichogramma* spp.
v. Installation of *T. absoluta* pheromone baits for monitoring and mass trapping male moths both in nursery and main field (40 traps /ha).
vi. Initiate the use of insecticide both in nursery and main field, if the moth catches in the pheromone trap is exceeding 20-30 moths/trap / week.
vii. Recommended the following insecticides (as per the decision taken at the 355th meeting of CIB registration committee held on 29.04.2015) for managing the pest on tomato.

Sl. No	Name	Dose/lit

1	Chlorantriniliprole (Rynaxypyr) 10.26% OD	0.3 ml/lit
2	Cynatriniliprole (Cynaxypyr) 18.5% SC	0.3 ml/lit
3	Flubendiamide 20% WG	0.3 ml/lit
4	Indoxacarb 14.5% SC	0.5 ml/lit
5	Imidacloprid 17.8% SL	0.3 ml/lit
6	Neem formulation (Azadirachtin content of either @ 1% or 5%)	2-3 ml/lit

a. Studies on papaya mealybug

Incidence of papaya mealybug was recorded below pest level in all the areas surveyed. However, in the summer of 2016, it was recorded in Andaman Islands causing 25-30% damage on papaya and other vegetable crops. Three consignments of parasitoids were sent for managing the same **(Table 3).**

Table 3. Incidence of papaya mealy bug and its natural enemies on papaya and other alternate hosts

Location	Area of plantation (ha)	No of plants with Papaya mealybug	Damage
Mandya	8.0	12	Trace
Raichur	1.5	2	Trace
Shimoga	0.5	Nil	-
Hassan	1.5	Nil	-
Gulbarga	0.5	Nil	-
Bangalore	0.5	2	Trace
Maddur	2.8	Nil	-
Ramnagar	0.5	7	Severe in one
Chamrajnagar	5.5	2	Trace
Chitradurga	0.5	Nil	-
Tumkur	1.0	Nil	-
Nelamangala	2.0	2	Trace
Coimbatore	0.5	2	Trace
Nashik	1.2	Nil	-
Nagpur	0.5	Nil	-
Hosur	2.5	7	Severe in 2 trees
Andaman Islands	0.5	15	Severe

Parasitism: A high level of parasitism was recorded from all the samples collected. *Acerophagus papayae* was the predominant parasitoid exercising control in addition *Pseudleptomastix mexicana* was recorded in all the samples with parasitism ranging from 5.0 to 20.0%. None of the samples recorded from any area was free from parasitoids showing their wide spread presence and their adaptability to Indian conditions.

Hyper parasitism: Parasitism of Acerophagus papayae by hyper parasitoids are showing increasing trend in Karnataka. The samples collected from Nelamangala, Chamarajnagar and Maddur had 6.0 to 7.0% hyperparasitism by *Chartocerus* sp. and 2.0 to 3.0% by *Marietta leopardina*.

Supply of natural enemies: *Acerophagus papayae* and *Pseudleptomastix mexicana* cultures were sent to OUAT Bhubaneswar, Andaman Islands, Hosur, Madurai, New Delhi, Gujarat, Pondicherry, Ananthpur, in addition to local supplies in Karnataka. Cultures of *Aenasius arizonensis*, *Zygogramma bicolorata*, *Neochetina* spp. were sent to the requested researchers and organizations.

b. Invasive whitefly, *Aleurothrixus trachoides*

The association between the invasive pest solanum whitefly *Aleurothrixus trachoides* (Back) and the predator *Axinoscymnus puttarudriahi* Kapur and Munshi on capsicum under natural conditions was studied. Spatial distribution pattern was studied and the variance to mean ratio being greater than unity indicated an aggregated distribution of the pest and the predator. The positive association between the pest and the predator was confirmed through correlation analysis and 2 x 2 Chi-square test. Releases of *Blaptostethus pallescens* nymphs indicated that it is a potential predator of *A. trachoides* and confirmatory small scale field trials would be taken up.

c. Host range of invasive Jack Beardsley mealybug, *Pseudococcus jackbeardsleyi* Gimpel and Miller in Karnataka

Survey of *P. jackbeardsleyi* was continued in Tamil Nadu and Karnataka, sometime it was found co-associated with papaya mealybug on papaya and with Madeira mealybug in hibiscus, *Cordyline terminalis* (Agavaceae), *Defembekia* sp. Incidence was very low compared to previous years. Some of the local natural enemies like *Cryptolaemus montrouzieri* Mulsant, *Spalgis epius* Westwood and many species of gnats are keeping the spread under check. *Nephus regularis* was found to be a major predator on eggs of *P. jackbeardsleyi* and was found to be a major limiting factor for spread of this mealybug.

d. Establishment of *Cecidochares connexa*, gall fly of *Chromolaena*

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

e. Survey for invasive thrips, *Frankliniella occidentalis*

Frequent collections of tomato, chilli and flowers were made to know the damage and spread of western flower thrips, *Frankliniella occidentalis* in India. The samples collected from different locations in Karnataka (Bangalore, Raichur, Shimoga, Hassan, Gulbarga, Chitradurga, Tumkur, Nelamangala), Tamil Nadu (Hosur, Dharmapuri and Coimbatore) and Maharastra (Nashik and Nagpur) did not yield any specimen of *F. occidentalis* showing its non occurrence in these locations.

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

Aenasius arizonensis (Girault) (Hymenoptera: Encyrtidae), a solitary endoparasitoid on *P. solenopsis* was active in all the cotton growing areas and also on other alternate hosts. Adult females showed preference to parasitize third instar nymphs. Reddish brown cocoons scattered in the mealybug colony indicates the parasitism by *A. arizonensis* and can easily be distinguished from the healthy colony. Studies on mass production of parasitoids using *Parthenium hysterophorus* as host revealed that the total developmental period: 16 to 20 days and pupal period of 6 to 8 days. Adult longevity: females: 13 to 30 days and males 8 to 10 days with fecundity of 130-150 eggs. Females are more in number compared to males (Around 30 males to 100 females in *Parthenium* host plant). Parasitoids were supplied to farmers on request.

g. Erythrina gall wasp managment

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

h. Incidence of leaf miner, *Chromatomyia syngenisiae*

Severe outbreak of *Chromatomyia syngenisiae* leaf miner was recorded from Coonor, Ooty and nearby areas including in poly houses across Nilgiri hills and Coimbatore. The incidence occurred in > 80.0% of the plants in the sampled area and the yellow traps were full by the end of the day of installation with adult flies. No parasitoids were recorded from the area. Release of *Diglyphus* sp. also did not bring down the damages. *Herbertia* sp. (Hymenoptera: Pteromalidae) was collected from the mummified puparium of the leaf miners.

i. New invasives and host extensions

- Banana skipper, *Erionota thrax* (Lepidoptera: Hespiridae) severity has come down.
- Root mealybugs on pepper, *Formicococcus polysperes* Williams and other species have become severe in Coorg and Chickmagalur area.
- The skipper, common banded awl, *Hasora chromus* (Cramer) (Lepidoptera: Hesperiidae), upsurge was recorded on *Pongamia pinnata* in and around Bangalore. In some localities

the caterpillars entered houses creating panic among people (in HSR Layout). High incidence was also noticed in ICAR-NBAIR research farm. The trees were entirely defoliated. Many insectivorous birds were seen feeding on the caterpillars.

- A looper (*Cleora* sp.) (Lepidoptera: Geometridae) was found to feed extensively on neem trees in a few villages of Samsthan Narayanpur Mandal of Nalgonda district in Telangana during October/November 2015. Similar damage was found in the nearby villages also. Previously this was recorded as a pest of pigeon pea from Hyderabad.
- Pepper root mealybugs: Mealybugs are major insect pests of black pepper plantations in southern parts of India. Five mealybugs species namely *Planococcus* sp., *Planococcus citri* (Risso), *P. lilacinus* Cockerell, *Dysmicoccus brevipes* (Cockerell) and *Ferrisia virgata* (Cockerell) are known to infest the roots and basal region of stem of black pepper vines. However *Formicococcus polysperes* Williams and other species have become severe in Coorg and Chickmagalur area.

viii. Biosystematics and diversity of entomogenous nematodes in India

One hundred and thirty three soil samples were collected randomly from vegetables, banana, rubber, sugarcane, forest land of Marampally, Mudical, Vanjnadu, Kalady, Pala, Nedumudy, Changanassery, Kozhenchery, Chengannur in Kerala, Koppa, Jayapura, Balehonnur, Rambhapuri, Ganganamakki in Karnataka, Kadapa, Ananthagiri, Kothavalasa, Araku valley and Aanakapalle in Andhra Pradesh, Pune in Maharashtra and Great Nicobar islands. Total three insect associated nematodes were (*Steinernema* sp, *Heterorhabidtis* sp and *Oscheius chromogenesis*) isolated from these places.

a. Efficacy of entomopathogenic nematodes on phorids

The pathogenicity of *Heterorhabditis indica*, *Steinernema capocapsae* and *Oscheius* sp were tested against maggots and pupae. These results showed that maggots were resistance to these nematodes and no mortality was observed. However, *Oscheius* sp showed mortality in pupae only.

b. Efficacy of entomopathogenic nematodes (Rhabditida: Steinernematidae and Heterorhabditidae) on developmental stages of house fly, *Musca domestica*

The efficacy of five species of entomopathogenic nematodes (EPN), *Heterorhabditis indica*, *S. carpocapsae*, *S. glaseri*, *S. abbasi* and *S. feltiae* against developmental stages of house fly was studied under laboratory condition. In this present study, none of the EPN species tested infection on egg and pupal stages, while the second and third instar larvae were susceptible to all EPN species but second instar was more susceptible than third instar. Among the EPN species tested, *S. carpocapsae* caused significantly greater mortality (81.25-100%) than the *H. indica* (62.5-100%), *S. glaseri* (25-100%), *S. abbasi* and *S. feltiae* (6.25-100%) of the second instars of *M. domectica*. Whereas, *H. indica* caused significantly greater mortality (18.75-100%) than the *S. carpocapsae*, *S. glaseri*, *S. abbasi* and *S. feltiae* (6.25-100%) of third instars of *M. domestica*

at 50-10000 IJs/maggot. EPN species @ 10000 IJs/larva caused up to 81.25% mortality in artificial diet and 25% mortality in the poultry manure @ 256000 IJs/maggot.

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

A dose of 200 IJs/pupae of *Oscheius sp.* caused 80% pupal mortality of *Bactrocera cucurbitae* after 48 hrs of inoculation.

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

Twenty five isolates of *Bacillus thuringiensis* with bipyrmadal crystals were isolated from 86 soil and insect samples collected from Western Ghats. Soil samples from Greater Nicobar Islands yielded 4 isolates of *Bt* expressing bipyramal and spherical crystals.

The trypsin activated vip3A protein (4 hrs IPTG inductions) caused 100% mortality of *Plutella xylostella* after 72 hours in all the protein concentrations tested. The highest mortality of 100% was recorded at 500 µg concentration after 48 hours. The LC_{50} value was calculated as 53.676 µg/ ml. Trypsin activated vip3A protein (16 hrs IPTG inductions) was also tested and the LC_{50} was calculated as 52.87 µg/ ml.

Cry8A expressing *B. thuringiensis* (NBAIR-BTAN4) caused 100% mortality of potato grub after 48 hrs.

Liquid formulation of NBAIR-BTG4 and standard HD-1 were tested against *Cryptolemus montrouzieri* and *Chrysoperla carnea* @ 1 and 2% concentrations. No mortality was recorded indicating their safety against the natural enemies.

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

a. Establishment of *B. bassiana* as endophyte in maize and sorghum

Glasshouse experiments were conducted to study the endophytic ability of six strains of *Beauveria bassiana* (NBAIR-Bb-5a, 7, 14, 19, 23 and 45) in maize (Var. Nithyashree) through foliar application of oil formulations and in sorghum through foliar application of aqueous conidial suspension. All six strains showed varying percent colonizations and persistence in stem and leaf tissues of maize and sorghum. In case of maize, Bb-45 isolate recorded the maximum colonization of *B. bassiana* in older stem (46.67%), older leaf (47.78%) and young stem (52.22%) tissues. Bb-5a isolate showed maximum colonization in young leaf tissues (57.78%). Bb-5a strain also showed continuous colonization upto 60 DAT in both older/young stem and leaf tissues. In case of sorghum, Bb-5a isolate recorded the maximum colonization in older stem (21.30%) and young leaf tissues (22.22%). Bb-14 isolate showed maximum colonization in young stem (18.52%) and in older leaf tissues (28.70%). Bb-5a isolate also showed continuous colonization upto 60 DAT in older & younger stem tissues and also in older leaf tissues. Bb-14 isolate showed continuous colonization upto 75 DAT in older leaf tissues.

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

Field trials were conducted to evaluate the endophytic isolates of *B. bassiana* (NBAIR-Bb-5a, 7, 14, 19, 23 and 45) through foliar applications of oil formulations against stem borer, *Chilo partellus* in maize and sorghum at ICAR-NBAIR, Attur Research Farm, Bengaluru.

In maize, Bb-5a isolate showed significantly lower dead hearts (10.2 and 7.1% during kharif and rabi seasons respectively), lowest no. of exit holes (1.80 and 1.07/plant) and stem tunneling (1.23 and 2.21cm/plant) as compared to untreated control which showed higher dead hearts (23.6 and 26.8%), exit holes (7.2 and 4.07/plant) and stem tunneling (5.2 and 7.8 cm/plant).

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

2.1.2 Indian Agricultural Research Institute, New Delhi

1. Evaluation of *Trichogramma* strains for searching efficiency, temperature tolerance and fecundity and breeding of better performing strains *Trichogramma chilonis* under laboratory conditions

The field collected strains were maintained under laboratory conditions using *C. cephalonica* eggs. The better performing strains were used for further crossings. Test and back crosses were made between different strains of *T. chilonis* AAA10 (relatively temperature tolerant) with other high fecundity strains, *viz*., FFF1, FFF2 and FFF3. The results indicated high mortality among the individuals in each generation. The crosses with high fecundity are relatively more susceptible to test temperature regimes coupled with higher percentage of males. With increase in temperature stress, percentage of males among the progenies also increased. In some of the crosses all the progenies were males. The details of the crosses made and their breeding performance have been presented in the following tables.

i. Breeding of *Trichogramma chilonis* for temperature tolerance under laboratory conditions

1. FFF1 (male) x AAA10 (female) (AD1): Out of 15 pairs selected, fecundity ranged from 23 to 70 progenies. At F10, generation 15 pairs were selected and shifted to 36 °C **(Table 4)**.
2. AAA10 (male) x FFF1 (female) (BD1): Out of 15 pairs selected, fecundity ranged from 32 to 72 progenies. At F10 generations, 15 pairs were selected and shifted to 36 °C **(Table 4)**.

Table 4. Number of progenies emerged from crosses made and maintained at 34 ^{o}C

	FFF1 (male) x AAA10 (female) AD1 34 °C		AAA10 (male) x FFF1 (female) BD1 34 °C
	No. of adults emerged in F10		No. of adults emerged in F10
1	60	1	58
2	65	2	42
3	55	3	69
4	70	4	56
5	54	5	60
6	63	6	65
7	42	7	49
8	49	8	38
9	50	9	32
10	52	10	51
11	36	11	47
12	31	12	71
13	29	13	72
14	23	14	64
15	45	15	39

3. FFF1 (male) x AAA10 (female) AD1: Out of 15 pairs selected, fecundity ranged from 29 to 66 progenies and arrhenotoky was observed in three crosses. At F10 generation, 15 pairs were selected and shifted to 38 °C **(Table 5)**.
4. AAA10 (male) x FFF1 (female) BD1: Out of 15 pairs selected, fecundity ranged from 35 to 71 progenies and arrhenotoky was observed in one cross only. At F10 generations, 15 pairs were selected and shifted to 38 °C **(Table 5)**.

Table 5. Number of progenies emerged from crosses made and maintained at 36 ^{o}C

	FFF1 (male) x AAA10 (female) AD1 36 °C		**AAA10 (male) x FFF1 (female) BD1 36 °C**
	No. of adults emerged in F10		**No. of adults emerged in F10**
1	29	1	44
2	Arrhenotoky	2	42
3	42	3	59
4	65	4	Arrhenotoky
5	Arrhenotoky	5	43
6	51	6	55
7	42	7	69
8	49	8	35
9	65	9	48
10	66	10	53
11	41	11	46
12	35	12	71
13	Arrhenotoky	13	42
14	44	14	64
15	47	15	45

5. FFF1 (male) x AAA10 (female) AD1: Out of 15 pairs selected, fecundity ranged from 31 to 53 progenies and arrhenotoky was observed in three crosses **(Table 6)**.
6. AAA10 (male) x FFF1 (female) BD1: Out of 15 pairs selected, fecundity ranged from 29 to 51 progenies and arrhenotoky was observed in one cross only **(Table 6)**.

Table 6. Number of progenies emerged from crosses made and maintained at 38^{o}C

	FFF1 (male) x AAA10 (female) AD1 38 °C		**AAA10 (male) x FFF1 (female) BD1 38 °C**
	No. of adults emerged in F10		No. of adults emerged in F10
1	Arrhenotoky	1	29
2	Arrhenotoky	2	Arrhenotoky
3	42	3	49
4	41	4	Arrhenotoky
5	Arrhenotoky	5	51
6	31	6	35
7	Arrhenotoky	7	36

8	32	8	Arrhenotoky
9	53	9	44
10	Arrhenotoky	10	39
11	44	11	Arrhenotoky
12	32	12	Arrhenotoky
13	42	13	42
14	Arrhenotoky	14	Arrhenotoky
15	Arrhenotoky	15	Arrhenotoky

7. FFF2 (male) x AAA10 (female) (AD1): Out of 15 pairs selected, fecundity ranged from 36 to 86 progenies. At F10 generation, 15 pairs were selected and shifted to 36 °C **(Table 7)**.
8. AAA10 (male) x FFF2 (female) (BD1): Out of 15 pairs selected, fecundity ranged from 36 to 68 progenies. At F10 generation, 15 pairs were selected and shifted to 36 °C **(Table 7)**.

Table 7. Number of progenies emerged from crosses made and maintained at 34 ^{o}C

	FFF2 (male) x AAA10 (female) AD2 34 °C		**AAA10 (male) x FFF2 (female) BD2 34 °C**
	No. of adults emerged in F10		**No. of adults emerged in F10**
1	57	1	47
2	39	2	63
3	67	3	57
4	54	4	36
5	86	5	68
6	75	6	59
7	66	7	41
8	45	8	54
9	38	9	38
10	65	10	45
11	54	11	51
12	36	12	62
13	55	13	48
14	64	14	50
15	44	15	38

9. FFF2 (male) x AAA10 (female) AD1: Out of 15 pairs selected, fecundity ranged from 21 to 60 progenies and arrhenotoky was observed in two crosses. At F10 generation, 15 pairs were selected and shifted to 38 °C **(Table 8)**.
10. AAA10 (male) x FFF2 (female) BD1: Out of 15 pairs selected, fecundity ranged from 17 to 53 progenies and no arrhenotoky was observed. At F10 generation, 15 pairs were selected and shifted to 38 °C **(Table 8)**.

Table 8. Number of progenies emerged from crosses made and maintained at 36 ^{o}C

	FFF2 (male) x AAA10 (female) AD2 36 °C		AAA10 (male) x FFF2 (female) BD2 36 °C
	No. of adults emerged in F10		**No. of adults emerged in F10**
1	32	1	47
2	39	2	53
3	47	3	41
4	28	4	36
5	21	5	51
6	46	6	42
7	44	7	39
8	39	8	17
9	Arrhenotoky	9	48
10	58	10	43
11	35	11	26
12	45	12	29
13	58	13	48
14	60	14	54
15	Arrhenotoky	15	18

11. FFF2 (male) x AAA10 (female) AD1: Out of 15 pairs selected, fecundity ranged from 14 to 45 progenies and arrhenotoky was observed in eight crosses **(Table 9)**.
12. AAA10 (male) x FFF2 (female) BD1: Out of 15 pairs selected, fecundity ranged from 11 to 48 progenies and arrhenotoky was observed in eight cross **(Table 9)**.

Table 9. Number of progenies emerged from crosses made and maintained at 38 ^{o}C

	FFF2 (male) x AAA10 (female) AD2 38 °C		AAA10 (male) x FFF2 (female) BD2 38 °C
	No. of adults emerged in F10		**No. of adults emerged in F10**
1	Arrhenotoky	1	Arrhenotoky
2	29	2	Arrhenotoky
3	Arrhenotoky	3	11
4	Arrhenotoky	4	26
5	Arrhenotoky	5	Arrhenotoky
6	37	6	Arrhenotoky
7	34	7	Arrhenotoky
8	Arrhenotoky	8	37
9	45	9	48
10	38	10	43
11	Arrhenotoky	11	Arrhenotoky
12	Arrhenotoky	12	Arrhenotoky
13	14	13	13
14	40	14	Arrhenotoky
15	Arrhenotoky	15	28

13. FFF3 (male) x AAA10 (female) (AD1): Out of 15 pairs selected, fecundity ranged from 29 to 82 progenies. At F10 generation, 15 pairs were selected and shifted to 36 °C **(Table 10)**.
14. AAA10 (male) x FFF3 (female) (BD1): Out of 15 pairs selected, fecundity ranged from 28 to 91 progenies. At F10 generation, 15 pairs were selected and shifted to 36 °C **(Table 10)**.

Table 10. Number of progenies emerged from crosses made and maintained at 34 ^{o}C

FFF3 (male) x AAA10 (female) AD3 34 °C			**AAA10 (male) x FFF3 (female) BD3 34 °C**
	No. of adults emerged in F10		**No. of adults emerged in F10**
1	43	1	28
2	29	2	46
3	56	3	76
4	41	4	64
5	64	5	62
6	62	6	52
7	47	7	46
8	73	8	49
9	82	9	58
10	79	10	91
11	24	11	39
12	36	12	51
13	40	13	58
14	45	14	37
15	53	15	40

15. FFF3 (male) x AAA10 (female) AD1: Out of 15 pairs selected, fecundity ranged from 22 to 71 progenies and arrhenotoky was observed in three crosses. At F10 generation, 15 pairs were selected and shifted to 38 °C **(Table 11)**.
16. AAA10 (male) x FFF3 (female) BD1: Out of 15 pairs selected fecundity ranged from 24 to 58 progenies and arrhenotoky was observed in three crosses. At F10 generation, 15 pairs were selected and shifted to 38 °C **(Table 11)**.

Table 11. Number of progenies emerged from crosses made and maintained at 36 ^{o}C

FFF3 (male) x AAA10 (female) AD3 36 °C			**AAA10 (male) x FFF3 (female) BD3 36 °C**
	No. of adults emerged in F10		**No. of adults emerged in F10**
1	43	1	58
2	29	2	39
3	Arrhenotoky	3	36
4	41	4	44
5	54	5	51

6	Arrhenotoky	6	34
7	48	7	31
8	22	8	24
9	Arrhenotoky	9	Arrhenotoky
10	26	10	Arrhenotoky
11	24	11	Arrhenotoky
12	36	12	41
13	41	13	48
14	52	14	34
15	74	15	50

17. FFF3 (male) x AAA10 (female) AD1: Out of 15 pairs selected, fecundity ranged from 20 to 44 progenies and arrhenotoky was observed in nine crosses **(Table 12)**.
18. AAA10 (male) x FFF3 (female) BD1: Out of 15 pairs selected, fecundity ranged from 16 to 46 progenies and arrhenotoky was observed in eight crosses **(Table 12)**.

Table 12. Number of progenies emerged from crosses made and maintained at 38 ^{o}C

FFF3 (male) x AAA10 (female) AD3 38 °C			**AAA10 (male) x FFF3 (female) BD3 38 °C**
	No. of adults emerged in F10		**No. of adults emerged in F10**
1	23	1	38
2	29	2	Arrhenotoky
3	Arrhenotoky	3	Arrhenotoky
4	31	4	24
5	44	5	41
6	Arrhenotoky	6	Arrhenotoky
7	Arrhenotoky	7	46
8	Arrhenotoky	8	39
9	Arrhenotoky	9	16
10	Arrhenotoky	10	32
11	34	11	Arrhenotoky
12	20	12	Arrhenotoky
13	Arrhenotoky	13	Arrhenotoky
14	Arrhenotoky	14	Arrhenotoky
15	Arrhenotoky	15	Arrhenotoky

ii. Greenhouse/net house trials for evaluating the performance of improved *Trichogramma chilonis* strains on cole crop insect pests (cauliflower and cabbage)

Experiments were carried out under net house conditions on cauliflower and cabbage crops. All the recommended agronomic package of practices were followed. Adults of *P. xylostella* and eggs of *P. brassicae* were introduced in the net house when the crop was two months old and then the improved strains of *T. chilonis* were released. The per cent parasitization was recorded. It was observed that the improved parasitoids performed as good as the wild ones when compared with the parasitization in open field.

2. Screening for temperature tolerance in Cotton mealybug parasitoid, *Aenasius arizonensis* (Girault) (=*Aenasius bambawalei* Hayat) (IARI and PAU)

i. PAU-Ludhiana

The specimens of mealybugs parasitized by *A. arizonensis* collected from different locations of Punjab were sent to concerned scientist at IARI New Delhi as given under:

Date of collection	Host	Location
4.7.15	*Hibiscus*	Ludhiana
14.7.15	*Abutilon* sp.	Gurdaspur
16.7.15	*Sida* sp.	Fazilka
16.7.15	Cotton	Abohar

ii. IARI-New Delhi

Report not received

2.1.3. Biodiversity of biocontrol agents from various agro ecological zones

i. AAU-Anand

a. *Trichogramma*

During 2015-16, trichocards with eggs of *Corcyra cephalonica* were placed on tomato, castor, groundnut and cotton fields for parasitism by *Trichogramma* in different geographical areas and collected after 3 days from the fields and observed in the laboratory for emergence of *Trichogramma*. Similarly, eggs of host insects *A. janata* were collected at fortnightly interval from castor. *Trichogramma chilonis* was the only *Trichogrammatid* recorded as evident from **(Table 13)**. As the numbers of *Trichogramma* collected was very low they were multiplied separately in the laboratory and few samples were sent to NBAIR, Bangalore.

Table 13. Biodiversity of *Trichogramma* around Anand in different crops

Crop	No. of *Trichogramma* emerged per Installation (100 eggs/card)				
	1st	2nd	3rd	4th	5th
Tomato	1	2	2	1	2
Castor	2	1	2	3	1
Ground nut	1	3	2	1	0
Cotton	2	3	3	2	1

b. *Chrysoperla*

Geographical populations of green lacewing were collected. *Chrysoperla zastrowi sillemi* (Esben-Peterson) was found in all the locations.

c. Coccinellids

Diversity of coccinellids from various crop ecosystems of the region was also studied.

d. *Cryptolaemus*

The natural population of *C. montrouzieri* was observed throughout the year. Moreover, peak population was rich when the incidence of host was higher.

e. Spiders

Total 17 spider specimens were collected, identified from paddy ecosystem and preserved as per the methodology given. Samples were sent to NBAIR for further studies and repository.

f. Insect-derived EPNs

Soil samples were collected from different geographical locations. Totally 300 samples were processed for EPN trapping and no positive EPN sample was found.

g. Isolation of native *Bt* isolates from soil

Isolation of *B. thuringiensis* was carried out as per the standard proceedure from 300 soil samples collected from the rhizospheres of pigeon pea, sorghum, cotton, Guwar., castor, paddy, banana, pearl millet, and tobacco from Panchmahal district of Gujarat. Fifty eight isolates of *Bt* were isolated from Panchmahal district.

h. Anthocorids

Regular surveys were carried out for anthocorid predators on thrips and mites infested plants. No predators were recorded.

ii. AAU-Jorhat

Survey, collection and diversity analysis of *Trichogramma, Chrysoperla*, Coccinelids, spiders, anthocorids and entomopathogens

Locations: Jorhat district

a. *Trichogramma*

Corcyra sentinel egg cards containing 100 numbers of eggs were placed in rice, sugarcane, castor, tea and vegetables (Okra, brinjal, tomato and cole crops) from July to December, 2015 for parasitisation by *Trichogramm* in and around Jorhat district. The cards were collected after 2 days from the fields and observed in the laboratory for the emergence of *Trichogramma* spp. The recovery of *Trichogramma* spp. (unidentified) was made only from rice.

The different stages of insect pests (egg, larvae, adult) were collected from different crop ecosystems (rice, sugarcane, papaya, cabbage, chilli, brinjal, tea) and kept in the laboratory for emergence of natural enemies, if any. The predators associated with the host plants were also collected. The natural enemies recovered from insect pests are presented in the following **Table 14**.

Table 14. Bioagents collected from different crop ecosystem

Crop and source of collection	Name of Insect	Natural enemies	
		Parasitoids	**Predator**
Rice a) ICR farm, AAU, Jorhat b) Borhola, Jorhat district	Eggs of *Scirpophaga incertulas*	*Trichogramma* spp.(unidentified) collected from Borhola, Jorhat. No parasitoids recovered from ICR farm ,AAU, Jorhat	Coccinellids (*Micraspis* sp.) and spiders like *Oxyopes* spp *Tetragnatha* spp. *Lycosa* spp. were collected from rice ecosystem
Sugarcane Titabor, Jorhat	1.Wooly aphid, *Ceratovacuna lanigera* 2. Larvae of Plassy borer, *Chilo tumidicostalis*	*Encarsia flavoscutellum* *Cotesia flavipes*	*Dipha aphidovora* *Chrysoperla* spp.
Papaya	Mealy bug, *Paracoccus marginatus*	*Acerophagus papaye*	*Spalgius epius, Cocinella septempunctata* and Spiders (Unindentified).
Cabbage, Horticultural farm, AAU, Jorhat	DBM, *Plutella xylostella* Cabbage aphid, *Brevicoryne brassicae*	*Cotesia plutellae*	*Cocinella septempunctata* *C. transversalis*
Hot chilli, Horticultural farm, AAU, Jorhat	*Aphis gossypi*	_____	*Cocinella septempunctata* *C.transversalis* *Brumoides suturalis* *Micraspis discolor*
Brinjal, Horticultural farm, AAU, Jorhat	Shoot and fruit borer, *Lucinoides orbanelis*	_____	Predatory mite (Unidentified) *C.transversalis*
Tea, Plantation garden, AAU, Jorhat	Eggs of *Helopeltis theivora*	*Telenomus* spp.	Spiders, *Oxyopes* spp
Okra, Horticultural farm, AAU, Jorhat	Whitefly, *Bemisia tabaci* Jassid, *Amrasca biguttula biguttula*	_____	*Coccinella septempunctata* *C. transversalis*
Potato, Horticultural farm, AAU, Jorhat	Potato aphid, *Myzus persicae*	_____	*Micraspis spp.*

b. *Crysoperla* spp. and Coccinelids

During the observation period, no chrysopids were found on rabi vegetables and sugarcane. A few Chrysopids were collected from sugarcane woolly aphid infested areas at Titabor, Jorhat. Coccinelids *viz.*, *Coccinella septempunctata, C. transversalis*, *Brumoides suturalis* and *Micraspis discolour* were collected from cole crops, chilli, okra and potato etc. from horticultural farm, AAU, Jorhat.

c. Spiders

Different spiders were collected from different types of habitats such as grasses, moist places, under stones, pebbles, dead leaves, humus, bushes, on the bark and branches of trees and houses. The most dominant spider species collected from rice ecosystem were *Oxyopes* sp. *Tetragnatha* sp. *Lycosa pseudoannulata* and *Argiope catenulate* from ICR farm, AAU, Jorhat and Borhola, Jorhat.

d. Anthocorids

No anthocorid predators were detected from thrips and mite infested plants particularly chilli, okra, brinjal, tomato and french-bean.

e. Insect derived EPN:

Eight insect cadavers from rice ecosystem were collected, but all were found free from EPN.

iii. ANGRAU- Anakapalle

Biodiversity of natural enemies of sugarcane, rice and maize pests:

Natural enemies of sugarcane, rice and maize pests were collected at RARS, Anakapalle during Rabi season, 2015 and the specimens were submitted to NBAIR.

iv. CISH-Lucknow

Survey and collection of natural enemies of mango pests

Five species of Coccinellids *viz.*, *Coccinella septempunctata, Cheilomenes sexmaculata, Serangium parcesetosum, Chilocorus rubidus, Scymnus sp.* have been observed feeding on mango hoppers and mealybugs. Most abundant predator was *C. septempunctata* followed by *C. sexmaculata.* Natural infestation of entomapathogenic fungus, *Beauveria bassiana* was observed on guava bark eating caterpillar, *Inderbela quadrinotata* and infested cadavers were collected from 8 locations and pure cultures of *B. bassiana* are maintained **(Table 15)**. Entomopathogenic fungus, *B. bassiana* infesting mango mealybug was collected from the experimental farm of CISH, Rehmankhera. The strain named CISH-MMB-Bb1 was isolated and pure culture is maintained. Entomopathogenic fungi infesting mango hopper was collected from Ranchi and

Malda. The identities of the fungi isolated are yet to be ascertained. Four parasitoids belonging to families Ichneumonidae and Braconidae were collected from the mango and guava ecosystem.

Table 15. Entomopathogenic fungus, *Beauveria bassiana* infesting guava bark eating caterpillar, *Inderbela* sp. from different locations of Uttar Pradesh

Sl. No	Location	Strain Name
1	Rehmankhera (Lucknow)	CISH-BEC-1
2	Sukhrakhera (Unnoa)	CISH-BEC-2 CISH-BEC-3
3	Asaravekela (Allahabad)	CISH-BEC-5 CISH-BEC-6
4	Hingopur (Kanpur)	CISH-BEC-7
5	Tikanpur (Kanpur)	CISH-BEC-8
6	Koulaha (Kausambhi)	CISH-BEC-9
7	Bheta (Kausambhi)	CISH-BEC-10
8	Bamrauli (Allahabad)	CISH-BEC-11

v. IGKV-Raipur

a. *Trichogramma*

Five districts namely, Raipur, Dhamtari, Rajnandgaon, Kawardha and Bilaspur were covered in the present study. Sentinel cards of *Corcyra* were placed in the agro-ecosystems of paddy, vegetables and legumes. The cards were sent for identification to NBAIR, Bangalore.

b. Braconid sp

In order to study the type of Braconid sp existing in the Chhattisgarh agro-ecosystem, plastic containers with sandwiched *Corcyra* larvae were placed in various agro-ecosystems in different districts of Chhattisgarh. The parasitised larvae were kept for emergence of parasitoids and were sent for identification to NBAIR, Bangalore. The results are awaited.

c. Entomopathogens

The infested larvae and cadavers were collected from fields of Raipur and sent for identification to NBAIR, Bangalore. The 14 infected samples did not yield any entomopathogenic fungi on isolation.

vi. IIRR-Hyderabad

Survey and collection of natural enemies of rice pests

Survey was made in different rice fields of Maruteru, West Godavari, Andhra Pradesh and at Indian Institute of Rice Research (IIRR), Hyderabad to record the pests and natural enemies. Samples were collected using sweep net and light trap. Three stem borer species were observed in the field, the yellow stem borer, *Scirpophaga incertulas*, the pink stem borer, *Sesamia inferens* and the dark headed borer. Three species of egg parasitoids were observed on eggs of *S. incertulus viz*., *Tetrastichus schoenobii*, *Trichogramma japonicum* and *Telenomus* spp. *Spodoptera mauritia* was observed in both Kharif and Rabi season. The coccinellid *Micraspis vincta* was observed in large numbers. The plant hoppers, *Nilaparvata lugens*, *Sogatella furcifera* and the leafhopper *Nephotettix virescens* were prevalent in large numbers. Egg baiting for egg parasitoids were carried out and presence of three species were observed *viz*., *Anagrus* sp, *Gonatocerus* sp (Mymaridae) and *Oligosita* sp (Trichogrammatidae). A parasitoid on grubs and pupae of the hispa beetle, *Dicladispa armigera* was collected from Himachal Pradesh and identified as *Chrysonotomyia* sp. (Eulophidae: Hymenoptera). Sixty eight per cent of grubs and 80% of pupae were found parasitised by *Chrysonotomyia* sp. (Eulophidae: Hymenoptera).

Data on stem borer species composition and its egg parasitoids were collected from 20 centres of AICRP on Rice. The stem borer species composition and the egg parasitoids observed were reported from 15 centres **(Fig 1 & Fig 2)**. Four species of stem borer were observed *viz*., yellow stemborer (YSB), *Scirpophaga incertulas*, pink stemborer (PSB), *Sesamia inferens*, dark headed borer (DHB), *Chilo polychrysus* and White stem borer (WSB), *Scirpophaga fusciflua*. YSB was the dominant species in twelve locations *viz*., Coimbatore, Chinsurah, Ghaghraghat, Karaikal, Karjat, Nellore, Navsari, Nawagam, Pantnagar, Ragolu, Rajendranagar and Raipur accounting for 67.69 -100% of the stem borer population. Of these centres, only YSB was reported from nine centres, excepting Rajendranagar and Raipur where PSB was observed as a second species accounting for 0.53 – 3.19% and at Navsari where WSB was prevalent along with YSB. At Aduthurai, Ludhiana and Moncompu other species dominated over the crop season. At Ludhiana three species were observed, PSB being dominant accounting for 73.91%, followed by YSB (19.7%) and WSB (6.39%). The population of YSB (29.62%) was less than PSB (62.96%) even up to tillering phase and the degree of infestation by PSB has increased over the previous year by 20%. PSB dominated from flowering to dough stage (66.67 to 92.11%). WSB accounted for 7.0-11.77% in the early stages but was not prevalent during harvest stage. At Moncompu, three species of stem borers were recorded namely YSB, PSB and WSB. WSB dominated up to tillering phase with 55.00-70.00% of the population after which it declined. During reproductive stage YSB population increased from 30.00 to 59.3% while PSB increased from 10.00 to 20.80% during this period. At Aduthurai, three species (YSB PSB and DHB) were observed over three dates of observation 15, 30 and 45 DAT. While YSB was reported as the dominant species in previous years accounting for 85-100% over the crop season, data reported this year indicated that DHB was dominant during the observation period. It accounted for 79.31 and 63.83% at 15 and 30 DAT, respectively while it reduced to 33.33% at 45 DAT when YSB became dominant (46.67%). The observation period falls short for the tillering, flowering and dough stages and is not indicative of the species composition across the crop growth stages. At Navasari, two stem borer species were observed over three dates of observation. YSB was again dominant,

accounting for 67.69%, the rest being WSB 32.31%. YSB population ranged from 59.38-73.68% across the crop stages while WSB peaked at 90 DAT reaching 40.63% of population which is also higher than the population recorded in the previous year.

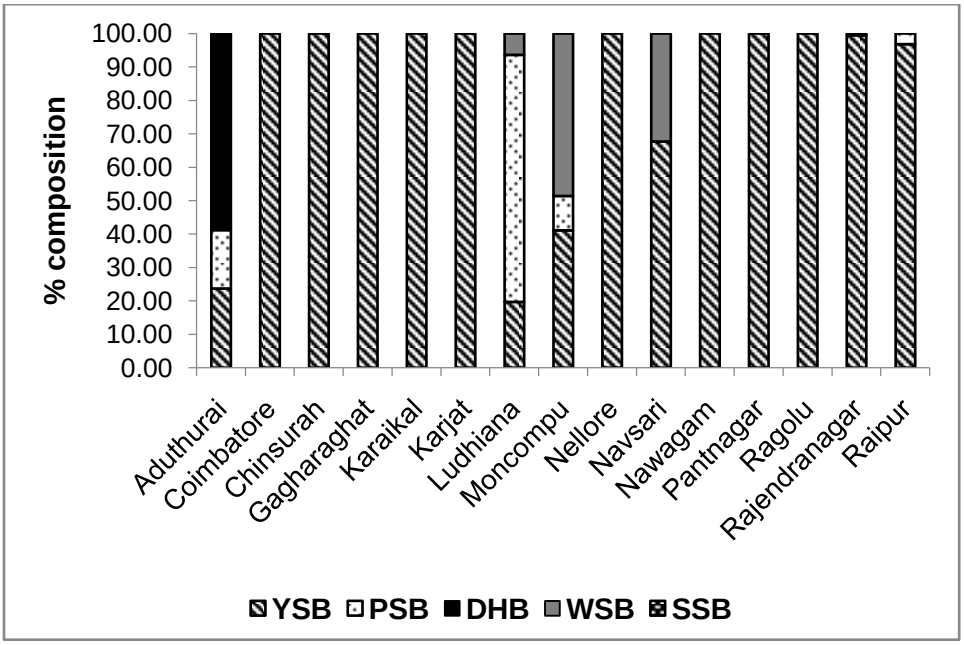


Fig 1. Stem borer species composition at various centres

Egg parasitoids of stem borer: Thirteen centres reported on the egg parasitoids of yellow stem borer. The egg mass parasitisation ranged from 16.11-86.74% while the egg parasitisation varied from 7.22 to 58.88% at various locations **(Fig 2)**. The mean egg mass parasitisation was 43.39 and mean egg parasitisation 35 per cent at Aduthurai over four dates of observation. The mean egg mass parasitisation was highest at Rajendranagar (86.74%) while the lowest was observed at Karjat (16.11%). The egg parasitisation was the lowest at Moncompu (7.22%) and highest at Chinsurah (58.88%) followed by Nawagam (37.25%). Three species of parasitoids were recorded and *Tetrastichus schoenobii* was the most prevalent parasitoid in five locations **(Fig 3)**. At Aduthurai *Trichogramma* species was the only parasitoid observed at 15 DAT causing 10 per cent egg parasitisation. After this date *Tetrastichus schoenobii* was dominant causing up to 90 percent egg parasitsation. It also accounted for 100 per cent of the egg parasitoids observed at Nawagam, 92.75% at Chinsurah and 83.33% at Nellore. *Telenomus* sp. was the dominant parasitoid at Pantnagar, Navsari and Raipur accounting for 100, 92.86 and 41.60% respectively. At Moncompu, Karjat, Rajendranagar and Coimbatore, *Trichogramma* was the major parasitoid accounting for 43.41 -95.54% of the parasitoid population. The average composition of the three parasitoids across locations was *Tetrastichus* (37.68%), *Telenomus* (28.81%) and *Trichogramma* (33.49%).

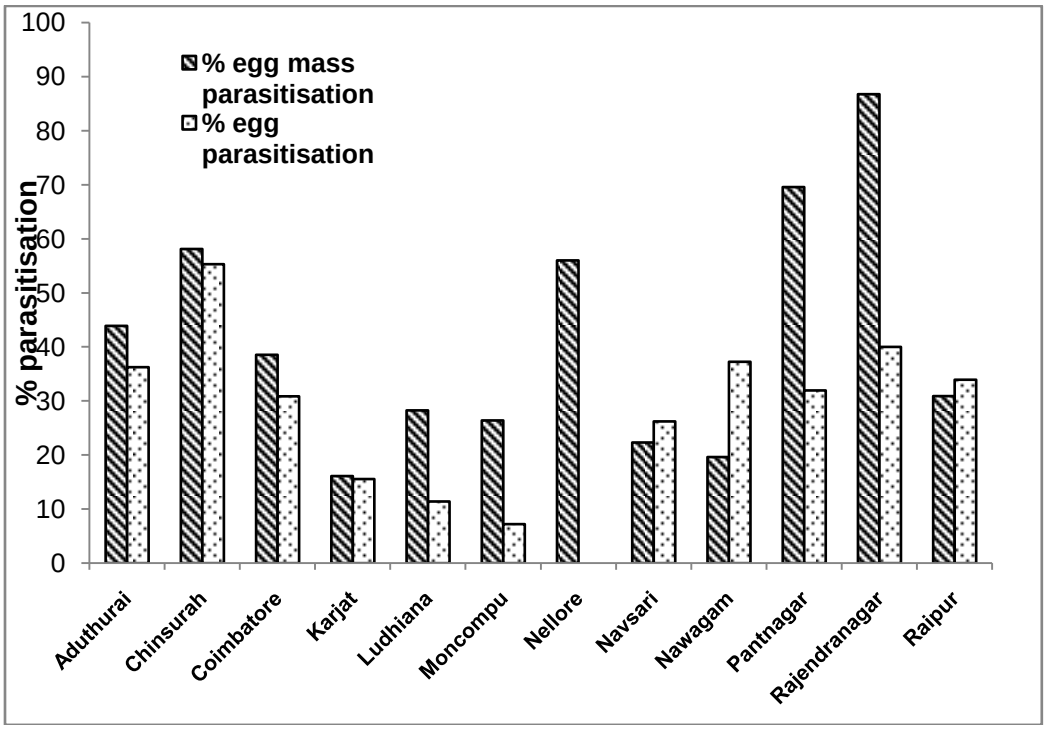


Fig 2. Parasitisation of stem borer eggs at various centres, 2015

Hopper species composition: This data was collected from twelve centres *viz*., Aduthurai, Coimbatore, Gangavathi, Karaikal, Maruteru, Navsari, Nawagam, New Delhi, Pantnagar and Pusa reported on the status of hoppers and their natural enemies. One centre *viz*., Aduthurai reported presence of population of only BPH while only WBPH populations were prevalent in Nawagam. All other locations had a mixed population of planthoppers. At Aduthurai BPH was reported among planthoppers along with GLH occurring at a very low mean population level of 0.67 and 0.38 hoppers/hill respectively. The highest population of planthoppers was observed at Maruteru and Gangavathi. At Maruteru a mixed population of BPH (37.1/hill) and WBPH (9.06/hill) occurred while at Gangavathi the WBPH population (55.6/hill) was more than that of BPH (29.46/hill). The WBPH population was always higher than that of BPH population ranging from 13.94 – 149.04/hill, during September to second week of November after which BPH population increased over WBPH. The highest population of brown planthopper occurred in Maruteru. Though both planthopper species were observed at Maruteru, BPH was dominant and built up in numbers as crop progressed from 2.60/hill to 59.60/hill whereas WBPH population ranged from 0-18.78/hill over the crop growth stages. At New Delhi, low incidence of BPH and WBPH was observed at 1.0 and 0.7 hoppers/hill respectively.

Natural enemies: In general, observations on hopper natural enemies were reported from nine locations. The egg parasitoids of hoppers were recorded at four locations, Gangavathi, Maruteru, Navasari and Nawagam. At Gangavathi, the total egg parasitisation was 16.84%, with *Anagrus, Oligosita and Gonatocerus* accounting for 63.55, 33.92 and 2.53% respectively causing 13.06, 7.96 and 2.53% parasitization in eggs. At *Navasari* the total egg parasitisation ranged from 16.67-50% and a mean parasitisation of 11.6%. *Anagrus* accounted for 100% of the parasitoids

observed. 12.77% of hopper eggs were found parasitized at Nawagam and *Anagrus* was the only parasitoid observed accounting for 3.99% egg parasitisation.

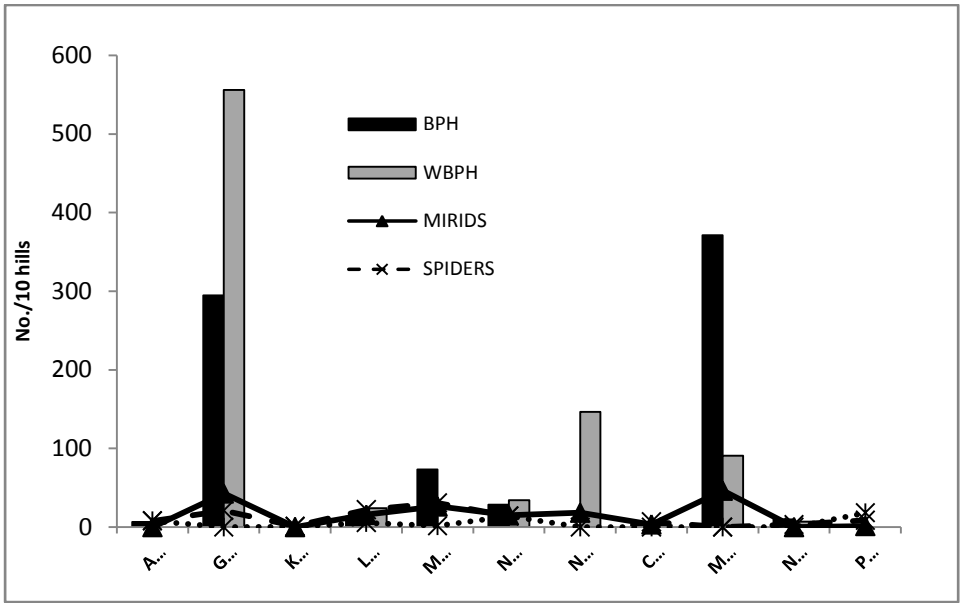


Fig 3 . Plant hopper population and their predators across locations, 2015

A mean egg parasitisation of 4.83% was observed at Maruteru. *Oligosita* was the only parasitoid observed. The predators of hoppers were recorded from 9 locations **(Fig 3)**. The mean population of spiders and coccinellids were observed at 0.78 and 0.80/hill respectively at Aduthurai; At Karaikal, Spiders and coccinellid was reported at 0.10 and 0.56/hill respectively. The highest population of mirids was observed at Maruteru (4.64/ hill) followed by Gangavathi (4.29/hill). The spider population was also the highest at Gangavathi (2.10/hill).

Gall midge parasitisation was reported from two centres, Moncompu and Ragolu. At Moncompu the 138 galls were observed, of which 28.3% were parasitized by *Platygaster* sp. At Ragolu only 2% of galls were observed to be parasitized by the same species.

vii. KAU-Thrissur

Specimens of crop pests as well as their natural enemies were collected from different agro ecosystems of Kerala and were sent to NBAIR, Bangalore at regular intervals for identification. The details are given in **Table 16**.

Table 16. Details of collection of insects and their natural enemies from agro ecosystems of Kerala

Sl. No	Date	No. of vials
1	08/09/15	20
2	07/12/15	28
3	04/01/16	4
4	08/02/16	32
5	22/03/16	26

viii. MPKV-Pune

Survey and collection of natural enemies *Trichogramma, Chrysoperla, Cryptolaemus,* spiders and entomopathogens

The insect pests of crops and biocontrol agents including parasitoids, predators and microorganisms associated with them were collected from fields of horticultural crops in MPKV jurisdiction from ten districts in western Maharashtra as per the protocol given in the technical programme of 2015-16. The specimens were brought to the laboratory, reared up to adult emergence, identified locally and maintained for record, whereas unidentified specimens of bioagents are sent to NBAIr, Bangalore for identification.

a. ***Trichogramma*-** Sentinel cards with the eggs of *Corcyra cephalonica* (100 eggs/ card) were displayed at seven locations in a cropped area for 24 hrs in cotton, pigeon pea, sugarcane, maize, soybean, tomato and paddy and repeated at fortnightly intervals during pest activity. The parasitized cards were maintained for *Trichogramma* emergence.

b. ***Chrysoperla*-** From custard apple, at least 20 live individuals (eggs/ larvae/ adults) were collected from five geographic locations.

c. ***Cryptolaemus*-** Live individuals (larvae/ adults) were collected from five geographic locations.

d. **Spiders**- Collected spiders and the specimens are preserved in 70% ethyl alcohol in screw cap tubes.

e. **Entomopathogens** - The cadavers of insects infected by entomopathogens collected in dry sterile vials.

The natural enemies recorded were Coccinellids, *Coccinella septempunctata* L. *Menochilus sexmaculata* (F.), *Scymnus* sp, *Encarsia flavoscuttellum, Dipha aphidivora* Meyrick, *Micromus igorotus* Bank., syrphids on SWA in sugarcane, *Coccinella transversalis* F., *M. sexmaculata, Brumoides suturalis* (F.), *Scymnus coccivora* Ayyar, *Triomata coccidivora* and *B. suturalis* in mealy bug colonies on custard apple, *Acerophagus papayae* N& S, *Pseudleptomastix mexicana* and *Mallada boninensis* Okam and *Spalgis epius* on papaya mealy bug.

The parasitism of *Trichogramma* was attempted to record in crops like cotton, maize, soybean, sugarcane, paddy and tomato in Pune region through display of sentinel egg-cards of *Corcyra* but it was not observed. The chrysopid, *Chrysoperla zastrowisillemi* Esb was recorded

in cotton, maize, French bean, *Rabi* jowar and brinjal while *M. boninensis* on cotton, sunflower, French beans, mango and papaya. The *Cryptolaemus* adults were recovered from the pre-released plots of custard apple and papaya. The entomopathogens particularly the cadavers of *S. litura* and *H. armigera* infected with *Nomuraea rileyi, Metarhizium anisopliae, Sl*NPV, *Ha*NPV were collected from farmer's field on soybean, potato and pigeon pea **(Table 17)**.

Table 17. Natural enemies recorded from western Maharashtra

Sl. No.	Natural Enemies	Crop	Remarks /Natural enemies identified
1	*Trichogramma*	Cotton, pigeon pea sugarcane, soybean, maize, paddy and tomato	Sentinel cards of *Corcyra* eggs for *Trichogramma* were displayed in the fields from April 2015 to March, 2016 at various crop stages and prevalence of caterpillar pests, but parasitoids were not recovered. Most of the places eggs of *Corcyra* on sentinel cards were eaten by spiders.
2	Chrysopid *Chrysoperla zastrowi sillemi* Esben-Petersen *Mallada boninensis* Okam.	Cotton, maize, brinjal, Okra and French bean Cotton, French bean, sunflower, papaya and mango	The eggs, grubs and adult stages were collected and identified locally The species were recorded from aphid colonies on cotton and identified locally.
3	*Cryptolaemus montrouzieri* Mulsant	Custard apple and papaya	The grubs and adult stages were collected and identified locally
4	Spiders	Cotton, sugarcane, maize, soybean, papaya, brinjal, lady's finger, French bean and mango	The specimens were collected
5 (a)	Entomopathogens *Nomuraea rileyi*	Soybean and potato	*Nomuraea rileyi* diseased cadavers of *S. litura* were collected and isolated the pathogen in laboratory.
(b)	*Sl*NPV/*Ha*NPV	Potato and capsicum Tomato and pigeon pea	*Ha* NPV and *Sl* NPV infected larvae of *H. armigera* were collected.
(c)	*Metarhizium anisopliae*	Mango	Mango hoppers infected with *M. anisopliae* were collected and isolated pathogen in laboratory.

ix. PAU-Ludhiana

1. Natural enemy complex of rice yellow stem borer and leaf folder

The seasonal incidence of sucking as well as lepidopteran pests was recorded on rice variety PR 114 at Punjab Agricultural University (PAU), Ludhiana. The crop was sown in first week of May, 2015 and was transplanted in June 2015. The seedlings were transplanted with inter and intra row spacing of 20 x 15 cm. The crop was kept unsprayed throughout the cropping season. All agronomic practices recommended by Punjab Agricultural University, Ludhiana were followed to raise the crop except for crop protection measures. Observations were recorded from 20 randomly selected plants at weekly intervals for leaf folder damage, dead hearts (DH), plant hoppers population starting after 30 days of transplanting. The data on number of white ears (WE) was recorded once at crop maturity. The population of predators was recorded on whole plant basis. The population of spiders was also recorded using pit fall traps. Different life stages *i.e.*, egg, larvae and pupae of rice stem borer and leaf folder were collected and brought to the laboratory to record parasitism.

Among the lepidopteran insect pests, the population of leaf folders varied from 0.0 to 0.3 larvae per plant. The incidence of damaged leaves due to leaf folder ranged from 0.0 to 6.2% throughout the cropping season **(Table 18)**. The overall incidence of stem borers in terms of dead hearts remained low throughout the cropping season and it ranged from 0.00 to 2.2 per cent. The incidence of white ears was 2.1% which was recorded at maturity. Among the sucking pests, the population of plant hoppers *i.e.*, brown plant hopper and white-backed plant hopper was recorded nil throughout the season.

Among predators, dragonflies, damselflies, coccinellids and spiders were recorded **(Table 18)**. The population of dragonflies and damselflies varied from 0.0 to 0.2 and 0.0 to 1.3 per plant, respectively. The population of spiders varied from 0.0 to 0.9 spiders per plant during the season with maximum population (0.9 spiders/plant) during 38th SMW (3rd week of September). The population of spiders in pitfall collection varied from 0.0 to 7.2 spiders/trap during the season with maximum population (7.2 spiders/trap) during 38th SMW (3rd week of September).

Among the parasitoids, nine species of parasitoids were found associated with stem borer and leaf folder **(Table 19)**. Three species of egg parasitoids, namely, *T. chilonis*, *T. japonicum* and *Telenomus* sp were recorded from stem borer only. The natural parasitism in the eggs of stem borer ranged from 4.89 to 22.15%. *Stenobracon nicevillei* was recorded from stem borer larvae and *Cotesia* sp was recorded from leaf folder larvae. *Bracon* sp was associated as larval parasitoid with both stem borer and leaf folder and the parasitism in the larvae of these pests varied from 3.84 to 5.46%. Among the pupal parasitoids, *Brachymeria* sp, *Tetrastichus* sp and *Xanthopimpla* sp were recorded from the pupae of stem borer whereas *Brachymeria* sp, *Tetrastichus* sp were also recorded from leaf folder. The parasitism varied from 1.66 to 4.34% in the pupae of stem borer and leaf folder.

Table 18. Seasonal abundance of sucking insect pests and their natural enemies in rice under unsprayed conditions at Ludhiana during 2015

Standard Met. Weeks	Leaf folder Damage		Stem borer damage		Plant hoppers population/ plant		No. of Grass hoppers /plant	Predators population/plant			Pitfall collection
	No. of larvae /plant	Damaged leaves (%)	DH (%)	WE (%)	BPH	WBPH		Dragonfly	Damselfly	Spiders	Spiders/ trap
32	0.3	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
33	0.0	0.4	1.5	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.6
34	0.1	0.4	1.4	0.0	0.0	0.0	0.0	0.1	0.0	0.5	0.8
35	0.0	0.2	2.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.5
36	0.0	0.4	1.9	0.0	0.0	0.0	0.0	0.0	0.8	0.4	1.0
37	0.2	1.0	1.7	0.0	0.0	0.0	0.0	0.2	1.3	0.0	7.2
38	0.0	0.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.9	6.6
39	0.0	0.5	2.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.4
40	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	1.6

Table 19. Parasitoids of rice stem borer and leaf folder at Ludhiana during 2015

Parasitoids	Host	Parasitism (%)
A. Egg Parasitoids		
- *Trichogramma chilonis*	*Scirpophaga incertulas*	6.75
	S. incertulas	4.89
- *T. japonicum*	*S. incertulas*	22.15
- *Telenomus* sp		
B. Larval Parasitoids		
- *Stenobracon nicevillei*	*S. incertulas*	5.46
	Cnaphalocrocis medinalis	3.84
- *Bracon* sp	*S. incertulas* & *C. medinalis*	5.02
- *Cotesia* sp		
C. Pupal Parasitoids		
- *Tetrastichus* sp	*S. incertulas* & *C. medinalis*	4.34
- *Brachymeria* sp	*S. incertulas* & *C. medinalis*	2.19
- *Xathopimpla* sp	*S. incertulas*	1.66

2. Isolation of entomopathogens from soil samples collected from different districts of Punjab

Thirty one rhizosphere soil samples were collected from different areas of survey and placed in plastic containers with lid and processed for isolation of EPF and bacteria. For isolation of EPF, *Galleria* bait method was employed and for isolation of *Bacillus* bacteria standard protocol for isolation was employed. Entomopathogenic fungi were isolated from soil samples collected from brinjal, turmeric, cauliflower, maize, sorghum and rice fields of Fatehgarh Sahib, Sangrur, Pathankot and Barnala, respectively, while *Bacillus* bacteria was isolated from soil samples collected from pigeonpea, barseem, chickpea, wheat and potato fields of Barnala, Patiala, SAS Nagar, Amritsar and Ludhiana, respectively **(Table 20)**. Slants of these microorganisms were sent to NBAIR, Bangalore for confirmation and identification. Ten samples were received on 18th April, 2016 at NBAIR, Bengaluru and are under process of identification.

Table 20. Mapping of microbials from soil samples collected from different districts of Punjab (2015-2016) (PAU)

Sl. No	District	Location	Distance from HQ (km)	Date of survey	Host crop	GIS data	Microbial isolate
1	Barnala	Sanghera	69.7 km	August 2015	Pigeonpea	30^0 39′ N 75^0 55′ E	Bacteria
2	Fatehgarh Sahib	Khamanon	59.5 km	August 2015	Brinjal	30°82’N 76°35’E	Fungus
3	Sangrur	Katron	73.4 km	July 2015	Turmeric	$30^0$12’N $75^0$53’E	Fungus
4	Patiala	Rajpura	92 km	January 2016	Barseem	30^0 20′ N 76^0 23′E	Bacteria
5	Sangrur	Malerkotla	47.8 km	February 2016	Cauliflower	30^0 31′N 75^0 51′ E	Fungus

6	Pathankot	Mangani	170.8 km	July 2015	Maize	32º17'N 75º42'E	Fungus
7	Barnala	Sanghera	69.7 km	July 2015	Sorghum	30^0 38′ N 75^0 42′ E	Fungus
8	SAS Nagar	Gharuan	78 km	December 2015	Chickpea	30^0 44′ N 76^0 38′ E	Bacteria
9	Amritsar	Amritsar (Khalsa college)	140 km	February 2016	Wheat	31^0 37′ N 35^0 18′ E	Bacteria
10	Ludhiana	PAU	0 km	January 2016	Potato	30^0 54' N 75^0 51' E	Bacteria

3. Mapping of EPN diversity in Punjab

For EPN diversity, 50 soil samples were collected from different locations of Punjab (Bathinda, Mansa, Fazilka, Ludhiana, Pathankot, Samrala, Malerkotla and Gurdaspur) during 2015. *Galleria* bait method was used for the isolation of native EPN strains. Out of these samples, EPNs have been recovered from 10 samples **(Table 21)**. The samples have been sent to Aligarh Muslim University, Aligarh for morphological identification.

Table 21. EPNs isolated from soil samples collected from different locations of Punjab (2015)

Sl. No.	Code	Date of collection	Location	District	GPS
1	PAU- 28	21.8.15	Raikot	Barnala	30° 48.586′ N 75° 39.425′ E
2	PAU - 36	24.8.15	Joga	Mansa	30° 04.788′ N 75° 25.488′ E
3	PAU - 39	24.8.15	Bhagi Wander	Bathinda	30° 02.626′ N 75° 03.078′ E
4	PAU - 40	24.8.15	Jeewan Singh wala	Bathinda	30° 04.430′ N 75° 01.540′ E
5	PAU - 44	4.9.15	Samrala	Ludhiana	-
6	PAU - 47	16.8.15	PAU field area	Ludhiana	30° 54.236′ N 75° 46.929′ E
7	PAU - 48	21.8.15	Issowaal	Ludhiana	30° 54.141′ N 75° 48.025′ E
8	PAU - 49	16.8.15	PAU field area	Ludhiana	30° 54.054′ N 75° 47.223′ E
9	PAU - 52	21.8.15	Sudhar	Ludhiana	30° 48.605′ N 75° 39.417′ E
10	PAU - 57	23.8.15	Entomological Research Farm (PAU)	Ludhiana	30° 53.954′ N 75° 48.251′ E

A total of 10 insect samples were sent to NBAIR for repository maintenance. Seven samples will be submitted during the workshop. A new Eulophid parasitoid, *Oomyzus scaposus* (Hymenoptera: Chalcidoidea: Eulophidae: Tetrastichinal) (as identified by Forest

Entomology Division, FRI Dehradun) has been recorded from *Coccinella septumpunctata* and *Cheilomenes sexmaculatus* pupae on wheat and *Brassica* crops from Punjab.

x. PJTSAU-Hyderabad

Survey, collection and diversity analysis of *Trichogramma, Chrysoperla, Goniozus, Braconid* species, *Cryptolaemus,* spiders and entomopathogens from Telengana state

a. *Trichogramma*

Ten geographical populations were collected from different crop ecosystems by placing sentinel cards with eggs of *Corcyra cephalonica*. Eggs of insect pests were also collected from different crops and maintained for the emergence of *Trichogramma.* Adults of Trichogramma emerging from these eggs were supplied with freshly laid, UV treated *Corcyra* eggs for parasitisation. Freshly parasitized eggs and live *Trichogramma* with UV treated *Corcyra* eggs were sent in suitable aerated containers to NBAIR, Bangalore. The cultures were also maintained at the centre. Dead *Trichogramma* were preserved in 70% alcohol and sent to NBAIR, Bangalore for identification. *Trichogramma* were collected from different crop ecosystems *viz.*, rice, sugarcane, cotton, castor, cashew, tea, ground nut, castor, maize and sunflower.

b. *Chrysoperla*

Five geographic populations (at least 20 in each population) were collected and live individuals (eggs/larvae/adults) were sent by speed post to NBAIR, Bangalore in proper aerated containers.

c. *Goniozus* and Braconid species

Five geographical populations were collected in coconut growing areas and live individuals were sent by speed post to NBAIR, Bangalore

d. *Cryptolaemus*

Five geographical populations were collected and live individuals (eggs/larvae/adults) were sent by speed post to NBAIR, Bangalore.

e. Entomopathogens

The cadavers of insects infected by entomopathogens were collected in dry sterile vials and were sent to NBAIR, Bangalore by speed post for identification**.** No samples of entomopathogens were received at NBAIR, Bengaluru.

Table 22. Details of the batches of the Bio Agent samples sent to NBAIR during Kharif & Rabi 2015-16

Sl. No.	Consignment No.	Period of Collection
1.	PJTSAU/KH/RNR/15-16/1	July, 2015
2.	PJTSAU/KH/RNR/15-16/2	August, 2015
3.	PJTSAU/KH/RNR/15-16/3	October, 2015
4.	PJTSAU/KH/RNR/15-16/4	November, 2015

xi. SKUAST-Srinagar

Survey and collection of natural enemy complex of pests of apple (Stem borer, San Jose scale, mite and other pests), apricot (borer from Ladakh and other pests), plum, pear, peach, cherry, walnut and almonds

A total of eighteen parasitoids and predators belonging to the orders Coleoptera, Diptera, Hymenoptera and Mesostigmata were collected during the surveys conducted in various fruit orchards from different districts of Kashmir and Laddakh during 2015-16. Among these (Plates 4-9), a majority of natural enemies were found on apple, associated with different insect pests. Nine natural enemies were recorded for the first time from Kashmir, in association with different insect pests which are as follows: i) an unidentified braconid on apple leaf miner (*Lyonetia* sp.) ii) *Cryptogonus schraiki* (Coleoptera: Coccinellidae) with apple aphid *(Aphis pomi*) iii) *Harmonia dimidiata* on Walnut aphid (*Panaphis juglandis*) iv) *Pachyneuron* sp. on braconid parasitizing aphid on pomegranate v) unidentified tachinid from pomegranate fruit borer vi) *Harmonia eucharis* with aphids on Pomegranate, vii) *Harmonia dimidiata* viii) an unidentified syrphid and ix) *Metaphycus* sp. (Hymenoptera: Encyrtidae) on *Lecanium* scale on plum. *Chilocorus infernalis* was found actively associated with *Lecanium* scale on plum. Taxonomical identifications of *Metaphycus* sp. (Hymenoptera : Encyrtidae) and *Harmonia eucharis* (Coleoptera: Coccinellidae) were done by Dr. Sudhir Singh, Head, Division of Forest Entomology, F.R.I., Dehradun (India) and Dr. Poorani, J. Principal Scientist, NBAIR respectively.

xii. TNAU-Coimbatore

Survey and collection of natural enemies of different crop pests, *Trichogramma, Chrysoperla, and Cryptolaemus*

Natural enemies *viz*., *Trichogramma, Chrysoperla, Cryptolaemus*, and parasitoids of papaya mealybug, scales and curry leaf psyllid were collected and sent for identification and documentation. Sixty one insect samples of insect pests and natural enemies preserved in 70 % alcohol were despatched to NBAIR for identification. The activity of egg parasitoid, *Trichogramma* sp. parasitizing fruit borer of tomato, bhendi and shoot and fruit borer of brinjal and the leaf roller of curry leaf and predators, *Cryptolaemus montrouzieri* , *Chrysoperla zastrowi sillemi* on mealybug, scales, psyllids infesting the crops namely tapioca, papaya, brinjal, guava and curry leaf were noted.

xiii. YSPUHF-Solan

Survey and collection of natural enemies of coconut black headed caterpillar, *Trichogramma, Chrysoperla, Cryptolaemus* and spiders

Diversity of biocontrol agents from various agroecological zones

a. Name of Insect: Coccinellids

Geographical & other details	Coccinellids
Scientific name of the insect	*Hippodamia varigieta, Coccinella septempunctata, Cheilomenes sexmaculata, Coccinella luteopicta, Propylea lutiopustulata, Chilocorus infernalis, Stethorus sp*
Common name of the insect	Lady birds
Location	Rekongpeo (310 Km), Sangla (330 Km) and Rakchham (345 Km) of dist. Kinnaur
Taluk, district & Agro- climatic zone	Dry temperate high hills
Distance from the HQ	310-345 Km
Date of survey	June to November
Host crop/ sole crop/ intercrop/ etc.	Apple and wild flora
Stage of the crop	Leaf fall stage of apple
Insect pest	Aphids, mites and San Jose scale of apple aphids on wild flora
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	-
GIS data	2300, 2800 and 2900 m AMSL
Pesticide usage pattern	-

b. Name of Insect: Coccinellid and staphylinid beetles

Geographical & other details	Coccinellid and staphylinid beetles
Scientific name of the insect	*Coccinella septempunctata*, *C. transversalis*, *Hippodomia variegata*, *Cheilomenes sexmaculata*, *Oenopia kirbyi*, *O. sauzeti*, *O. sexareata*, *Illeis* sp, *Coelophora bisselata*, *Pharoscymnus flexibilis Scymnus posticalis*, *Stethorus sp*, *Oenopia conglobata*, *Chilocorus circumdatus*, *Calvia punctata*, *Phrynicaria unicolor*, *Illeis* sp *nr confusa*, *Ortalia* sp, an unidentified scymnini and *Oligota* sp
Common name of the insect	Lady birds and rove beetles
Location	Solan and surrounding areas
Taluk, district & Agro- climatic zone	Sub temperate
Distance from the HQ	Upto 35 Km
Date of survey	Between March and November
Host crop/ sole crop/ intercrop/ etc.	Cabbage, cauliflower, mustard, cucurbits, capsicum, tomato, okra, brinjal, rose carnation, *Unimus*, chrysanthemum, stone fruits, ashwagandha and weeds
Stage of the crop	Vegetative and flowering stage
Stage of the insect pest	Nymphs and adults of different aphids, whiteflies, scales and mites.
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	-
GIS data	1200-1500 m AMSL
Pesticide usage pattern	-

c. Name of Insect: Coccinellid beetles

Geographical & other details	Coccinellid beetles
Scientific name of the insect	*Coccinella septempunctata*, *Hippodomia variegata*, *Cheilomenes sexmaculata*, *O. sauzeti*, *O. sexareata* and *scymnus* sp.
Common name of the insect	Lady birds
Location	Kullu valley
Taluk, district & Agro- climatic zone	Sub temperate and temperate
Distance from the HQ	220- 270 Km
Date of survey	September
Host crop/ sole crop/ intercrop/ etc.	Vegetables, ornamentals, fruits and weeds
Stage of the crop	Vegetative and flowering stage
Stage of the insect pest	Nymphs and adults of homopterans
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	-
GIS data	1200-2450 m AMSL

Pesticide usage pattern	-

d. Name of Insect: Coccinellid beetles

Geographical & other details	Coccinellid beetles
Scientific name of the insect	*Coccinella septempunctata*, *Hippodomia variegata*, *Cheilomenes sexmaculata*, *Propylea lutiopustulata*,
Common name of the insect	Lady birds
Location	Nerwa and Chopal
Taluk, district & Agro- climatic zone	Sub temperate and temperate
Distance from the HQ	270 and 245 Km
Date of survey	September-October
Host crop/ sole crop/ intercrop/ etc.	Vegetables, ornamentals and apple
Stage of the crop	Vegetative and flowering stage
Stage of the insect pest	Nymphs and adults of homopterans
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	-
GIS data	1600-2200 m AMSL
Pesticide usage pattern	-

e. Name of Insect: Predatory mites

Geographical & other details	Predatory mites
Scientific name of the insect	*Euseius eucalypti, Ambluseius herbicolus, Agistimus fleschneri, Amblyseius* sp., *Euseius alstoniae*, *Euseius prasadi, Typhlodromus mori, Neoseiulus paspalivorus*
Common name of the insect	Predatory mites
Location	Solan, Nerwa and Chopal
Taluk, district & Agro- climatic zone	Sub temperate to temperate
Distance from the HQ	20-270 Km
Date of survey	March - October
Host crop/ sole crop/ intercrop/ etc.	Tomato, cucumber brinjal, Rose, Plum, Apple, Apricot and Toona
Stage of the crop	Vegetative stage
Stage of the insect pest	All stages of spider mite
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	-
GIS data	1200-2200 m AMSL
Pesticide usage pattern	-

f. Name of Insect: *Chrysoperla*

Geographical & other details	*Chrysoperla*
Scientific name of the insect	*Chrysoperla zastrowi sillemi*
Common name of the insect	Green lace wing
Location	Solan, Nerwa, Kullu and Rekongpeo
Taluk, district & Agro- climatic zone	Sub temperate to dry temperate zone
Distance from the HQ	30-300 Km
Date of survey	March-November
Host crop/ sole crop/ intercrop/ etc.	Rose, apple and cucumber
Stage of the crop	Vegetative growth and Fruit bearing
insect pests	Aphids and whiteflies
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	-
GIS data	1200-2200 m AMSL.
Pesticide usage pattern	-

g. Name of Insect/ microbial agent: Syrphid flies

Geographical & other details	Syrphid flies
Scientific name of the insect	*Episyrphus balteatus, Metasyrphus confrator, Eupeodes frequens, Melanostoma univitatum, Betasyrphus serarius, Sphaerophoria indiana, Ischiodon scutellaris* and *Scaeva pyrastri*
Common name of the insect	Syrphid flies, hover flies
Location	Ghumarwin, Solan, Nerwa, Kullu and Rekongpeo
Taluk, district & Agro- climatic zone	Sub-tropical to temperate
Distance from the HQ	10-300 Km
Date of survey	March - November
Host crop/ sole crop/ intercrop/ etc.	Different flowering plants
Stage of the crop	flowering stage
Stage of the insect pest	Adults
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	-
GIS data	500-2200 m AMSL
Pesticide usage pattern	-

h. Name of Insect/ microbial agent: Apple root borer/ infected larvae

Geographical & other details	Apple root borer/ infected larvae
Scientific name of the insect	*Dorysthenes hugelii*
Common name of the insect	Apple root borer
Location	Solan, Nerwa, Kullu and Rekongpeo
Taluk, district & Agro- climatic zone	Sub temperate to dry temperate
Distance from the HQ	10-370 Km
Date of survey	March - November
Host crop/ sole crop/ intercrop/ etc.	Bearing plants
Stage of the crop	
Stage of the insect pest	Adults and larvae
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	-
GIS data	1200-2200 m AMSL
Pesticide usage pattern	-

i. Name of Insect: Thrips

Geographical & other details	Thrips
Scientific name of the insect	*Thrips tabaci, T. palmi, T. flavus, T. flavidulus, T. carthami, T. alatus, T simplex, T hawaiiensis, T. florum, Taeniothrips sp, Scirtothrips dorsalis, Haplothrips tenuipennis* and *H. clarisetis.*
Common name of the insect	Thrips
Location	Solan,
Taluk, district & Agro- climatic zone	Sub temperate
Distance from the HQ	Up to 30 Km
Date of survey	March - November
Host crop/ sole crop/ intercrop/ etc.	Different horticultural crops
Stage of the crop	flowering stage
Stage of the insect pest	Adults
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	-
GIS data	1200-1400 m AMSL
Pesticide usage pattern	-

j. Name of Insect/ microbial agent: Parasitoids of coccinellids

Geographical & other details	Parasitoids of coccinellids
Scientific name of the insect	*Pediobius foveolatus*, *Nothosurphus mirabilis* and *Dinocalpus coccinellae*
Common name of the insect	Parasitoids of coccinellids
Location	Solan and surroundings
Taluk, district & Agro- climatic zone	Sub-temperate
Distance from the HQ	Upto 30 Km
Date of survey	March to October
Host crop/ sole crop/ intercrop/ etc.	Different vegetable and fruit crops
Stage of the crop	Vegetative and flowering stage
Host insects	*Megalocaria delatata, Hippodamia variegata* and *Coccinella septempunctata,* respectively.
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	-
GIS data	1200 – 1400 m AMSL
Pesticide usage pattern	

k. Name of Insect/ microbial agent: Parasitoids of DBM

Geographical & other details	Parasitoids of DBM
Scientific name of the insect	*Diadegma* sp, *Cotesia vestalis* and *Diadromus collaris*
Common name of the insect	DBM parasitoids
Location	Solan and surroundings
Taluk, district & Agro- climatic zone	Sub-tempeate
Distance from the HQ	
Date of survey	March- April
Host crop/ sole crop/ intercrop/ etc.	Cauliflower and cabbage
Stage of the crop	Vegetative
Host insects	Larvae and pupae of *Plutella xylostella*
Weather parameters recorded (max, min temp; rainfall, no. of rainy days)	
GIS data	1200-1400 m AMSL
Pesticide usage pattern	

Besides above mentioned natural enemies, *Orius* sp.and *Anthocoris* sp. were collected from peach trees. *Baryscapus galactopus* and an unidentified pteromalid were collected as hyperpasitoids of *Cotesia glomerata* parasitizing *Pieris brassicae* in cauliflower. *Campoletis chloridae* was reared from field collected larvae of *Helicoverpa armigera.*

***Trichogramma*:** Eggs of *Helicoverpa armigera* (from), *Plutella xylostella* and *Pieris brassicae* (from cauliflower and cabbage) were collected periodically and brought to the laboratory for *Trichogramm*a emergence. Sentinel cards having UV eradiated *Corcyra* eggs were also placed in the fields of tomato, carnation, rose, peas and antirrhinum for trapping/collection of *Trichogramma* but no *Trichogramma* was trapped/ collected from any of the cropping system.

Insect derived EPNs: Soil samples were collected from apple orchards infested with root borer grubs. The experiment was conducted in the laboratory for trapping EPNs as per the protocol supplied by NBAII, Bangalore, but no EPNs were collected/ trapped from any location.

Entomopathogens: Cadavers of apple root borer, *Dorysthenes hugelii* from the basins of apple plant were collected from experimental plants in Nerwa area of district Shimla.

viv. UAS-Raichur

Survey and collection of *Trichogramma*, *Chrysoperla* and *Cryptolaemus*

Trichogramma spp were collected by keeping sentinel cards in different crop ecosystem at every fortnight interval, after 24 hours sentinel cards collected back to the laborotary and kept for emergence. Chrysoperla grubs are collected from different crop ecosystem and kept in laborotary for to become adult by providing sufficient food. *Cryptolaemus montrouzieri* and parasitoids of tomato pinworm, *Tuta absuluta* (Meyrick) were collected and the same was sent to NBAIR, Bengalure for identification.

2. Surveillance for alien invasive pests in vulnerable areas (AAU-A, AAU-J, KAU, MPKV and YSPUHF)

AAU-Anand

Periodic surveys were carried out. New invasive pest of tomato South American pinworm, *Tuta absoluta* and papaya mealybug, *Paracoccus marginatus* were recorded.

AAU-Jorhat

Periodic surveys were carried out from August, 2015 in the district of Jorhat, Assam for alien invasive pests. Except *Paracoccus marginatus* infesting papaya and ornamental plants (marigold, croton, hibiscus, ornamental tapioca etc.), none of the invasive pests listed above were found. Regular surveys was also done in the vegetable market yard of Jorhat at weekly intervals to detect the presence alien invasive pests of fruits and vegetables, but no infestation was observed during the survey period.

KAU-Thrissur

No invasive pests have been collected from any of the locations surveyed.

MPKV-Pune

The field as well as horticultural cropped area and ornamental plantations were surveyed in western Maharashtra covering five agro-ecological zones and the fields and orchards in Pune region were frequently visited for the record of pests species *viz.*, coconut leaf beetle *Brontispa longissima*, spiralling white fly *Aleurodicus dugessi*, mealy bugs *Phenacoccus manihoti, Paracoccus marginatus, Phenacoccus madeirensis, Pseudococcus jackbeardsleyi* and other alien invasive pests. These alien insects are already causing considerable losses to several crops in the neighboring countries. The stages of *Pseudococcus jackbeardsleyi* and *Paracoccus marginatus* W. and G. were collected for record of natural enemies. The pests infested fruits and vegetables were collected from city market yards and investigated in the laboratory for alien invasion of pest species and natural enemies.

Amongst the target pests, *Tuta absoluta* was recorded on Tomato in Junnar Tahsil of Pune district. Papaya mealybug, *Paracoccus marginatus* W & G was observed in the papaya orchards on main host papayain western Maharashtra along with the encyrtid parasitoid, *Acerophagus papayae* N & S, *Pseudleptomastix mexicana* and *Spalgis epius* and nine coccinellids, anthocorids, chrysopids, syrphids and spiders in Dhule and Pune region.

YSPUHF-Solan

Different vegetable and fruit ecosystems at Solan, Ghumarwinn Sundernagar, Mandi, Kullu, Manali, Nerwa, Rekongpeo, Sarahan, were surveyed for the collection of pests like, *Aleyrodicus digessi, Phenacoccus manihoti, Paracoccus marginatus*, *Phenacoccus madeirensis* and *Tuta absoluta* but only *Tuta absoluta* was recorded from tomato at Nauni, Solan (HP).

2.2. Biological control of plant diseases using antagonistic organisms

1. Field evaluation of the promising *Trichoderma, Pseudomonas* and *Bacillus* isolates for the management of diseases and improved crop growth in rice, chickpea and pea (GBPUAT)

i. Rice

A field experiment was conducted at Crop Research Centre, Pantnagar to evaluate eight potential bioagents on the rice var. Pant Dhan-14 during June-Nov. 2015 for improvement of plant vigour and management of rice diseases. The bioagents were applied as soil application in nursery beds and in field before planting (FYM colonized with bio-agents @ 10 q/ha mixed in quantity of FYM to be applied by the farmers), seed bio-priming (10 g or 10 ml/kg seed), seedling root dip treatment (10 g or 10 ml/lit water) and as three foliar sprays (10 g or 10 ml/lit water): 1st at 45 DAS, 2nd at 70 DAS and 3rd at 95 DAS. The experiment was laid in a randomized block design in three replications with a plot size of 2 x 3 $m^{2.}$

Plant vigour at seedling stage: In nursery beds, significantly maximum fresh weight was observed with *Bacillus* sp. (4.87 g/ seedling). Significantly maximum dry weight was observed with PBAT-3 (1.48 g/seedling) followed by Psf-173 (1.44 g/seedling) and TCMS-9 (1.41 g/seedling) which were at par with each other but significantly different from control (0.78 g/seedling). Significant maximum seedling length was observed with PBAT-3 (53.0 cm) followed by TCMS 36 (51.64 cm), Psf-2 (51.62 cm) TCMS-9 (51.31 cm) and *Bacillus* sp. (51.23 cm) which were at par with each other but was significantly different from the control (41.48 cm) (**Table 23**).

Table 23. Efficacy of promising bio-agents on the growth of rice seedlings (var. Pant Dhan-4) in the nursery

Treatment	Fresh Weight* (g/seedling)	Dry weight* (g/seedling)	Length* (cm)
TCMS 43	4.43	1.23	45.76
TCMS 36	4.17	1.12	**51.64**
TCMS 9	4.50	**1.41**	**51.31**
Th 14	4.25	0.94	49.82
PBAT 3	4.50	**1.48**	**53.00**
Psf 173	4.43	**1.44**	50.10
Psf 2	4.21	1.07	**51.62**
***Bacillus* sp.**	**4.87**	1.27	**51.23**
Carbendazim	4.31	1.08	44.03
Control	**3.90**	**0.78**	**41.48**
CD (0.05)	0.27	0.23	2.70
CV (%)	3.72	11.4	3.21

*average of 10 seedlings

Occurrence of diseases: During the cropping season sheath blight (*Rhizoctonia solani*) was the major problem followed by brown spot (*Drechslera oryzae*). However, occurrence of bacterial leaf blight (*Xanthomonas oryzae* pv. *oryzae*) and false smut (*Ustilaginoides virens*) was very low. Sheath rot (*Sclerotium rolfsii*) disease was not observed. Minimum brown spot disease severity was recorded in carbendazim (5.0%) which was on par with TCMS 43

(6.0%), Psf 2 (6.0%), Psf 173 (9.3%) and *Bacillus* sp (9.7%) but significantly different from the control (16.0%). Minimum sheath blight disease incidence was observed with carbendazim (8.7%) that was at par with TCMS 9 (10.0%) and TCMS 36 (11.2%) but significantly different from the control (40.7%). Significantly low sheath blight disease severity was recorded with carbendazim (5.9%) which was on par with TCMS-9 (7.4%) and TCMS-36 (9.7%), *Bacillus* sp (12.6%), Psf2 (16.2%) and TCMS 43 (16.3 but significantly different from the control ((33.3%). Significantly minimum false smut disease was observed with *Bacillus* sp. (0.6%) followed by Psf 2 (0.7%), Psf 173 (1.0%) TCMS 43 (1.0%) and Th 14 (1.0%) as compared to the control (1.5%) **(Table 24).**

Table 24. Efficacy of promising bio-agents against brown spot, sheath blight and false smut diseases of rice (variety Pant Dhan-4)

Treatment	Brown spot		Sheath blight			False smut	
	Disease severity (%)	Disease reduction (%)	Disease incidence (%)	Disease severity (%)	Disease reduction (%)	Disease severity (%)	Disease reduction (%)
TCMS 43	**6.0 (14.0)**	62.5	24.3 (29.5)	**16.3 (23.7)**	51.0	**1.0 (5.9)**	28.4
TCMS 36	10.0 (18.3)	37.5	**11.2 (19.5**)	**9.7 (17.0**)	70.8	1.1 (6.1)	23.8
TCMS 9	12.3 (20.5)	22.9	**10.0 (18.3**)	**7.4 (15.6)**	77.7	1.4 (6.9)	3.9
Th 14	10.0 (18.3)	37.5	17.8 (24.7)	22.2 (28.0)	33.3	**1.0 (5.8**)	31.1
PBAT 3	10.0 (18.0)	37.5	24.8 (29.8)	28.1 (35.2)	15.4	1.4 (6.9)	2.6
Psf 173	**9.3 (17.3)**	41.6	30.1 (33.2)	25.9 (30.5)	22.2	**1.0 (5.7)**	32.4
Psf 2	**6.0 (14.1)**	62.5	13.5 (23.7)	**16.2 (23.7)**	51.1	**0.7 (4.6**)	54.3
***Bacillus* sp.**	**9.7 (18.1)**	39.5	16.2 (17.1)	**12.6 (16.2)**	62.1	0.6 (4.3)	62.2
Carbendazim	**5.0 (12.9)**	68.7	**8.7 (21.5)**	**5.9 (13.9**)	82.2	1.1 (6.0)	25.1
Control	**16.0 (23.6)**	-	**40.7 (39.6)**	**33.3 (32.0)**	-	**1.5 (6.9)**	-
CD (0.05)	4.9 (4.9)	-	3.3 (2.6)	11.2 (10.7)	-	0.4 (1.2)	-
CV (%)	30.7 (16.3)	-	9.8 (5.9)	36.8 (26.5)	-	24.3 (11.9)	-

Plant growth: Statistically significant differences were not observed with regard number of tillers/plant among the different bioagents and untreated control, although TCMS 43 showed maximum tillers (11.43 tillers/plant). Significantly maximum plant height was observed in PBAT 3 (114.07 cm) and *Bacillus* sp. (113.73 cm) as compared to control (108.07 cm) (**Table 25).**

Yield: Significantly maximum yield was obtained with Th 14 (56.33 q/ha) followed by PBAT 3 (54.66 q/ha), TCMS 9 (53.49 q/ha), Psf2 (52.92 q/ha) and (52.92 q/ha) as compared to the control (46.33 q/ha). Significantly maximum 1000 grain weight was observed with Th 14 (30.23 g) as compared to control (26.90 g) (**Table 25**). Of all the isolates **TCMS 9** and **PBAT 3** were found comparatively better in reducing sheath blight and brown spot diseases and improving plant health, and increasing yield.

Table 25. Efficacy of promising bio-agents on plant growth and yield of rice

Treatment	Plant growth		Yield			
	Plant height	Tiller/hill (90DAT)	Yield /plot (6 m^2)	Yield/ha	Yield increase over control	1000 grain wt
	(cm)	(no.)	(kg)	(q)	(%)	(g)
TCMS 43	112.20	11.43	3.01	50.16	8.2	28.50
TCMS 36	110.47	11.10	3.11	51.83	11.8	28.16
TCMS 9	111.53	11.10	**3.21**	**53.49**	15.4	29.25
Th 14	111.60	10.87	**3.38**	**56.33**	21.5	**30.23**
PBAT 3	**114.07**	11.13	**3.28**	**54.66**	17.9	29.34
Psf 173	**110.67**	**10.63**	**3.16**	**52.66**	13.6	27.85
Psf 2	**113.33**	**11.09**	**3.20**	**52.92**	7.7	28.30
Bacillus	**113.73**	10.63	2.99	49.83	7.5	28.19
Carbendazim	109.20	11.17	3.21	53.49	15.4	29.59
Control	108.07	10.33	2.78	46.33	-	26.90
CD(0.05)	0.56	1.10	0.23	-	-	0.37
CV (%)	2.17	11.22	4.33	-	-	7.20

CFU of bio-agents in rhizosphere and rhizoplane: After 45 DAT, significantly maximum population of bioagents in rhizosphere was observed in *Bacillus* sp ($50.0x10^4$ CFU/g) followed by Psf-173 ($29.0x10^4$ CFU/g), Psf-2 ($25.670x10^4$ CFU/g) and TCMS 9 ($7.67x10^4$ CFU/g) as compared to control ($1.67x10^4$ CFU/g). After 90 DAT significantly maximum population of bio-agents in rhizosphere was observed in *Bacillus* sp. ($37.6x10^4$CFU/g) followed by Psf-2 ($32.0x10^4$ CFU/g), Psf-173 ($9.67x10^4$ CFU/g) and TCMS 36 ($6.67x10^4$ CFU/g) as compared to control ($1.0x10^4$ CFU/g) respectively **(Table 26).**

Significant maximum population of bioagents on rhizoplane at 45 DAT was found in *Bacillus* sp ($45.0x10^4$ CFU/g) followed by Psf-173 ($21.67x10^4$ CFU/g), Psf-2 ($20.670x10^4$ CFU/g) and TCMS 9 ($20.0x10^4$ CFU/g) as compared to control ($3.0x10^4$ CFU/g). Significantly maximum population of bio-agents in rhizoplane at 90 DAT was found in *Bacillus* sp ($30.67x10^4$ CFU/g) followed by TCMS 43 ($14.0x10^4$ CFU/g), TCMS 9 ($11.3x10^4$ CFU/g) and Psf-2 ($10.3x10^4$ CFU/g) as compared to control ($2.0x10^4$ CFU/g). The results revealed that maximum CFU of bio-agents was observed at 45 DAT **(Table 26).**

Table 26. Population dynamics of potential bio-agents in rhizosphere and rhizoplane of rice (x10^4 CFU/g)

Treatment	Population dynamics					
	Rhizosphere (1x10^4 CFU/g)			Rhizoplane (1x10^4 CFU/g)		
	0 DAS	45 DAS	90 DAS	0 DAS	45 DAS	90 DAS
TCMS 43	0.67	6.00	5.33	4.33	17.33	14.00
TCMS 36	7.67	6.67	6.67	4.00	9.33	9.33
TCMS 9	1.67	7.67	2.33	3.33	20.00	11.33
Th 14	7.33	6.67	1.00	10.00	11.33	2.33
PBAT 3	1.00	3.33	8.00	3.00	4.33	2.00
Psf 173	12.33	29.00	9.67	18.00	21.67	9.33
Psf 2	13.00	25.67	32.00	18.00	20.67	10.33
***Bacillus* sp.**	11.00	**50.00**	**37.67**	12.33	**45.00**	**30.67**
Carbendazim	1.00	3.33	2.67	1.67	4.67	7.33
Control	0.67	1.67	1.00	1.00	3.00	2.00
CD (0.05)	3.3	4.8	4.7	2.3	6.6	4.3
CV (%)	34.6	20.1	26.4	18.3	24.8	26.1

ii. Pea

A field experiment was conducted at Crop Research Centre, Pantnagar during Rabi 2015-16 to evaluate eight potential isolates of bioagents on pea (variety Azad) for improvement of plant vigour and management of diseases. These bioagents were applied as soil application in field before sowing (1 kg bioagent colonized vermicompost /plot), seed bio-priming (10 g or 10 ml/kg seed) and as two foliar sprays (10 g or 10 ml/lit water), 1st at 45 DAS and 2nd at 70 DAS. Carbendazim applied as seed treatment (1 g/kg seed) and two foliar sprays @ 0.1% as above served as standard check. The experiment was laid in a randomized block design in three replications with a plot size of 2x3 $m^{2.}$

Occurrence of Diseases: Minimum seed mortality was observed with TCMS 9 (41.4%) as compared to carbendazim (43.0%) and control (56.6%). Germination was very poor due to heavy rain just after sowing. Significantly minimum plant mortality (30-70 DAS) was observed with *Bacillus* sp (0.8%) followed by TCMS 43 (2.5%), Psf-173 (2.6%) and PBAT-3 (3.2%) as compared to carbendazim (11.9%) and control (21.08%) **(Table 27)**. The bioagents were found effective in reducing post emergence mortality but ineffective in reducing downy mildew and rust diseases. **TCMS 9, PBAT-3 and Psf-173** was found comparatively better in reducing seed and plant mortality in the field**.** The optimum yield data was not recorded due to heavy rains and storm just after harvesting.

Table 27. Efficacy of promising bio-agents against seed and plant mortality in pea

Treatment	Plant Stand (30 DAS)	Germination (30 DAS)	Seed mortality	Plant stand (70 DAS)	Plant mortality (30-70DAS)
	No.	(%)	(%)	No.	(%)
TCMS 43	116.33	48.4	51.6	113.33	**2.5**
TCMS 36	125.00	52.0	48.0	109.67	12.2
TCMS 9	140.67	58.6	**41.4**	119.33	15.1
Th 14	106.33	44.3	55.7	100.67	5.3
PBAT 3	134.33	55.9	**44.1**	130.00	**3.2**
Psf 173	127.00	52.9	47.1	123.67	**2.6**
Psf 2	124.00	51.6	48.4	106.33	14.2
Bacillus	112.00	46.6	53.4	111.00	**0.8**
Carbendazim	137.00	57.0	**43.0**	120.67	11.9
Control	104.33	43.4	56.6	82.33	21.08
CD(0.05)	15.0	-	-	12.4	-
CV (%)	7.1	-	-	6.4	-

*No of seed sown 240/ plot

CFU count of bio-agents in rhizosphere and rhizoplane: Maximum population of bioagents in rhizosphere at 45 DAS was recorded in *Bacillus* sp. ($37.3x10^4$ CFU/g) followed by Psf-2 (30.0×10^4 CFU/g), Psf-173 ($25.0x10^4$ CFU/g) and TCMS 9 ($10.3x10^4$ CFU/g) as compared to control ($1.6x10^3$ CFU/g). Maximum population of bioagents on rhizoplane at 45 DAS was observed in Psf-2 (37.6×10^3 CFU/g) followed by *Bacillus* sp. (34.6×10^4 CFU/g), Psf-173 (28.0×10^4 CFU/g) and TCMS-9 ($19.3x10^4$ CFU/g) as compared to control ($1.3x10^4$ CFU/g) (**Table 28**).

Table 28. Population dynamics of promising bio-agents in rhizosphere & rhizoplane of Pea (var. Azad)

Treatment	Population dynamics (45DAS)	
	Rhizosphere ($x10^4$ CFU/g)	Rhizoplane ($x10^4$ CFU 45/g)
TCMS 43	7.00	12.00
TCMS 36	10.00	18.00
TCMS 9	10.33	19.33
Th 14	8.67	13.33
PBAT 3	3.00	5.33
Psf 173	25.00	28.00
Psf 2	**30.00**	**37.67**
Bacillus	**37.33**	**34.67**
Carbendazim	5.33	5.00
Control	1.67	1.33
CD (0.05)	2.6	3.2
CV (%)	11.3	10.8

iii. Chickpea

A field experiment was conducted at Crop Research Centre, Pantnagar during *Rabi* 2015-16 to evaluate eight potential isolates of bioagents on chickpea (variety PG-186) for the management of diseases and improvement of plant vigour. These bioagents were applied as soil application in field before sowing (1kg bio-agent colonized vermin-compost /plot), seed bio-priming (10 g or 10 ml/kg seed), and as two foliar sprays (10 g or 10 ml/lit water), 1st at 45 DAS and 2nd at 70 DAS. Carbendazim applied as seed treatment (1 g/kg seed) and two foliar sprays @ 0.1% served as standard check. The experiment was laid in a randomized block design in three replications with a plot size of 2x3 m^2.

Occurrence of Diseases: Minimum seed mortality was observed with Psf-173 (12.5%) followed by Psf-2 (13.4%), PBAT-3 (13.8%) and TCMS 36 (14.0%) as compared to carbendazim (16.7%) and control (23.3%) Minimum plant mortality (30-70 DAS) was observed with TCMS-9 (2.1%), followed by PBAT-3 (3.1%), Psf-2 (3.8%) and Th-14 (4.8%) as compared to carbendazim (11.5%) and control (13.8%) **(Table 29).**

Final mortality of the plants would be recorded one week before harvesting and yield data will be recorded after harvesting the crop i.e. during 1st week of May. Of all the isolates **PBAT-3** and **Psf-2** were found comparatively better than other isolates in reducing seed and plant mortality in field**.**

Table 29. Efficacy of promising bioagents against seed and plant mortality of chickpea in field

Treatment	Plant Stand (30 DAS)	Germination (30 DAS)	Seed mortality	Plant stand (70 DAS)	Plant mortality (30-70DAS)
	No.	(%)	(%)	No.	(%)
TCMS 43	203.67	78.3	21.7	174.33	14.4
TCMS 36	223.67	86.0	14.0	189.67	15.2
TCMS 9	219.67	84.4	15.6	215.00	**2.1**
Th 14	206.33	79.3	20.7	196.33	4.8
PBAT 3	224.33	86.2	**13.8**	217.33	**3.1**
Psf 173	227.67	87.5	**12.5**	202.00	11.2
Psf 2	225.33	86.6	**13.4**	216.67	**3.8**
Bacillus	219.67	84.4	15.6	205.00	6.6
Carbendazim	216.00	83.3	16.7	191.00	11.5
Control	**199.67**	**76.7**	**23.3**	**172.00**	**13.8**
CD(0.05)	12.3	-	-	17.6	-
CV (%)	3.3	-	-	5.1	-

*260 counted seeds were sown in each plot

CFU of *Trichoderma* in rhizosphere and rhizoplane: Significantly maximum population of potential bioagents in rhizosphere and rhizoplane at 45 DAS was recorded in Psf-2 (37.6 & 34.0 x10^4 CFU/g) followed by *Bacillus* sp. (34.6& 33.67 x10^4 CFU/g), Psf-173 (28.0 & 29.0 x10^4 CFU/g) and TCMS 9 (19.3 & 17.3 x10^4 CFU/g) as compared to control (1.3 & 2.0 x 10^4 CFU/g), respectively **(Table 30)**.

Table 30. Population of promising bio-agents in rhizosphere and rhizoplane of chickpea (PG-186)

Treatment	Rhizosphere (x10^4 CFU/g) 45 DAS	Rhizoplane (x10^4 CFU/g) 45 DAS
TCMS 43	12.00	14.67
TCMS 36	18.00	17.33
TCMS 9	19.33	15.00
Th 14	13.33	14.00
PBAT 3	5.33	10.00
Psf 173	28.00	29.00
Psf 2	37.67	34.00
Bacillus	34.67	33.67
Carbendazim	5.00	7.33
Control	1.33	2.00
CD (0.05)	2.1	2.9
CV (%)	7.2	9.6

2. Evaluation of potential isolates of *Trichoderma, Pseudomonas* and *Bacillus* for the management of pre & post-emergence damping-off and improved growth in vegetable Nursery beds of tomato onion and chilli (GBPUAT)

i. Tomato: The trial was conducted at Vegetable Research Centre, Pantnagar in nursery beds to evaluate eight potential isolates of bioagents (*Trichoderma, Pseudomonas, Bacillus*) to manage pre and post emergence damping-off and to improve plant vigour on tomato variety Pant-T3 during 2015. The experiment was laid out in a randomized block design in three replications with nursery plot size of 0.5 X 1.0 m^2.

Seed treatment: Seed bio-priming with bio-agent @ 10 g or ml/ kg seed

Soil application

***Trichoderma*:** 1g formulation/100g vermi-compost per m^2
***Pseudomonas/Bacillus*:** 1 ml formulation/100 g vermi-compost per m^2

Foliar spray: Three foliar sprays at 15, 30 and 45 DAS with bio-agent @ 10 g or ml/litre of water. Seed treatment with metalaxyl (6 g/kg seed) and three foliar sprays with metalaxyl @ 0.1% as above served as standard check.

Plant vigour: Maximum plant vigour index was observed with Psf-173 (320.9) followed by Psf-2 (307.8) and PBAT 3 (255.8) as compared to metalaxyl (72.6) and control (148.7) **(Table 31).**

Occurrence of diseases: Significantly minimum pre-emergence seed mortality (30 DAS) was observed with Psf-173 (13.1%) followed by Psf-2 (14.8%) as compared to metalaxyl (66.2%) and control (29.2%) **(Table 32)**. Significantly minimum post- emergence mortality (30-60 DAS) was observed with TCMS 43 (14.0% and TCMS 36 (14.2%), as compared to metalaxyl (17.3%) and control (16.7%).

Table 31. Efficacy of promising bio-agents on plant vigour of tomato seedlings in nursery bed

Treatment	Seedling Length*	Shoot length*	Root length*	Fresh weight*	Fresh shoot weight*	Fresh root weight*	Vigour index
	(cm)	(cm)	(cm)	(g/seedling)	(g/seedling)	(g/seedling)	
TCMS 43	28.17	21.67	6.50	5.35	4.89	0.47	199.9
TCMS 36	28.00	20.87	7.13	4.76	4.25	0.49	232.1
TCMS 9	24.40	19.50	4.90	4.84	4.45	0.36	174.9
Th14	28.34	22.27	6.07	4.86	4.28	0.48	228.1
PBAT 3	30.13	23.20	6.93	8.95	8.41	0.56	255.8
Psf 173	**37.67**	**29.37**	**8.30**	**9.70**	**8.81**	**0.74**	**320.9**
Psf 2	**36.14**	**28.07**	**8.07**	**10.39**	**9.85**	**0.64**	**307.8**
Bacillus	26.13	20.83	5.30	3.89	3.44	0.46	209.3
Metalaxyl	21.47	17.70	3.77	3.68	3.22	0.45	72.6
Control	**21.07**	17.50	3.57	3.08	2.75	0.30	148.7
CD(0.05)	2.5	2.0	1.3	0.6	0.6	0.1	-
CV (%)	5.2	5.4	12.5	6.8	7.1	18.2	-

*Mean of 10 seedlings

Table 32. Efficacy of promising bioagents against seed and seedling mortality of tomato in nursery beds

Treatment	Plant Stand (30 DAS)	Germination (30 DAS)	Pre – emergence mortality	Plant stand (45 DAS)	Plant stand (60 DAS)	Post-emergence mortality (30-60DAS)
	no.	(%)	(%)	no.	no.	(%)
TCMS 43	177.33	70.9	29.1	174.67	152.33	**14.0**
TCMS 36	205.33	82.1	17.9	202.00	**176.00**	**14.2**
TCMS 9	184.33	73.7	27.3	172.33	154.67	16.0
Th 14	201.33	80.5	19.5	189.33	151.67	24.6
PBAT 3	211.33	84.5	15.5	207.33	**171.00**	19.0
Psf 173	**217.33**	**86.9**	**13.1**	**215.00**	159.33	26.6
Psf 2	**213.00**	**85.2**	**14.8**	**210.67**	165.00	22.5
Bacillus	200.33	80.1	19.9	198.67	168.00	16.0

Metalaxyl	84.67	33.8	66.2	76.33	70.00	17.3
Control	177.00	70.8	29.2	176.00	147.33	16.7
CD(0.05)	23.4	-	-	20.7	27.1	-
CV (%)	7.2	-	-	6.6	10.4	-

*****250 counted seeds were sown in each treatment

ii. Onion: The trial was conducted at Vegetable Research Centre, Pantnagar in nursery beds to evaluate eight potential isolates of bio-agents (*Trichoderma, Pseudomonas, Bacillus*) to manage pre and post emergence damping off and to improve seedling vigour in onion. The experiment was laid out in a randomized block design in three replications with nursery plot size of 0.5 X 1.0 m^2.

Plant vigour: Significant maximum plant vigour index was observed with PBAT 3 (268.4) followed by *Bacillus* sp. (211.5) as compared to metalaxyl (64.2) and control (132.3) **(Table 33)**.

Occurrence of diseases: Significantly minimum pre-emergence mortality (30 DAS) was observed with PBAT 3 (12.5%) followed by *Bacillus* sp. (14.9%) as compared to metalaxyl (65.3%) and control (27.6%). Significantly minimum post-emergence mortality (30-75 DAS) was observed with PBAT 3 (2.8%) followed by Psf 173 (7.8%), as compared to metalaxyl (30.2%) and control (16.3%) **(Table 34)**.

Table 33. Efficacy of promising bio-agents against plant vigour of onion (N-53) in nursery

Treatment	Length of seedling	Shoot length	Root length	Fresh seedling weight	Fresh Shoot weight	Fresh Root weight	Vigour index
	(cm)	(cm)	(cm)	(g)	(g)	(g)	
TCMS 43	23.13	19.53	3.60	1.44	1.13	0.28	177.0
TCMS 36	20.37	17.60	2.77	1.03	0.81	0.22	139.9
TCMS 9	20.33	16.93	3.40	1.14	0.87	0.27	157.5
Th14	21.03	17.33	3.70	1.18	0.95	0.23	157.6
PBAT 3	30.40	26.60	3.80	2.95	2.43	0.49	**268.4**
Psf 173	21.07	18.67	2.40	1.16	0.97	0.23	146.6
Psf 2	20.33	17.30	3.03	1.29	1.11	0.18	142.2
Bacillus	24.56	21.13	3.43	2.01	1.61	0.40	**211.5**
Metalaxyl	17.96	15.73	2.23	0.91	0.68	0.16	64.2
Control	20.86	18.63	2.23	1.41	1.18	0.23	132.3
CD(0.05)	0.19	2.2	0.5	0.1	0.1	0.08	-
CV (%)	5.1	6.9	9.5	6.7	6.8	18.0	-

*250 counted seeds were sown in each treatment

Table 34. Efficacy of promising bio-agents against seed and seedling mortality of onion

Treatment	Plant Stand (30 DAS)	Germination (30 DAS)	Pre-emergence mortality	Plant stand (45 DAS)	Plant stand (60 DAS)	Plant stand (75 DAS)	Post-emergence mortality (30-75 DAS)
	no.	(%)	(%)	no.	no.	no.	(%)
TCMS 43	188.67	75.4	29.6	187.00	180.00	170.00	9.8
TCMS 36	172.00	68.8	31.2	166.33	162.67	152.00	11.6
TCMS 9	193.33	77.3	23.7	189.67	174.33	166.33	13.9
Th 14	186.67	74.6	26.4	185.33	167.33	160.00	14.2
PBAT 3	**221.33**	**88.5**	**12.5**	**218.33**	**216.33**	**215.00**	**2.8**
Psf 173	174.00	69.6	31.4	166.67	165.00	160.33	**7.8**
Psf 2	174.33	69.7	31.3	173.33	158.00	155.67	10.7
Bacillus	**215.33**	**86.1**	**14.9**	**210.00**	**200.00**	**190.00**	11.7
Metalaxyl	89.33	35.7	65.3	83.00	65.00	62.33	30.2
Control	158.67	63.4	27.6	153.33	137.67	132.67	16.3
CD(0.05)	17.5	-	-	9.9	9.8	13.6	-
CV (%)	5.7	-	-	3.3	3.5	5.1	-

*250 counted seeds were sown in each treatment

3. Evaluation of promising biological control agents against chilli anthracnose (AAU-A, GBPUAT and PAU)

AAU-Anand

Location: Agronomy farm, BACA, Anand Agricultural University, Anand.

Season and year: *Kharif 2015*

Experimental details

Treatments : 6
Replication : 4
Design : Randomized Block Design (RBD)
Crop / variety : Chilli (GCV-131)
Spacing : 60 x 60 cm
Plot size : Gross : 5.4 x 4.2 m
Net : 2.7 x 3.4 m

Details of treatments

T1: *Pichia guilliermondii* (Y12) Seed treatment, Seedling dip & Foliar spray ($2x10^8$ cfu ml^{-1})
T2: *Hanseniaspora uvarum* (Y73) Seed treatment, Seedling dip & Foliar spray ($2x10^8$ cfu ml^{-1})
T3: *Trichoderma harzianum* (Th-3) Seed treatment, Seedling dip & Foliar spray ($2x10^8$ cfu g^{-1})
T4: *Pseudomonas fluorescence* Seed treatment, Seedling dip & Foliar spray ($2x10^8$ cfu g^{-1})

T-5: Recommended fungicide control (Carbendazim 0.05%) Seed treatment, Seedling dip & Foliar spray
T-6: Untreated control

Method of application

a) Seed treatment: The seeds were treated with formulations before sowing into nursery. Ten ml or grams of concentrated formulation was mixed with 100 ml of water and used to treat 1 kg of seeds. The seeds were soaked in formulation for 5 minutes with constant shaking and then the treated seeds were shade dried for 1 hour and used for sowing.

b) Seedling dip: Chilli seedlings were raised in plastic trays or nursery beds were treated with antagonist formulation just before transplantation. Twenty ml or 20gm of formulation was mixed in 1litre water to obtain antagonist suspension for seedling treatment. Seedlings were uprooted carefully from plastic trays or nursery beds and roots were dipped in antagonist suspension for 5-10 minutes and transplanted to main field.

c) Foliar/fruit spray: Foliar spray of antagonist formulation was given at the rate of 10 g or 10 ml per litre of water using a high volume sprayer with a spray fluid volume of 500 L ha^{-1}. First spray was given at initiation of fruit ripening and later 3 sprays were given at monthly intervals or until the last harvest.

Among the different biocontrol treatments under study, seed treatment, seedling dip and foliar spray ($2x10^8$ cfu ml^{-1}) of *P. guilliermondii* (Y12) found best with low disease intensity (13.56%) and higher yield (38.16 q/ha) followed by seed treatment, seedling dip and foliar spray ($2x10^8$ cfu ml^{-1}) of *P. fluorescens* with disease intensity (14.22%) and yield (33.68 q/ha), *H. uvarum* (Y73) with disease intensity (15.11%) and yield (29.21 q/ha) and *T. harzianum* (Th-3) with disease intensity (16.43) and yield (21.79 q/ha). Further it was observed that chemical treatment (carbendazim 0.05%) showed the lowest disease intensity (10.09 %) and highest yield (49.17 q/ha) was recorded **(Table 35)**.

Table 35. Biological control of chilli anthracnose disease

Sl. No.	Treatment	Disease intensity (%)					Disease control over untreated (%)	Yield (q/ha)
		At 1st spray	At 2nd spray	At 3rd spray	At 4th spray	Pooled		
T_1	*P. guilliermondii* (Y12) Seed treatment, Seedling dip & Foliar spray ($2x10^8$cfu ml^{-1})	15.48 (7.12)	14.24 (6.05)	13.20 (5.21)	11.33 (3.86)	13.56 (5.50)	64.72	38.16
T_2	*H. uvarum* (Y73) Seed treatment, Seedling dip & Foliar spray ($2x10^8$cfu ml^{-1})	16.98 (8.53)	15.20 (6.87)	14.79 (6.52)	13.49 (5.44)	15.11 (6.80)	56.38	29.21
T_3	*T. harzianum* (Th-3) Seed treatment, Seedling dip & Foliar spray ($2x10^8$cfu g^{-1})	17.73 (9.27)	16.88 (8.43)	16.19 (7.77)	14.91 (6.62)	16.43 (8.00)	48.69	21.79
T_4	*P. fluorescens* Seed treatment, Seedling dip & Foliar spray ($2x10^8$cfu g^{-1})	16.52 (8.02)	14.02 (6.42)	14.28 (5.98)	12.08 (4.79)	14.22 (6.30)	59.58	33.68
T_5	Recommended fungicide (Carbendazim 0.05%)	11.49 (3.97)	10.65 (3.42)	9.43 (2.68)	8.79 (2.34)	10.09 (3.07)	80.31	49.17

	control Seed treatment, Seedling dip & Foliar spray							
T_6	Untreated control	20.09 (11.80)	21.50 (13.43)	24.86 (17.67)	26.61 (20.06)	23.26 (15.59)	-	16.10
S.Em. ±		0.98	0.83	0.86	0.90	0.45	-	1.53
C. D. (5 %)		3.02	2.55	2.65	2.78	1.27	-	4.71
C.V. %		11.99	10.54	10.97	12.01	11.40	-	9.90

Figures outside the parentheses are arcsine transformed values, those inside are retransformed values

GBPUAT Pantnagar

A field experiment was conducted at Vegetable Research Centre, GBPUAT, Pantnagar during Rabi 2015 to evaluate the efficacy of different biological control agents viz. *Trichoderma harzianum* (Th-3), *Pichiaguillier mondii* (Y-12) and *Hanseniaspora uvarum* (Y-73) received from NBAIR, Bangalore and Th-14, SBIT-2 (*Trichoderma harzianum* from Pantnagar) and carbendazim (standard check) were used against chilli anthracnose. The experiment was laid in a randomized block design in three replications with a plot size of 3 x 2 m. 1st foliar spray of all bioagents (10 g/lit. of water) was given after fruit setting and before appearance of anthracnose symptoms on 20th May 2015 then at an interval of 15 days. A total of four foliar sprays were given.

Method of application

i. Seed treatment: Soaked the seeds in suspension for 5 min. then dried under shade before sowing in nursery beds.

a. Bio-agents @ 10 g or 10 ml formulation in 100 ml water/kg seed
b. carbendazim @ 1 g/kg seed

ii. Seedling dip treatment: dipped the seedlings in bio-agent suspension as above for 5 min.
iii. Foliar sprays: 10 g or 10 ml formulation in 1lit.water. 1st spray at initiation of fruiting, then 3-4 sprays at 15 days intervals or until the last harvest.

Significantly minimum fruit rot incidence was found with carbendazim (10.8%) followed by Th-3 (13.1%), Y-12 (13.6%) and SBIT-72 (14.7%) as compared to control (18.8%). Significantly maximum fruit yield was observed with SBIT-72 (14.6 q/ha) followed by carbendazim (13.6 q/ha), Th-3 (13.4 q/ha) and Y-12 (13.3 q/ha) as compared to control (8.7 q/ha) **(Table 36).**

Table 36. Efficacy of bioagents against chilli anthracnose and yield

Treatment	No. of fruits/plot*				Yield (q/ha)	Increase in yield over control %
	Healthy fruits (No.)	Diseased Fruits (No.)	Fruit rot incidence %	Reduction in incidence %		
Th-3	1828.3	276.6	13.14	30.3	13.43	53.4
Y-12	1833.3	290.0	13.65	27.6	13.32	52.2
Y-73	1760.0	441.6	20.05	-6.3	9.41	7.5
PBAT-3	1718.3	365.0	17.52	7.1	12.92	47.6
Th-14	1608.3	325.0	16.81	10.8	10.69	22.1
SBIT-72	2056.6	356.6	14.77	21.6	14.67	67.6
Carbendazim	1564.3	190.1	10.80	4.2	13.68	56.3
Control	1340.0	311.6	18.86	-	8.75	-
CD(0.05) **CV (%)**	2.1 3.0	1.1 3.5	-	-		

* Mean of three plots (each plot with 20 plants)

PAU-Ludhiana

The experiment was conducted on Chilly variety CH 1 at Entomological Research Farm, Punjab Agricultural University, Ludhiana in Randomized Block Design. There were five treatments, viz *Pichia guilliermondii*, *Hanseniaspora uvarum*, *Trichoderma harzianum*, recommended fungicide (Indofil M-45) and untreated control with four replications each. The chilly seedlings were transplanted as per agronomic norms with spacing of 2x3 feet (plant to plant and row to row). The chilly seedlings were treated with antagonists formulation just before transplantation. The formulations @ 20 ml were mixed with one litre water to obtain antagonist suspension for seedling treatment. Seedlings were uprooted carefully from the beds and the roots were dipped in these antagonist suspensions for 5-10 minutes and transplanted to main field. Secondly, foliar sprays of antagonists were given at the rate of 10 g per liter of water. The first spray was given at initiation of fruit ripening and the subsequent sprays were given at monthly intervals until last picking. The data on per cent fruit rot incidence and yield were recorded.

Disease incidence during the month of May was low and varied from 4.37 to 9.17%, During June the percent disease incidence varied from 13.71 to 21.38% and was non significant. During month of July, lowest per cent fruit rot (19.26%) was recorded in chilly plot treated with chemical control (Indofil M-45 @ 750 g in 250 litre water/acre) which was significantly better than all other treatments. This was followed by plots treated with *P. guilliermondii* and *T. harzianum* which recorded 22.15 and 24.25% fruit rot incidence respectively and were at par with each other **(Table 37)**. During August also, lowest fruit rot incidence (19.24%) was in chemical treated plot. This was followed by *P. guilliermondii* and *T harzianum* which recorded 27.67 and 32.02% fruit rot incidence and were at par with each other. However, both were significantly better than *H. uvarum* (38.72%). All the treatments were significantly better than untreated control (39.80%). Yield was maximum (67.66 q/ac) in chemical treated plot and was significantly better than other treatments. Among bioagents, *P. guilliermondii and T. harzianum* treated plots recorded yield of 58.5 and 56.72 q/acre,

respectively **(Table 37)**. Yield in untreated plot was 49.0 q/acre and was at par with *H. uvarum* (50.1 q/acre).

Table 37. Evaluation of fungal antagonists against chilly anthracnose disease

Treatments	Per cent Fruit rot incidence				Yield (q/acre)
	May	June	July	August	
Pichia guilliermondii	5.50	15.01	22.15[b]	27.67[b]	58.52
Hanseniaspora uvarum	6.55	15.56	27.88[c]	38.72[c]	50.16
Trichoderma harzianum	4.92	14.32	24.25[bc]	32.02[bc]	56.72
Indofil M 45@ 750g in 250 litre water/acre	4.37	13.71	19.26[a]	19.24[a]	67.66
Untreated control	9.17	21.38	38.58[d]	39.80[c]	49.0
C.V.	18.21	14.42	5.92	9.13	4.53

4. Management of bacterial wilt an isolate of *Pseudomonas florescence* (CAU)

The susceptible variety Anamika (Brinjal) was used in the experiment. The seedlings were raised in the month of September and 30 days old seedlings were transplanted in October. The experimental field was laid out in randomized block design with a plot size of (12.6 X 6.6 m) and crop was transplanted at (60 X 60 cm) spacing. A total eight treatments including an untreated control *viz*., intercropping with marigold (one row after every nine rows of brinjal and border), mustard oil cakes @ 5 q/ha as soil amendments, seedlings root dip with CHF*Pf*-1 (a formulation prepared with a local strain of *Pseudomonas fluorescens* 2 x 10^8 cfu/gm) @ 25 g/litre of water dipping for 30 minutes before transplanting, soil drenching with CHF*Pf*-1 @ 2.5 g/litre of water at 20 days after transplanting (DAT), seedlings root dip + soil drenching with CHF*Pf*-1, soil drenching with streptocycline (streptomicin sulphate 90 % + tetracycline hydrochloride 10%) of Hindustan Antibiotics Ltd, Pune, India @ 400 ppm at 20 DAT, soil drenching of bleaching powder of J. Industries, Guwahati, India @ 5 gm/litre of water at 20 DAT and untreated control were evaluated. Three replications were maintained for each treatment. The observations on bacterial wilt incidence were recorded for every 10 days after transplantation. The wilted plants were first confirmed with oozed test and the confirmed plants were recorded and converted into per cent wilted plants. The plant characters *i.e.*, plant height was recorded at 60 and 80 days after transplanting. The number of fruits and weight of the fruits in each plucking were recorded from 10 marked plants in each plot and average number and weight of fruit/plant was worked out. The yield per ha for each treatment were calculated based on the survive plants, average number and weight of fruit/plant.

All the treatments showed a significantly lower wilt incidence of bacterial wilt disease than the untreated control. The lowest incidence of bacterial wilt with 14.16% wilted plant was recorded in the plot treated with seedling root dip + soil drenching with CHF*Pf*-1 and it was significantly different from other treatments. Untreated control showed 57.43% of wilted

plants. The highest yield per ha was recorded in treatment with seedling root dip + soil drenching with CHF*Pf*-1 (235.65 q/ha) and it was significantly different form all other treatments. Untreated control gave a yield of 78.65 q/ha **(Table 38).**

Table 38. Bio-efficacy of *Pseudomonas fluorescens* against bacterial wilt of brinjal

Treatments	Per cent wilt incidence	Plant height (cm)	No. of fruit/ plant	Fruit weight (g)	Yield (q /ha)
Marigold (after every 9 rows of brinjal and borders)	39.65 (39.03)	62.87	6.75	106.98	89.30
Mustard oil cakes @5q/ha as soil amendment	19.03 (25.89)	66.93	7.87	108.42	184.00
Soil drenching with *P. fluorescens* @2.5g/litre of water	18.62 (25.56)	67.52	8.35	112.04	115.30
Seedlings root dip with *P. fluorescens* @25g/ litre of water	20.65 (27.03)	66.20	7.91	109.11	178.60
Seedlings root dip with *P. fluorescens* @25g/ litre of water + soil drenching with *P. fluorescens* @2.5g/litre of water at 20 DAT	**14.86 (22.76)**	**68.06**	**8.42**	**113.16**	**235.65**
Streptomycin (streptomycin sulphate 90 % + tetracycline hydrochloride 10%) @200ppm soil drenching at 20 DAT	17.53 (24.75)	65.30	7.06	107.36	172.24
Bleaching powder @ 5g/litre of water soil drenching at 20 DAT	19.67 (25.66)	65.93	7.32	107.16	175.90
Untreated control	**57.43 (49.27)**	**63.98**	**6.80**	**108.86**	**78.65**
SE(m)±	0.49	0.57	0.43	1.10	11.06
CD at (P=0.05%)	1.49	1.72	1.31	3.32	33.10
CV (%)	2.84	1.52	10.07	1.70	12.47

*Figures in parentheses are angular transformed values.

2.3. Biological suppression of Sugarcane pests

1. Monitoring the sugarcane woolly aphid (SWA) incidence and impact assessment of natural enemies on its biosuppression (MPKV, TNAU, PJTSAU and UAS-R)

MPKV-Pune

The incidence of sugarcane woolly aphid (SWA) and occurrence of its natural enemies (*Encarsia flavoscutellum, Dipha aphidivora, Micromus igorotus,* syrphid, spider) were recorded from five agro-ecological zones of western Maharashtra covering Pune, Satara, Sangli, Kolhapur, Solapur, Ahmednagar, Nashik, Nandurbar, Jalgaon and Dhule districts. The SWA incidence, pest intensity rating (1-6 scale) and natural enemies population on leaf at five spots and 5 clumps per spot from each plot were recorded during crop growth period.

The sugarcane fields were surveyed during June, 2015 to March, 2016. The pest incidence was recorded shade along riverside and canal areas. The SWA incidence was recorded along with natural enemies of SWA in fields. The villages *viz.,* Kasarsai, Ravet, Jambh, Dattawadi and Marunji in Mulshi Tahsil; Babulgao and Padasthal in Inadapur Tahsil; Nirawagaj and Malad in Baramati Tahsil of Pune district; Umbraj, Bhavaninagar and Koparde in Karad Tahsil, Nele, Kidgaon, Dhavadashi and Kalambe in Satara Tahsil of Satara district, Akluj, Malinagar, Malsirus, Teburni and Pandharpur in Solapur district, Bhilwadi, Ankalkhop ad Dudhodi in Palus Tahsil, Kasegaon, Walwa , Bavchi and Borgaon in Walwa Tahsil of Sangli district. Jakhuri in Sangamner Tahsil of Ahmedangar district, Kuditre and Kupire in Karveer Tahsil of Kolhapur district. Incidence of Sugarcane woolly aphid was very low in few pockets of Western Maharashtra due to the establishment of the natural enemies. The predators were recorded from the month of July onwards, *Micromus igorotus* recorded from July to November, 2015 and *Dipha aphidivora* recorded from October to March, 2016. The predators, *Micromus igorotus* and *Dipha aphidivora* were well established in sugarcane areas. *Encarsia flavoscutellum* was observed in Solapur, Pune and Satara district of western Maharashtra.

In general, this year the incidence of SWA has slightly increased in Sangli and Kolhapur districts as compared to last year. The natural enemies occurred immediately after the incidence of SWA. The average pest incidence and intensity were 1.54 per cent and 1.57, respectively. The natural enemies recorded in the SWA infested fields were mainly predators like *Dipha aphidivora* (0.6-3.0 larvae/leaf), *Micromus igorotus* (1.2–5.2 grubs/leaf), syrphid, *Eupoderes confractor* (0.2- 1.0 larvae/leaf) and spider (0.1-0.3 /leaf) from July to February, 2016 **(Table 39)**. The parasitoid, *Encarsia flavoscutellum* distributed and established well in sugarcane fields and suppressed the SWA incidence in Pune, Solapur and Satara districts of Maharastra.

Table 39. Effect of natural enemies on incidence of sugarcane woolly aphids in Maharashtra

Districts	SWA incidence (%)	Pest intensity rating (1-6)	Natural enemies/leaf				Spiders
			D. aphidivora	*M. igorotus*	*E. flavosc-utellum*	*E. confra-ctor*	
Pune	1.0	1.0	0.8	3.8	2.3	0.6	0.1
Satara	1.6	2.0	1.6	3.8	8.0	0.6	0.1
Sangli	2.3	2.0	1.8	4.8	7.0	0.6	0.3
Kolhapur	2.4	2.0	3.0	5.2	5.8	0.3	0.3
Ahmednagar	0.8	1.0	0.6	1.2	1.6	0.4	0.1
Solapur	2.1	2.0	1.2	2.6	10.2	1.0	0.3
Nashik	0.6	1.0	0.6	1.2	0.6	0.2	0.1
Average	**1.54**	**1.57**	**1.37**	**3.22**	**5.07**	**0.52**	**1.8**
Range	**0.6–2.4**	**1 -2**	**0.6-3.0**	**1.2–5.2**	**0.6 -10.2**	**0.4- 1.0**	**0.1-0.3**

Pest Intensity Rating **1**=0, **2**= 1-20, **3**= 21–40, **4**=41–60, **5**=61–80, **6**=81-100 % leaf covered by SWA.

TNAU-Coimbatore

The sugarcane crop grown in various regions of Tamil Nadu were observed for the incidence of sugarcane woolly aphid. In addition, the presence of natural enemies along with sugarcane woolly aphid was also noticed.

The incidence of SWA, pest intensity rating and natural enemy populations on leaf at five spots and five clumps/ spot were recorded at monthly intervals during crop growth period. Monitoring of sugarcane woolly aphid incidence was carried out from April 2015 to March 2016 at 7 major sugarcane growing districts of Tamil Nadu *viz.*, Coimbatore, Erode, Tiruppur, Karur, Cuddalore, Villupuram and Vellore. The prevalence of sugarcane woolly aphid was noted from July 2015 in Coimbatore followed by Tiruppur in August 2015. But the incidence of sugarcane woolly aphid was absent in all the districts surveyed during September, October, November, December 2015 and January 2016. Subsequently the presence of sugarcane woolly aphid was noticed again during February 2016 in Erode, Namakkal, Karur and Coimbatore.

Among the seven districts surveyed, the incidence of sugarcane woolly aphid was noted in Coimbatore from July 2015 at low intensity which recorded a grade of 0-1 **(Table 40 and 41)**. The SWA was noticed in patches and the occurrence of *Micromus igorotus* and *Encarsia flavoscutellum* were also observed **(Table 40)** along with the population of SWA. The occurrence of SWA in Tiruppur during August 2015 is 8.6 SWA/2.5 sq.cm. The prevalence of SWA incidence during February 2016 in Erode, Karur, Coimbatore and Namakkal with the maximum population upto 9.4 SWA /2.5 sq.cm leaf in Erode district. The population was high during March 2016 in Erode and Namakkal district. The level of SWA incidence during March 2016 increased in Erode district (18.4 SWA/2.5 sq. cm) followed by Namakkal district (12.6 SWA /2.5 sq. cm leaf area).

Table 40. Mean population of Sugarcane Woolly Aphid and its natural enemies in different zones of Tamil Nadu

Districts surveyed	July 2015				August 2015				February 2016				March 2016			
	SWA/ 2.5 sq.cm	*Dipha/ leaf*	*Encarsia/ leaf*	*Micromus / leaf*	*SWA/ 2.5 sq.cm*	*Dipha/ leaf*	*Encarsia/ leaf*	*Micromus / leaf*	*SWA/ 2.5 sq.cm*	*Dipha/ leaf*	*Encarsia/ leaf*	*Micromus / leaf*	*SWA/ 2.5 sq.cm*	*Dipha/ leaf*	*Encarsia/ leaf*	*Micromus / leaf*
Erode	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	0.5	2.8	1.5	18.4	1.2	4.6	2.3
Tiruppur	0.0	0.0	0.0	0.0	8.6	0.0	1.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coimbatore	4.2	0.0	3.2	1.2	0.0	0.0	0.0	0.0	3.6	0.0	1.5	1.0	0.0	0.0	0.0	0.0
Karur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	2.0	0.7	5.8	1.0	2.3	1.5
Cudalore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Namakkal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6	0.0	0.0	0.6	12.6	1.0	2.8	2.0
Vellore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 41. Mean incidence of Sugarcane Woolly Aphid (Intensity rating) in different zones of Tamil Nadu

Districts surveyed	July 2015		August 2015		September 2015		October 2015		November 2015		December 2015		January 2016		February 2016		March 2016	
	% incidence	*Grade*	*% incidence*	*Grade*	*% incidence*	*Grade*	*% incidence*	*Grade*	*% incidence*	*Grade*	*% incidence*	*Grade*	*% incidence*	*Grade*	*% incidence*	*Grade*	*% incidence*	*Grade*
Erode	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.8	2.0	14.2	2.0
Tiruppur	0.0	0.0	5.8	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coimbatore	3.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.0	0.0	0.0
Karur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	1.0	6.3	1.0
Cuddalore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nammakkal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	1.0	10.4	2.0
Vellore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PJTSAU-Hyderabad

The sugarcane growing areas of Telangana *viz*., Nizamabad and Medak were surveyed for infestation and intensity of Sugarcane woolly aphid incidence. Except for patchy appearance of SWA in some fields, the overall scenario showed negligible incidence levels of SWA in Telangana areas.

UAS-Raichur

No report received

2. Management of White grub, *Holotrichia consanguinea* Blanch in sugarcane using Bioagents (ANGRAU, Anakapalle)

Endemic areas of Naikampalli – Yellamilli (Dandepalli mandal) in Navabharat ventures (Sugar division) operational area, Samarlkota, East Godavari dist, Andhra Pradesh were selected as the test site for the conduct of experiment in farmers field.

Variety : 2003V46 Seedlings
Age of the crop : 6 months
Date of ratooning : 11.01.2015
Date of harvest : 18.12.2015
Treatments : 9

T1 : *Beauveria bassiana* @ 5 kg ha^{-1} 1 $x10^8$ spores/ gm in 250 kg FYM
T2 : *Metarrhizium anisopliae* @ 5 kg ha^{-1} 1 $x10^8$ spores/ gm in 250 kg FYM
T3 : *Heterorhabditis sp.* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1}
T4 : *Steinernema sp.* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1}
T5 : *Heterorhabditis sp*. WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1} two times at two intervals
T6 : *Steinernema sp.* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1} two times at two month interval
T7 : Neem cake @ 500 kg ha^{-1}
T8 : Phorate 10G @ 15 kg ha^{-1}
T9 : Untreated control

Time of Application: Treatments applied after the onset of monsoon (27.07.2015)

White grub damage was below 5% with the application of entomopathogenic fungi and entomopathogenic nematode treatments after onset of rains. White grub damage was low in *Metarrhizium anisopliae* (1.47%) followed by *Heterorhabditis indica* twice application (2.17%), *Steinernema sp.* twice application (2.79%), *Beauveria bassiana* (3.0%), *Steinernema sp.* (3.16%) and *Heterorhabditis* sp. (4.61%). Plant damage due to white grub was high in untreated control (48.04%) followed by neem cake (25%) and phorate (12.65%) **(Table 42)**.

White grub population was low in *Metarrhizium anisopliae* (0.67 grub/ 10 m row) followed by *Heterorhabditis* sp. twice application (1.33 grub/ 10 m row) and *Beauveria bassiana*

and *Steinernema sp.* (1.67 grubs/ 10 m row) and high in untreated control (13.67 grubs/10 m row), Neem cake (9.0 grubs/10 m row) and phorate (6.33 grubs/10 m row).

Cane yield was high in *Metarrhizium anisopliae* (87.4 t/ha) followed by *Heterorhabditis sp.* twice application (77.08 t/ha), *Beauveria bassiana* (74.99 t/ha) and *Steinernema sp.* twice application (73.42 t/ha) and was low in control (24.93t/ha), phorate (61.59 t/ha) & neem cake (61.91 t/ha) **(Table 43)**.

Soil application of entomopathogenic fungi, entomopathogenic nematodes after the onset of mansoon were found effective in reducing the white grub damage, white grub population and recorded higher cane yields.

Table 42. Efficacy of Entomopathogenic fungi and EPN against white grub in sugarcane ratoon crop

Treatment	White grub damage (%)	White grubs / 10 m row	Per cent reduction in White grub damage over control
T1 : *Beauveria bassiana* @ 5 kg ha^{-1} 1 $x10^8$spores/ gm in 250 kg FYM	3.0	1.67	93.76
T2 : *Metarrhizium anisopliae* @ 5 kg ha^{-1} 1 $x10^8$spores/ gm in 250 kg FYM	1.47	0.67	96.94
T3 : *Heterorhabditis sp.* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1}	4.61	2.67	90.40
T4 : *Steinernema sp.* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1}	3.16	1.67	93.42
T5 : *Heterorhabditis sp.* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1} two times at two month interval	2.17	1.33	95.48
T6 : *Steinernema sp.* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1} two times at two month interval	2.79	1.67	94.19
T7 : Neem cake @ 500 kg ha^{-1}	25.0	9.0	47.96
T8 : Phorate 10G @ 15kg ha^{-1}	12.65	6.33	73.67
T9 : Untreated control	48.04	13.67	
CD(P=0.05)	8.35	0.51	
CV%	21.23	14.13	

Table 43. Effect of entomopathogenic fungi and EPN on the yield of sugarcane ratoon crop

Treatment	NMC '000/ha	Cane yield t /ha	Yield increase over control t/ha
T1 : *Beauveria bassiana* @ 5 kg ha^{-1} (1 $x10^8$spores/ gm) in 250 kg FYM	83.00	74.99	50.06
T2 : *Metarrhizium anisopliae* @ 5 kg ha^{-1} (1 $x10^8$spores/ gm) in 250 kg FYM	90.00	87.41	62.48
T3 : *Heterorhabditis sp.* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1}	80.33	70.77	45.84
T4 : *Steinernema sp.* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1}	79.33	70.09	45.16
T5 : *Heterorhabditis sp*. WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1} two times at two month interval	86.33	77.08	52.15
T6 : *Steinernema sp.* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1} two times at two month interval	84.17	73.42	48.49
T7 : Neem cake @ 500 kg ha^{-1}	78.67	61.91	36.98
T8 : Phorate 10G @ 15kg ha^{-1}	78.67	61.59	36.66
T9 : Untreated control	44.33	24.93	
CD(P=0.05)	3.05	3.7	
CV%	13.59	2.42	

3. Bioefficacy of entomopathogenic fungi and entomopathogenic nematodes in suppression of termite incidence in sugarcane (ANGRAU- Anakapalle)

Date of planting : 07.08.2015
Crop : Sugarcane
Variety : 2009 A 107
Date of harvest : yet to be harvested during June, 2016

Treatments imposed

T1 : *Beauveria bassiana* @ 5 kg/ha ($1x10^8$ spores/ gm) in 250 kg FYM
T2 : *Metarhizium anisopliae* @ 5kg/ha ($1x10^8$ spores/ gm) in 250 kg FYM
T3 : *Heterorhabditis indica* WP @ 20 kg/ha in 150 kg moist sand ha^{-1}
T4 : *Steinernema* sp. WP @ 20 kg/ha in 150 kg moist sand ha^{-1}
T5 : Neem cake @ 500 kg/ha at planting
T6 : Chlorpyriphos 50 TC @ 5 ml/L Soil drenching at planting
T7 : Untreated control
T8 : *Heterorhabditis* sp. WP @ 20 kg/ha in 150 kg moist sand ha^{-1} two times at two months interval
T9 : *Steinernema* sp. WP @ 20 kg/ha in 150 kg moist sand ha^{-1} two times at two months interval

Entomopathogenic fungal cultures, *Beauveria bassiana* and *Metarhizium anisopliae* were mixed with FYM @ 1 kg / 100 kg FYM for 15 days enrichement before soil application.

Sugarcane germination was high in *Metarhizium anisopliae* (59.62%), *Beauveria bassiana* (58.15%) and *Heterorhabditis indica* twice application (58.07%) and was low in control (44.1%). Bud damage recorded was low in *Metarhizium anisopliae* (40.38 %), *Beauveria bassiana* (41.85%) and *Heterorhabditis indica* two times application (41.93%) and high in Chlorpyriphos (58.14%). Seedling mortality was low in *Steinernema sp* (6.02%), *Heterorhabditis indica* twice application (6.24%) and *Beauveria bassiana* (8.54%) and was high in control (19.62%) **(Table 44)**. Data on termite Damage (%), cane yield t/ha, sucrose (%) and shoot population '000/ha will be recorded at harvest during the month of June, 2016. Entomopathogenic fungi, *Metarhizium anisopliae* and *Beauveria bassiana*, entomopathogenic nematode, *Heterorhabditis indica* twice application were effective in reducing bud damage due to termites resulted in higher germination compared to untreated control.

Table 44. Bioefficacy of entomopathogenic fungi and EPN in the management of termites in sugarcane during kharif.

Treatment	Germination %	Bud damage %	Seedling mortality (%)
T1 *Beauveria bassiana* @ 5kg ha^{-1} ($1x10^8$ spores/ gm) in 250 kg FYM	58.15	41.85	8.543
T2 *Metarhizium anisopliae* @ 5kg ha^{-1} ($1x10^8$ spores/ gm) in 250 kg FYM	59.62	40.38	12.04
T3 *Heterorhabditis indica* WP @ 20 kg/ha in 150 kg moist sand ha^{-1}	54.75	45.63	11.72
T4 *Steinernema* sp. WP @ 20 kg/ha in 150 kg moist sand ha^{-1}	56.84	43.16	13.71
T5 Neem cake @ 500 kg/ha	52.13	47.87	14.6
T6 Chlorpyriphos 50 TC @ 5 ml/lt.	41.86	58.14	14.38
T7 Untreated control	44.1	55.90	19.62
T8 *Heterorhabditis* sp. WP @ 20 kg/ha in 150 kg moist sand ha^{-1} two times at two months interval	58.07	41.93	6.24
T9 *Steinernema* sp. WP @ 20 kg/ha in 150 kg moist sand ha^{-1} two times at two months interval	54.37	45.25	6.02
CD(P=0.05)	4.62	4.66	5.77
CV%	10.73	12.26	15.39

4. IPM module for the sustainable management of early shoot borer (*Chilo infuscatellus*) and internode borer (*Chilo infuscatellus* and *Chilo sacchariphagus indicus*) in sugarcane (ANGRAU- Anakapalle)

Date of planting : 14.04.2015
Crop : Sugarcane
Variety : 2000 A 56
Date of harvest : 11.01.2016
Treatments : 9 (IPM Modules)

Treatment details

Module 1 : Trash mulching + *Trichogramma chilonis* release @ 50,000/ha from 30 DAP for 4 times at 7 -10 days interval;
Module 2: Trash mulching + *T. chilonis* release @ 50,000/ha from 30 DAP for 4 times and 2 releases after node formation;
Module 3: Trash mulching + *T. chilonis* release @ 50,000/ha from 30 DAP for 6 times and 2 releases after node formation;
Module 4: Trash mulching + *T. chilonis* release @ 75,000/ha from 30 DAP for 4 times and 2 releases after node formation;
Module 5 : Trash mulching + *T. chilonis* release @ 75,000/ha from 30 DAP for 6 times
Module 6 : Trash mulching + *T. chilonis* release @ 75,000/ha from 30 DAP for 6 times and 2 releases after node formation;
Module 7 : Trash mulching + Soil application of Carbofuran 3G @ 33 kg/ha at planting
Module 8 : Trash mulching + Soil application of Carbofuran 3G @ 33 kg/ha at planting and at 90 days after planting
Module 9 : Untreated Control (Trash mulching)

Cumulative incidence of early shoot borer was recorded low in Module 2- Trash mulching+ *Trichogramma chilonis* release @ 50,000/ha from 30 DAP - 4 releases at 7-10 day interval and 2 releases after node formation (3.3 %) followed by Module 3 - Trash mulching+ *T. chilonis* release @ 75,000/ha from 30 DAP - 6 releases at 7-10 day interval and 2 releases after node formation (4.94% **(Table 45)**. Cumulative incidence of early shoot borer was high in Module 9-Trash mulching (11.38%). Module 6 - Trash mulching + Soil application of Carbofuran 3G @ 33 kg/ha at planting and at 90 days after planting (7.13%) and Module 1- Trash mulching + *T. chilonis* release @ 50,000/ha from 30 DAP - 4 releases at 7-10 days interval (6.68 %). Internode borer incidence and intensity was recorded low in Module 2- Trash mulching+ *T. chilonis* release @ 50,000/ha from 30 DAP - 4 releases at 7-10 day interval and 2 releases after node formation (43.3% and 2.73 %) followed by Module 3 - Trash mulching+ *T. chilonis* release @ 75,000/ha from 30 DAP - 6 releases at 7-10 day interval and 2 releases after node formation (50% and 2.7%). Internode borer incidence and intensity was high in Module 9- Trash mulching (76.67% and 6.07%), Module 1- Trash mulching + *T. chilonis* release @ 50,000/ha from 30 DAP - 4 releases at 7-10 days interval (70% and 4.56%) and Module 8- Trash mulching + Soil application of Carbofuran 3G @ 33 kg/ha at planting and at 90 days after planting (66.67 % and 4.19%). Cane yield was recorded high in Module 6 - Trash mulching + *T. chilonis* release @ 75,000/ha from 30 DAP for 6 times and 2 releases after node formation

(124.59 t/ha), Module 1- Trash mulching + *T. chilonis* release @ 50,000/ha from 30 DAP - 4 releases at 7-10 days interval (123.19 t/ha) followed by Module 3-Trash mulching + *T. chilonis* release @ 50,000/ha from 30 DAP for 6 times and 2 releases after node formation (121.6 t/ha) and cane yield was recorded low in Module 9- Trash mulching (93.55 t/ha) **(Table 46)**. Module 3- Trash mulching + *T. chilonis* release @ 50,000/ha from 30 DAP for 6 times and 2 releases after node formation and Module 6- Trash mulching + *T. chilonis* release @ 75,000/ha from 30 DAP for 6 times and 2 releases after node formation are effective in managing shoot borers in sugarcane with high incremental benefit cost ratio. IPM module with trash mulching + *Trichogramma chilonis* release @ 50,000/ ha or 75,000/ha from 30 DAP for 6 times and 2 releases after node formation was effective in management of early shoot borer and internode borer in sugarcane with high incremental benefit cost ratio.

Tabel 45. Impact of IPM module for the sustainable management of sugarcane shoot borers

Module	ESB Incidence (%DH)			Cumulative incidence of ESB (%DH)	INB incidence (%)	INB Intensity (%)	INB Infestation index (%)
	45 DAP	90 DAP	120 DAP				
Module 1 : Trash mulching + *Trichogramma chilonis* @ 50,000/ha - 4 releases	3.33	3.35	0.0	6.68	70	4.56	3.8
Module 2 : Trash mulching + *T. chilonis* @ 50,000/ha - 4 +2 releases	2.85	0.45	0.0	3.31	43.33	2.73	1.28
Module 3 : Trash mulching + *T. chilonis* @ 50,000/ha - 6+2 releases	3.02	1.92	0.0	4.94	50.0	2.70	1.84
Module 4 : Trash mulching + *T. chilonis* @ 75,000/ha - 4+2 releases	4.8	0.77	0.0	5.56	50.0	4.037	2.53
Module 5 : Trash mulching + *T. chilonis* @ 75,000/ha from 30 DAP for 6 releases	3.38	1.8	0.0	5.21	60.0	5.45	3.27
Module 6 : Trash mulching + *T. chilonis* @ 75,000/ha from 30 DAP for 6 + 2 releases after node formation	6.33	0.8	0.0	7.13	60.0	3.33	2.34

Module 7 : Trash mulching + Soil application of Carbofuran 3G @ 33 kg/ha at planting	2.58	2.47	0.0	5.06	66.67	3.33	2.56
Module 8 : Trash mulching + Soil application of Carbofuran 3G @ 33 kg/ha at planting and at 90 days after planting	4.93	0.57	0.0	5.49	66.67	4.19	3.22
Module 9: Untreated Control (Trash mulching)	7.93	0.89	2.56	11.38	76.67	6.07	4.70
CD (P=0.05)	2.3	1.95		1.8	2. 37	3.36	
CV %	2.95	8.13		18.57	31.54	38.15	

Tabel 46. Impact of IPM module for the sustainable management of sugarcane shoot borers

Module	Cane yield t /ha	Sucrose (%)	NMC '000 /ha	Yield increase (%)	Cost of input for PP Rs./ha	Additional income Rs./ha	Incremental benefit cost ratio
Module 1 : Trash mulching + *T. chilonis* @ 50,000/ha - 4 releases	123.19	19.48	95.78	31.68	550	71,136	1: 129.3
Module 2 : Trash mulching + *T. chilonis* @ 50,000/ha - 4 + 2 releases	120.01	18.68	101.77	28.28	725	63,504	1:873.80
Module 3 : Trash mulching + *T. chilonis* @ 50,000/ha - 6+2 releases	121.60	19.12	102.04	51.36	900	1,15,320	1: 128.1
Module 4 : Trash mulching + *T. chilonis* @ 75,000/ha - 4 + 2 releases	117.95	17.74	91.21	26.08	1075	58,560	1: 54.47
Module 5 : Trash mulching + *T. chilonis* @ 75,000/ha from 30 DAP for 6 releases	106.42	17.93	90.00	13.86	1040	31,128	1: 29.93
Module 6 : Trash mulching + *T. chilonis* @ 75,000/ha from 30 DAP for 6 + 2 releases after node	124.59	18.27	98.95	54.56	1320	1,22,496	1: 92.8

formation							
Module 7 : Trash mulching + Soil application of Carbofuran 3G @ 33 kg/ha at planting	108.04	18.22	101.01	15.49	3280	34,776	1: 10.6
Module 8 : Trash mulching + Soil application of Carbofuran 3G @ 33 kg/ha at planting and at 90 days after planting	111.46	18.53	91.65	19.14	4580	42,984	1: 9.39
Module 9: Untreated Control (Trash mulching)	93.56	17.28	92.96	-	-	-	-
CD (P=0.05)	14.9	17.61	6.68				
CV %	8.68	19.98	7.16				

2.4. Cotton

1. Monitoring biodiversity and outbreaks for invasive mealybugs on cotton, survey for incidence of mealybugs on cotton and collection of their natural enemies (MPKV, PAU, PJTSAU, TNAU, and UAS-R)

MPKV-Pune

Cotton seeds (var. Jai, Bollgard II) were sown on 24th July 2015 at 90 x 60 cm spacing in 40 x 40 m^2 plot on the research farm of Agril. Entomology Section, College of Agriculture, Pune. All the recommended agronomic practices were followed except pesticide application to maintain healthy crop growth. The incidence of cotton mealybug, *Phenacoccus solenopsis* Tinsley and occurrence of natural enemies was monitored at fortnightly interval from the day of germination.

The incidence of mealybug was started recording on cotton from 1st fortnight of August 2015 till December, 2015 in the experimental plot. However, the mealybug was not observed on cotton up to harvesting of the crop. The natural enemies like predatory coccinellids, *Coccinella, Menochilus* and *Scymnus*, Chrysopids, *Brumoides* and spiders was observed in cotton ecosystem.

During the survey, less pest infestation was noticed in the months of November and December, 2015.The parasitism of *Anaesis arizonensis* was found common on cotton, parthenium and marigold and hibiscus. The cotton mealybug on *Hibiscus* was effectively controlled by *A. arizonensis.*

PAU-Ludhiana

Regular surveys were conducted to collect mealybugs and its natural enemies from different hosts from Ludhiana and other major cotton growing areas (Bathinda and Abohar) of Punjab. During the survey, only one mealybug species, *Phenacoccus solenopsis* Tinsley was recorded on cotton crop. The incidence of mealybug was observed at isolated places on cotton and weed hosts (*Abutilon* sp. and *Sida* sp.) and there was no major outbreak of the pest. Predatory fauna included coccinellid predators such as *Cheilomenus sexmaculata, Coccinella septempunctata* and *B. suturalis,* and green lace wing, *Chrysoperla zastrowi sillemi* feeding on mealybug and their population varied from 0.1 to 2.2 predators per plant. The overall parasitization by parasitoids under field conditions varied from 40 to 68.2%. The infested plant parts were collected and brought back to the laboratory and were kept under caged conditions for the emergence of parasitoids. The solitary nymphal endoparasitoid *Aenasius arizonensis* and hyperparasitoid *Promuscidea unfasciativentris* were emerged from the infested samples. Out of these, *A. arizonensis* was predominant species (73.2%) and *P. unfasciativentris* parasitized (26.8%) of the primary paratoids.

During survey, five mealybug species, *i.e.,* pink sugarcane mealybug, *Saccharicoccus sacchari* (Cockerell), papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink, mango mealybug, *Drosicha mangiferae* Stebbins, spherical mealybug, *Nipaecoccus viridis* (Newstead) and striped mealybug, *Ferrisia virgata* (Cockerell) were noticed in different

agro-ecosytems of Punjab on *Saccharum officinarum L.*, *Plumeria alba* L., *Mangifera indica* L. *Hibiscus rosa-sinenis* L. and *Psidium guajava* L., respectively. The extent of parasitization by *A. arizonensis* was recorded on these five mealybug species under field conditions. Fifty mealybugs were observed at 15 days interval on each host to find the number of parasitized mealybugs. These mummies were brought to the laboratory and kept in glass vials to see the emergence of *A. arizonensis* adults. Under natural field conditions, the parasitization by *A. arizonensis* was observed only on *P. solenopsis*. However, no parasitization by *A. arizonensis* was recorded on *S. sacchari, P. marginatus, D. mangiferae, N. viridis* and *F. virgata* **(Table 47)**.

Table 47. Mean parasitization of different mealybug species by *Aenasius arizonensis* under field conditions

Mealybug species	Hosts	Mean parasitization by *Aenasius arizonensis* (%)
Phenacoccus solenopsis	*Gossypium hirsutum*	42.3
	Abutilon sp.	64.9
Drosicha mangiferae	*Mangifera indica*	0.0
Paracoccus marginatus	*Plumeria alba*	0.0
Saccharococcus sacchari	*Saccharum officinarum*	0.0
Nipaecoccus viridis	*Hibiscus rosa-sinensis*	0.0
Ferrisia virgata	*Psidium guajava*	0.0

PJTSAU-Hyderabad

Fortnightly surveys were conducted in the cotton growing areas of Telangana, *viz*., Mahabubnagar and Rangareddy for infestation and intensity of mealybug incidence. Infested plant parts were brought back to the laboratory and held under caged conditions for emergence of natural enemies. Alternate host plants were also recorded. Specimens of mealybugs and natural enemies collected were sent to NBAIR. Crop wise records were maintained for extent of damage by the mealybug, level of natural enemies present, etc. The overall scenario showed marginal incidence levels of three different Mealybugs, *viz*., *Meconellicoccus hirsutus*, *Phenococcus solenopsis* and *Paracoccus marginatus* in cotton growing districts of Telangana state.

TNAU-Coimbatore

Survey conducted in Coimbatore, Erode and Tiruppur districts of Tamil Nadu on cotton and other host plants indicated the incidence of five species of Mealybugs, *viz.*, *Paracoccus marginatus, Maconellicoccus hirsutus*, *Phenacoccus solenapsis, Nipaecoccus viridis* and *Ferrisia virgata* **(Table 48)**. *Phenacoccus solenapsis* and *Nipaecoccus viridis* were the predominant species recorded on cotton. *Paracoccus marginatus* was observed on papaya, cotton, tapioca, mulberry, jatropa and other host plants. The natural enemies, *viz.*, *Acerophagus papayae, Cryptolaemus montrouzieri, Scymnus coccivora, Spalgis epius, Coccinella septumpunctata, Mallada* sp, *Chrysoperla zastrowi sillemi* and *Menochilus sexmaculatus* were recorded on different species of mealybugs from the surveyed cotton fields.

Table 48. Sucking pests and their natural enemies recorded in cotton

Sl. No.	Species of sucking pests	Host Plants	Natural enemies recorded
1	*Phenacoccus solenopsis*	cotton, sunflower, bhendi, parthenium, Black night shade and *Hibiscus*	*Cryptolaemus montrouzieri, Coccinella septumpunctata Chrysoperla zastrowi sillemi, Spalgis epius, Scymnus coccivora*
2	*Ferrisia virgata*	Cotton, tapioca, custard apple, guava, Papaya and tuberose	*Scymnus coccivora, Cryptolaemus montrouzieri, Menochilus sexmaculatus, Mallada* sp.
3	*Paracoccus marginatus*	Cotton, Papaya, tapioca, *Jatropha curcas*, mulberry, bhendi, sunflower, hibiscus, marigold and parthenium	*Acerophagus papaya, Chrysoperla zastrowi sillemi, Spalgis epius,Cryptolaemus montrouzieri, Scymnus coccivora, Menochilus sexmaculatus*
4	*Nipaecoccus viridis*	Cotton, mango, gooseberry, tamarind and jack	*Scymnus coccivora, Cryptolaemus montrouzieri, Menochilus sexmaculatus*
5	*Maconellicoccus hirsutus*	Cotton, bhendi, grapevine, guava, hibiscus and mulberry	*Scymnus coccivora,Cryptolaemus montrouzieri, Mallada* sp.
6	*Amrasca devastans, Oxycarenus laetus*	Cotton and bhendi	Anthocorid bugs
7	*Thrips tabaci*	Cotton and bhendi	*Chrysoperla zastrowi sillemi*
8	*Aphis gossypii*	Cotton and bhendi	Syrphids, *Chrysoperla zastrowi sillemi*
9	*Aleurodicus disperses*	Cotton, bhendi, guava, papaya and ornamentals	*Cryptolaemus montrouzieri*, *Mallada* sp. syrphids
10	Mirid bug	Cotton and bhendi	

UAS-Raichur

Variety : KCH-14K59 (Jadoo) BG II
DOS : 21-08-2015
Area : 50 sqm,
Situation : Unprotected

Twenty plants were randomly selected to record the incidence of cotton mealybug at an interval of fifteen days. During heavy infestation, five twigs were considered and later the number of crawlers was expressed as number per 10 cm apical shoot length.

The incidence of mealybug was noticed during second fortnight of October and the peak activity was noticed during second week of February (85.42 mealybugs/ plant) which was also coincided with the peak activity of its primary parasitoid, *Anesius arizonesis* (18.05/ plant) and the peak activity of *Anagyrus dactylopii* was noticed during second fortnight of January. The decline in mealybug was noticed during second fortnight of February **(Table 49)**.

Table 49. Monitoring biodiversity and outbreaks for invasive mealybugs on cotton

Year 2015	Std Week	Mealy bugs/ shoot length (10 cm)	Natural Enemies		
			Coccinellids	*Anseis arizonensis*	*Anagyrus dactylopii*
Oct 22-Oct 28	43	0.00	0.00	0.00	0.00
Oct 29-Nov 04	44	0.22	0.08	0.04	0.00
Nov 05-Nov 11	45	0.30	0.10	4.50	1.73
Nov 12-Nov 18	46	1.50	0.11	5.22	2.77
Nov 19-Nov 25	47	3.82	0.56	6.33	3.12
Nov 26-Dec 02	48	4.50	1.00	5.33	3.50
Dec 03-Dec 09	49	8.90	0.33	6.37	3.75
Dec 10- Dec 16	50	10.22	0.30	4.05	3.20
Dec 17- Dec 23	51	13.81	0.30	5.11	4.50
Dec 24- Dec 31	52	30.38	1.30	8.65	4.85
Jan 01-07	1	39.52	1.50	9.05	5.54
Jan 8-14	2	44.24	1.80	6.05	5.20
Jan 15-21	3	47.62	1.50	5.05	5.10
Jan 22-28	4	56.81	0.33	8.33	6.58
Jan 29-Feb 4	5	68.46	0.30	10.18	5.44
Feb 5 - 11	6	78.32	0.20	12.50	3.24
Feb12 - 18	7	85.42	0.10	18.05	1.22
Feb 19- 25	8	65.32	0.35	15.35	1.07
Feb 26- Mar 4	9	44.24	0.42	21.46	1.22
Mar 5-11	10	15.18	0.16	18.35	1.16

2. Monitoring biodiversity and outbreaks of sap sucking pests including mirids and their natural enemies in *Bt* cotton (MPKV, PJTSAU and UAS-R)

MPKV-Pune

Bt cotton var. Jai, Bollgard II was raised separately on the research farm of Agril. Entomology section, College of Agriculture, Pune. Seeds were sown on 24th July 2015 on ridges and furrows at 90 x 60 cm spacing in 40 x 40 m^2 size plots. All the recommended agronomic practices were followed except pesticide application. The sucking pests and natural enemies were recorded from randomly selected and tagged 25 plants from the plot at fortnightly interval. The pest population was recorded from three leaves (top, middle and lower portion) per plant. Similarly, the natural enemies were also recorded on the plant. It is seen from the **Table 50** that the incidence of aphids, jassids, thrips and whitefly was recorded from1st week of August 2015 (32nd MW) except mealybug.The peak incidence of jassids, white fly and thrips was recorded during 1st week of September 2015 (36th MW). The aphid population was noticed maximum during 3rd week of August 2015 (35thMW). The infestation of mealybug was not observed during the period under observation, *i.e*., August to December 2015.

Table 50. Incidence of sucking pests and their natural enemies in *Bt* cotton

Date of record	Average population / 3 leaves / plant							
	Aphids	Jassids	Thrips	Whit e flies	Mealybug	Chrysopid	Coccinellids	Spiders
7/8/2015	5.33	1.00	1.50	0.00	0.00	0.33	0.10	0.44
21/8/2015	20.33	2.00	8.67	1.33	0.00	0.44	2.22	0.33
4/9/2015	15.66	8.50	12.33	5.67	0.00	2.33	8.33	1.00
19/9/2015	7.67	1.67	3.67	1.33	0.00	1.33	5.66	0.33
3/10/2015	7.00	1.33	2.67	3.33	0.00	0.67	0.70	0.89
17/10/2015	10.33	2.00	5.33	5.40	0.00	0.89	1.11	0.67
31/11/2015	8.67	2.33	6.33	3.33	0.00	0.33	0.55	1.00
14/11/2015	9.33	2.00	7.33	2.80	0.00	0.33	0.44	1.00
28/11/2015	7.33	2.00	4.67	2.67	0.00	0.22	0.22	0.67
12/12/2015	4.67	1.33	1.66	1.33	0.00	0.22	0.33	0.33
26/12/2015	03.0	1.00	1.33	0.33	0.00	0.33	0.10	0.44

The natural enemies, coccinellids, *Menochilus sexmaculata* Fab., *Coccinella septempunctata* Linn. and spiders were recorded from 1st week of August to 4th week of December 2015. The chrysopid, *Chrysoperla zastrowi sillemi* Esb. and spider observed from the 1st week of August 2015 (32nd MW) and maximum population was recorded in 1st week of September 2015 (36th MW). The severe incidence of pink boll worm, *Pectinophora gossipiella* (70 to 80%) was observed in *Bt* cotton during later stage of the crop in Dhule and Nadurbar district

PJTSAU-Hyderabad

The *Bt* cotton growing areas of Telangana were surveyed for infestation and intensity of sucking pest incidence. The overall scenario showed incidence of Jassids to a greater extent followed by whiteflies and thrips.

UAS-Raichur

Variety : KCH-14K59 (Jadoo) BG II:
DOS : 21-08-2015
Area : 50 sqm,
Situation : Unprotected

Twenty plants were randomly selected to record the incidence of cotton mirid bug at an interval of fifteen days. Number of mirid bugs was counted on squares and flowers. In each plant five squares and five flowers were observed for the incidence of mirid bugs and later converted to plant basis.

The incidence of mirid bug was noticed at second fortnight of October with a peak population during first week of December (1.33 mirid bugs/ plant). Over all incidence of mirid bug was negligible during current season **(Table 51)**.

Table 51. Incidence of mirid bug and its predators on *Bt* cotton ecosystem

Year 2015	Std Week	Number of mirid bugs/plant	Predators per plant		
			Coccinellids	Chrysoperla	Spiders
Sep 24-Sep30	39	0.00	0.03	0.07	0.20
Oct 01-Oct 07	40	0.00	0.03	0.15	0.30
Oct 08-Oct 14	41	0.00	0.01	0.10	0.20
Oct 15-Oct 21	42	0.00	0.10	0.05	0.20
Oct 22-Oct 28	43	0.33	0.11	0.30	0.10
Oct 29-Nov 04	44	0.33	0.06	0.31	0.16
Nov 05-Nov 11	45	0.33	0.13	0.31	0.20
Nov 12-Nov 18	46	0.33	0.16	0.10	0.23
Nov 19-Nov 25	47	0.33	0.30	0.12	0.10
Nov 26-Dec 02	48	0.66	0.30	0.05	0.01
Dec 03-Dec 09	49	1.33	0.15	0.10	0.10
Dec 10- Dec 16	50	0.33	0.30	0.11	0.34
Dec 17- Dec 23	51	0.33	0.40	0.01	0.33
Dec 24- Dec 31	52	0.33	0.10	0.11	0.25
Jan 01-07	1	3.33	0.15	0.01	0.20
Jan 8-14	2	0.00	0.30	0.00	0.20
Jan 15-21	3	2.00	0.20	0.00	0.02
Jan 22-28	4	0.66	0.10	0.00	0.00
Jan 29-Feb 4	5	0.00	0.01	0.00	0.00

3. Diversity of sucking pests, bollworms and their natural enemies in transgenic *Bt* and non- *Bt* cotton (PAU-Ludhiana)

Treatments

1. Bt unsprayed (transgenic cotton without insecticide application)
2. Bt sprayed (transgenic cotton with need based insecticide application)
3. Non-Bt unsprayed (non-transgenic cotton without insecticide application)
4. Non-Bt sprayed (non- transgenic cotton with need based insecticide application)

Bt cotton (NCS 855 BGII) and non-Bt cotton (F 2228) was sown at the Entomological Research Farm, Punjab Agricultural University (PAU), Ludhiana on 9th May, 2015, under sprayed and unsprayed conditions. The row-to-row spacing and plant-to-plant spacing was 67.5 and 75 cm for NCS 855 BGII and 67.5 and 60 cm for F 2228, respectively. Each plot was divided into three blocks as replicates. All agronomic practices recommended by PAU, Ludhiana, were followed to raise the crop. Under sprayed conditions, imidacloprid 200 SL @ 100 ml/ha was sprayed twice on the basis of the economic threshold level, *i.e.*, downward curling and yellowing of leaves at margins for the control of leafhopper. Against whitefly, one spray of diafenthiuron 50 WP @ 500 g/ha was applied when the population exceeded six adults/ leaf. The crop was sprayed three times for the control of bollworms on the basis of ETL (5% damage in freshly shed fruiting bodies) on non-*Bt* cotton. All sprays were done with the help of manually operated knapsack sprayer using 250 litres of water per hectare.

The population of sucking insect pests was recorded from 10 plants selected randomly from 3 fully formed leaves of the upper canopy from each block at weekly interval, *i.e.*, Standard Meteorological Weeks (SMW) throughout the cropping season. Damage by bollworms was recorded from 10 randomly selected plants in each block at weekly intervals. *In situ* green bolls were counted from each plant and those showing damage were expressed as percent boll damage. Damage in freshly shed fruiting bodies comprising squares, flowers and green bolls was recorded on whole block basis throughout the cropping season at weekly intervals. The old shed fruiting bodies were removed from each plot 24 hours prior to each observation to ensure the collection of freshly shed fruiting bodies. All the freshly shed fruiting bodies lying on the ground were collected and those showing bollworm damage were counted and per cent damage was worked out. The larval population of American bollworm, spotted bollworm and spiny bollworm was also recorded from 10 plants at weekly interval. Pink bollworm population was recorded from 20 green bolls at 120, 135 and 150 days after sowing (DAS). The incidence in harvestable bolls was recorded on open boll and loculi basis at harvest from randomly selected 10 plants in each block. The population of predators was recorded on whole plant basis. The immature stages of whitefly were collected and brought to the laboratory to observe the emergence of parasitoids. Seed cotton yield was recorded on whole plot basis.

Among sucking insect pests, leafhopper, *Amrasca biguttula biguttula* and whitefly, *Bemisia tabaci* were key pests and remained active through out the cropping season on both Bt and non-Bt cotton. *Thrips tabaci* population was only observed in early stages of the crop growth, whereas, aphid, *Aphis gossypii* population remained nil throughout the cropping season. Under unsprayed conditions, the population of leafhopper, whitefly and thrips on *Bt* cotton

varied from 0.0 to 5.9, 0.2 to 33.0, 0.0 to 16.1 per three leaves, respectively **(Table 52)**. The peak population of leafhopper nymphs (5.9/ 3 leaves) was recorded in 30th SMW (fourth week of July). The population of whitefly adults remained above ETL (6 adults/ leaf) from 27th, 28th and 30th SMW and was maximum (33.0/ 3 leaves) during 27th SMW (first week of July). Thrips population showed its peak (16.1/ 3 leaves) during 26th SMW (end-June). No bollworm incidence was recorded on *Bt* cotton hybrid throughout the cropping season **(Table 52 & 54)**.

On non-*Bt* cotton, the population of leafhopper, whitefly and thrips varied from 0.2 to 6.5, 0.4 to 20.0 and 0.0 to 24.0 per three leaves, respectively, under unsprayed conditions **(Table 56)**. The peak population of leafhopper nymphs (6.5/ 3 leaves) was recorded in 33th SMW (2nd week of August). The population of whitefly adults was above ETL (6 adults/ leaf) in 27th SMW (first week of July). Thrips population showed its peak (24.0/ 3 leaves) during 25th SMW (third week of June). Among bollworms, *Helicoverpa armigera*, *Earias vittella* and *E. insulana* were observed on cotton crop. Among these, *E. vittella* was the predominant species. Therefore, the damage in green bolls, freshly shed fruiting bodies and open bolls can be attributed primarily to *E. vittella* on non-Bt cotton **(Tables 56 & 58)**. Under unsprayed conditions, the peak larval population (6.0/10 plants) were recorded in 36th SMW (1st week of September). The damage in freshly shed fruiting bodies and green bolls varied from 0.0 to 36.36% and 0.0 to 3.68%, respectively under unsprayed conditions **(Table 56)**. The corresponding figures under sprayed conditions varied from 0.0 to 20.59% and 0.0 to 1.72%, respectively **(Table 58)**.

Among predators, coccinellids (*Coccinella septempuntata*, *Cheilomenes sexmaculata* and *Brumus suturalis*), green lacewing (*Chrysoperla* spp.), *Gecocoris* sp., *Zanchius* sp. and spiders were recorded **(Tables 53, 55, 57 and 59)** on both *Bt* and non-*Bt* cotton. Under unsprayed conditions, the population of coccinellids and *Chrysoperla* on both *Bt* and non-Bt cotton was maximum during 30th SMW (end-July) **(Tables 53 & 57)**. The spider population showed its peak during 34th and 35th SMW. The population of *Geocoris* sp. and *Zanchius* sp. was maximum during 29th and 36th SMW, respectively on both *Bt* and non-Bt cotton under unsprayed conditions. No parasitoid emerged from immature stages (nymphs and pupae) of whitefly collected from field.

The incidence of sucking insect pests was less in sprayed conditions as compared to unsprayed conditions **(Table 60)**. No bollworm incidence was observed on *Bt* cotton. However, on non-Bt cotton the mean larval population, damage in freshly shed fruiting bodies, green boll damage, damage in open bolls both on boll and loculi basis was comparatively more under unsprayed condition as against sprayed conditions. The seed cotton yield was more in *Bt* cotton in comparison to non-*Bt* cotton both under sprayed and unsprayed conditions. The predator population (spiders, coccinellids, *Chrysoperla*, *Geocoris* sp., and *Zanchius* sp) was more in unsprayed conditions as against sprayed conditions on both *Bt* and non-*Bt* cotton.

Table 52. Seasonal abundance of sucking insect pests and bollworms in *Bt* cotton under unsprayed conditions at Ludhiana during 2015

Standard weeks	Sucking insect pests / 3 leaves / plant				Bollworm incidence						
					Larval population/10 plants			PBW larvae / 20 green bolls	FSFB (%)	*Earias* larvae/10 FSFB	Green boll damage (%)
	Leaf-hopper	White-fly	Thrips	Aphid	*Helicoverpa armigera*	*Earias vittella*	*Earias insulana*				
23	0.4	1.8	0.0	0.0	-	-	-	-	-	-	-
24	0.6	2.2	3.0	0.0	-	-	-	-	-	-	-
25	0.9	7.3	12.6	0.0	-	-	-	-	-	-	-
26	3.1	7.9	16.1	0.0	-	-	-	-	-	-	-
27	3.8	33.0	11.5	0.0	-	-	-	-	-	-	-
28	5.2	28.3	8.1	0.0	0.0	0.0	0.0	-	0.0	0.0	-
29	5.3	13.1	6.5	0.0	0.0	0.0	0.0	-	0.0	0.0	-
30	5.9	21.8	6.6	0.0	0.0	0.0	0.0	-	0.0	0.0	-
31	3.0	10.0	3.5	0.0	0.0	0.0	0.0	-	0.0	0.0	-
32	2.2	5.5	0.8	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
33	4.4	3.1	0.8	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
34	1.5	1.1	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
35	1.4	0.7	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
36	0.9	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	0.8	2.8	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
38	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	0.2	0.5	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
40	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PBW – pink bollworm (*Pectinophora gossypiella*); FSFB – Freshly shed fruiting bodies

Table 53. Seasonal abundance of predators in *Bt* cotton under unsprayed conditions at Ludhiana during 2015

Standard weeks	Predators / 10 plants								
	Coccinellids			*Chrysoperla zastrowi sillemi*			*Geocoris* sp.	*Zanchius* sp.	Spiders
	Coccinella septempunctata	*Cheilomenes sexmaculata*	*Brumus suturalis*	*Eggs*	*Larvae*	*Adults*			
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	3.0	0.0	0.0	1.0	0.0	1.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
29	1.0	0.0	0.0	2.0	0.0	7.0	12.0	0.0	0.0
30	4.0	4.0	0.0	13.0	3.0	0.0	5.0	1.0	1.0
31	1.0	1.0	0.0	0.0	0.0	0.0	2.0	1.0	2.0
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	6.0
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	2.0
35	0.0	0.0	0.0	0.0	3.0	0.0	0.0	15.0	8.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	7.0
37	0.0	0.0	1.0	2.0	0.0	0.0	0.0	4.0	4.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	1.0
39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
40	0.0	0.0	0.0	1.0	0.0	0.0	0.0	4.0	0.0

Table 54. Seasonal abundance of sucking insect pests and bollworms in *Bt* cotton under sprayed conditions at Ludhiana during 2015

Standard weeks	Sucking insect pests / 3 leaves / plant				Bollworm incidence						
					Larval population/10 plants			PBW larvae / 20 green bolls	FSFB (%)	*Earias* larvae/10 FSFB	Green boll damage (%)
	Leaf-hopper	White-fly	Thrips	Aphid	*Helicoverpa armigera*	*Earias vittella*	*Earias insulana*				
23	0.2	2.0	0.0	0.0	-	-	-	-	-	-	-
24	0.7	2.9	2.8	0.0	-	-	-	-	-	-	-
25	0.9	5.3	12.3	0.0	-	-	-	-	-	-	-
26	3.0	6.1	15.6	0.0	-	-	-	-	-	-	-
27	4.2	30.2	10.6	0.0	-	-	-	-	-	-	-
28	1.2	8.0	6.5	0.0	0.0	0.0	0.0	-	0.0	0.0	-
29	2.8	6.6	7.0	0.0	0.0	0.0	0.0	-	0.0	0.0	-
30	3.2	10.6	8.0	0.0	0.0	0.0	0.0	-	0.0	0.0	-
31	3.0	6.9	3.6	0.0	0.0	0.0	0.0	-	0.0	0.0	-
32	2.7	4.3	0.4	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
33	4.5	3.2	0.3	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
34	0.2	0.9	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
35	1.2	0.4	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
36	0.9	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	0.7	2.3	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
38	0.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	0.2	0.9	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
40	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PBW – pink bollworm (*Pectinophora gossypiella*); FSFB – Freshly shed fruiting bodies

Table 55. Seasonal abundance of predators in *Bt* cotton under sprayed conditions at Ludhiana during 2015

Standard weeks	Predators / 10 plants								
	Coccinellids			*Chrysoperla zastrowi sillemi*			*Geocoris* sp.	*Zanchius* sp.	Spiders
	Coccinella septempunctata	*Cheilomenes sexmaculata*	*Brumus suturalis*	*Eggs*	*Larvae*	*Adults*			
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
27	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	1.0
28	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0
29	0.0	2.0	0.0	0.0	0.0	0.0	3.0	0.0	1.0
30	3.0	0.0	0.0	12.0	4.0	2.0	1.0	0.0	0.0
31	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	4.0
33	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	5.0
36	0.0	0.0	0.0	2.0	0.0	0.0	0.0	23.0	2.0
37	0.0	0.0	0.0	2.0	0.0	0.0	0.0	4.0	2.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0
40	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0

Table 56. Seasonal abundance of sucking insect pests and bollworms in non-Bt cotton under unsprayed conditions at Ludhiana during 2015

Standard weeks	Sucking insect pests / 3 leaves / plant				Bollworm incidence						
					Larval population/10 plants			PBW larvae / 20 green bolls	FSFB (%)	*Earias* larvae/10 FSFB	Green boll damage (%)
	Leaf-hopper	White-fly	Thrips	Aphid	*Helicoverpa armigera*	*Earias vittella*	*Earias insulana*				
23	0.2	0.9	0.6	0.0	-	-	-	-	-	-	-
24	0.4	4.5	16.6	0.0	-	-	-	-	-	-	-
25	0.9	6.8	24.0	0.0	-	-	-	-	-	-	-
26	2.0	9.2	17.7	0.0	-	-	-	-	-	-	-
27	3.9	20.0	13.6	0.0	-	-	-	-	-	-	-
28	4.4	15.3	10.9	0.0	0.0	0.0	0.0	-	0.00	0.00	-
29	4.5	8.8	7.7	0.0	0.0	0.0	0.0	-	0.00	0.00	-
30	3.1	14.1	4.2	0.0	0.0	0.0	0.0	-	11.76	0.29	-
31	2.9	9.3	2.3	0.0	0.0	0.0	0.0	-	12.50	0.31	-
32	2.3	8.2	1.1	0.0	0.0	0.0	2.0	-	13.51	0.27	0.00
33	6.5	9.0	0.0	0.0	0.0	1.0	0.0	-	-	-	0.41
34	4.5	4.1	0.0	0.0	2.0	4.0	0.0	-	36.36	0.68	1.64
35	3.7	2.4	0.0	0.0	0.0	5.0	0.0	-	24.14	0.34	2.26
36	0.8	2.8	0.0	0.0	0.0	6.0	0.0	0.0	30.77	0.38	3.33
37	2.5	12.1	0.0	0.0	0.0	1.0	0.0	-	7.46	0.15	1.47
38	0.4	0.9	0.0	0.0	0.0	4.0	0.0	0.0	6.09	0.09	1.84
39	0.4	0.6	0.0	0.0	0.0	3.0	0.0	-	7.55	0.19	3.68
40	0.2	0.4	0.0	0.0	0.0	2.0	0.0	0.0	-	-	3.39

PBW – pink bollworm (*Pectinophora gossypiella*); FSFB – Freshly shed fruiting bodies

Table 57. Seasonal abundance of predators in non-Bt cotton under unsprayed conditions at Ludhiana during 2015

Standard weeks	Predators / 10 plants								
	Coccinellids			*Chrysoperla zastrowi sillemi*			*Geocoris* sp.	*Zanchius* sp.	Spiders
	Coccinella septempunctata	*Cheilomenes sexmaculata*	*Brumus suturalis*	*Eggs*	*Larvae*	*Adults*			
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	2.0
27	0.0	0.0	0.0	1.0	0.0	0.0	2.0	0.0	0.0
28	1.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	2.0
29	1.0	2.0	0.0	5.0	0.0	3.0	7.0	0.0	1.0
30	3.0	4.0	0.0	4.0	2.0	9.0	5.0	1.0	1.0
31	1.0	1.0	0.0	0.0	0.0	1.0	2.0	1.0	2.0
32	0.0	0.0	0.0	0.0	2.0	0.0	0.0	2.0	3.0
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	4.0
34	0.0	0.0	0.0	1.0	0.0	0.0	0.0	17.0	8.0
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.0	2.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.0	6.0
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	2.0
39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0

Table 58. Seasonal abundance of sucking insect pests and bollworms in non-Bt cotton under sprayed conditions at Ludhiana during 2015

Standard weeks	Sucking insect pests / 3 leaves / plant				Bollworm incidence						
					Larval population/10 plants			PBW larvae / 20 green bolls	FSFB (%)	*Earias* larvae/10 FSFB	Green boll damage (%)
	Leaf-hopper	White-fly	Thrips	Aphid	*Helicoverpa armigera*	*Earias vittella*	*Earias insulana*				
23	0.0	0.6	0.4	0.0	-	-	-	-	-	-	-
24	0.6	4.2	17.2	0.0	-	-	-	-	-	-	-
25	0.8	5.7	23.3	0.0	-	-	-	-	-	-	-
26	2.2	9.7	17.0	0.0	-	-	-	-	-	-	-
27	3.5	19.6	12.5	0.0	-	-	-	-	-	-	-
28	1.0	5.4	5.7	0.0	0.0	0.0	0.0	-	0.00	0.00	-
29	2.2	6.8	6.0	0.0	0.0	0.0	0.0	-	0.00	0.00	-
30	4.5	10.4	4.4	0.0	0.0	0.0	0.0	-	0.00	0.00	-
31	3.2	8.3	2.8	0.0	0.0	0.0	0.0	-	0.00	0.00	-
32	3.0	8.1	1.4	0.0	0.0	0.0	1.0	-	3.23	0.00	0.00
33	4.9	8.6	0.0	0.0	0.0	0.0	0.0	-	-	-	0.51
34	0.6	1.7	0.0	0.0	1.0	3.0	0.0	-	6.02	0.48	1.46
35	1.6	1.6	0.0	0.0	0.0	2.0	0.0	-	20.59	0.00	0.88
36	0.9	2.1	0.0	0.0	0.0	1.0	0.0	0.0	5.26	0.00	1.38
37	3.0	8.9	0.0	0.0	0.0	1.0	0.0	-	6.67	0.13	1.25
38	0.2	1.0	0.0	0.0	0.0	3.0	0.0	0.0	3.45	0.14	1.08
39	0.4	0.3	0.0	0.0	0.0	2.0	0.0	-	6.45	0.32	1.45
40	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	-	-	1.72

PBW – pink bollworm (*Pectinophora gossypiella*); FSFB – Freshly shed fruiting bodies

Table 59. Seasonal abundance of predators in non-Bt cotton under sprayed conditions at Ludhiana during 2015

Standard weeks	Predators / 10 plants								
	Coccinellids			*Chrysoperla zastrowi sillemi*			*Geocoris* sp.	*Zanchius* sp.	Spiders
	Coccinella septempunctata	*Cheilomenes sexmaculata*	*Brumus suturalis*	*Eggs*	*Larvae*	*Adults*			
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0
27	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	1.0	2.0	0.0	2.0	0.0	3.0	5.0	0.0	0.0
30	1.0	1.0	0.0	2.0	2.0	4.0	3.0	1.0	0.0
31	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
33	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	2.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	5.0
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	4.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.0	6.0
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	1.0
39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 60. #Overall incidence of insect pests and natural enemies population in Bt and non-*Bt* cotton under sprayed and unsprayed conditions during 2015

Parameters	Bt cotton		Non-Bt cotton	
	Unsprayed	Sprayed	Unsprayed	Sprayed
Sucking pests				
Leafhopper (no./3 leaves)	2.22	1.66	2.42	1.81
Whitefly (no./3 leaves)	7.83	5.14	7.19	5.74
Thrips (no./3 leaves)	3.86	3.73	5.48	5.04
Aphid (no./3 leaves)	0.0	0.0	0.0	0.0
Bollworms				
H. armigera / 10 plants	0.0	0.0	0.15	0.08
E. vittella / 10 plants	0.0	0.0	2.00	0.92
E. insulana / 10 plants	0.0	0.0	0.15	0.08
P. gossypiella / 20 green bolls	0.0	0.0	0.0	0.0
FSFB (%)	0.0	0.0	13.65	4.70
E. vittella larvae/ 10 FSFB	0.0	0.0	0.25	0.10
Green boll damage (%)	0.0	0.0	2.00	1.08
Open boll damage (%)	0.0	0.0	25.24	12.95
Loculi damage (%)	0.0	0.0	12.14	6.03
Seed cotton yield (q/ha)	6.58	7.39	4.47	5.94
Predators / 10 plants				
Coccinella septempunctata	0.39	0.22	0.33	0.11
Cheilomenes sexmaculata	0.28	0.11	0.39	0.17
Brumus suturalis	0.06	0.00	0.06	0.00
Chrysoperla zastrowi sillemi • Eggs • Larvae • Adult	 1.17 0.33 0.39	 1.11 0.22 0.11	 0.89 0.22 0.72	 0.61 0.11 0.39
Geocoris sp.	1.11	0.33	0.89	0.56
Zanchius sp.	4.28	2.61	5.39	3.50
Spiders	2.00	1.17	2.06	1.39

#Average of weekly observations; FSFB – Freshly shed fruiting bodies

Outbreak of whitefly in cotton belt of Punjab

During 2015, whitefly, *B. tabaci* appeared in epidemic form in cotton belt (south western districs) of Punjab. Higher incidence of whitefly was observed in the Abohar and Khuian Sarwar block of Fazilka district, followed by Bathinda, Muktsar and Mansa districts. The possible reasons for its outbreak may be due to following factors:

- High humidity and moderate temperature due to frequent rains during June appeared to be the possible reason for high incidence of whitefly in July. Normally, heavy showers in July-September wash out the adults of whitefly but during 2015, no heavy rains were recorded during this period.
- Due to delayed harvesting of wheat, the cotton sowing was delayed. The incidence of whitefly was higher in relatively late sown crop, *i.e.*, after 15 May. The cotton area sown after 15th May was 75% in Punjab.

- Stress due to various factors such as lack of moisture, water logging, saline soil, poor quality water, nutrients deficiency, poor weed management, etc. led to poor growth and higher damage as compared to well managed crops. Some of the farmers applied higher dose of nitrogen and sprayed acephate and monocrotophos (both are not recommended) that favoured higher incidence of whitefly.
- Use of unrecommended mixture of insecticides (readymade as well as tank made mixture), and sub standard and spurious insecticides aggravated the pest scenario, further.
- Adoption of agro-advisory by the farmers from unauthorized sources such as input dealers and commission agents.
- Survival and multiplication of whitefly on alternate weed host plants like peeli booti, kangi booti, puth kanda, etc.
- Survival and multiplication of whitefly on alternate cultivated crops namely *moong*, *mash*, okra, potato, brinjal, tomato, etc.
- Survival of whitefly under mild winter conditions (higher minimum temperature, increased humidity, no frost) during December 2014 and January 2015 led to its early build up
- Tractor mounted gun sprayers are widely used by the farmers, which do not ensure proper spray coverage.
- Due to high incidence of whitefly on cotton, some farmers neglected the crop and did not apply any insecticides. Consequently, whitefly population increased and later migrated to adjoining cotton fields.

4. Bioefficacy of microbial insecticides against sucking pests in *Bt* cotton (AAU-A)

Location **:** Agronomy farm, BACA, Anand Agricultural University, Anand.
Season and year **:** *Kharif* 2015

Experimental details

Treatments : 10
Replication : 3
Design : Randomized Block Design (RBD)
Crop / variety : *Bt* cotton - BG-6
Spacing : 120 x 60 cm

Details of treatments

T_1 : *Beauveria bassiana* (2×10^8 cfu g^{-1}) @ 30 g /10 litres water
T_2 : *Beauveria bassiana* (2×10^8 cfu g^{-1}) @ 40 g /10 litres water
T_3 : *Verticillium lecanii* (2×10^8 cfu g^{-1}) @ 30 g /10 litres water
T_4 : *Verticillium lecanii* (2×10^8 cfu g^{-1}) @ 40 g /10 litres water
T_5 : *Metarhizium anisopliae* (2×10^8 cfu g^{-1}) @ 30 g /10 litres water
T_6 : *Metarhizium anisopliae* (2×10^8 cfu g^{-1}) @ 40 g /10 litres water
T_7 : *Nomurea rileyi* (2×10^8 cfu g^{-1}) @ 30 g /10 litres water
T_8 : *Nomurea rileyi* (2×10^8 cfu g^{-1}) @ 40 g /10 litres water
T_9 : Recommended insecticide (Thiamethoxam 25 WG @ 20 g/ 10 litres water)
T_{10} : Control (water spray)

The bioefficacy of microbial insecticides was evaluated against aphid, *Aphis gossypii*; jassid, *Amrasca biguttula biguttula*; whitefly, *Bemisia tabaci;* and thrips, *Thrips tabaci*. Considering the pest population in experimental area, two sprays were applied on need basis.

The observations on population of sucking pests [Aphid, *A. gosypii*; Jassid, *A. bigutulla bigutulla*; Whitefly, *B. tabaci* and Thrips, *T. tabaci*] were made on five plants selected randomly in each plot. On each plant, three leaves were selected randomly from top, middle and bottom canopy and population counts were made one day before the first spray as well as 3 and 7 days after each spray. The periodical data on pest population were subjected to ANOVA after transforming them to square root. The data were also pooled over periods, sprays and years. Moreover, **s**eed cotton yield in kilograms was recorded plot-wise and picking-wise. The yield data was summed-up plot wise, converted to quintal/ha and subjected to ANOVA.

Among the different microbial insecticides used at different concentrations, significantly lower number of jassids (1.04/leaf), whiteflies (1.72/leaf), aphids (2.38/leaf) and thrips (1.31/leaf) were recorded in the treatment *L. lecanii* (40 g/10 L of water), followed by *B. bassiana* and *M. anisopliae* (40 g/10 L of water). None of the microbial insecticides found superior than chemical insecticide used. Further, it was found that lowest number of jassids (0.94/leaf), whiteflies (1.39/leaf), aphids (1.92/leaf) and thrips (1.01/leaf) were recorded in insecticide (thiamethoxam) treated plot **(Tables 61-64)**. Similarly, among the microbial insecticides, higher seed cotton yield was obtained in the treatment of *L. lecanii* @ 40 g/10 L of water (28.96 q/ha), followed by *B. bassiana* @ 40 g/10 L of water (25.98 q/ha) and *M. anisopliae* @ 40 g/10 L of water (25.29 q/ha). However, the highest seed cotton yield was recorded in chemical insecticide treated plot (31.26 q/ha) **(Table 65)**.

Table 61. Bio-efficacy of microbial insecticides against jassid infesting *Bt* cotton

Treatments		No. of jassid/leaf									
		Before spray	3 days after spray				7 days after spray				Pooled
			1st spray	2nd spray	3rd spray	Pooled	1st spray	2nd spray	3rd spray	Pooled	
T1:	*B. bassiana* @ 30 g /10 litres water	2.34 (4.98)	1.58 (2.00)	1.34 (1.30)	1.23 (1.01)	1.38 (1.41)	1.23 (1.01)	1.23 (1.01)	1.05 (0.60)	1.17 (0.86)	1.28^{de} (1.14)
T2:	*B. bassiana* @ 40 g /10 litres water	2.25 (4.56)	1.29 (1.16)	1.25 (1.06)	1.05 (0.60)	1.20 (0.94)	1.05 (0.60)	1.05 (0.60)	1.00 (0.50)	1.03 (0.57)	1.12^{bc} (0.75)
T3:	*V. lecanii* @ 30 g /10 litres water	2.41 (5.31)	1.70 (2.39)	1.46 (1.63)	1.23 (1.01)	1.46 (1.63)	1.34 (1.30)	1.34 (1.30)	1.23 (1.01)	1.30 (1.20)	1.38^{e} (1.40)
T4:	*V. lecanii* @ 40 g /10 litres water	2.31 (4.84)	1.46 (1.63)	1.05 (0.60)	0.88 (0.27)	1.13 (0.78)	1.05 (0.60)	0.91 (0.33)	0.88 (0.27)	0.95 (0.39)	1.04^{ab} (0.58)
T5:	*M. anisopliae* @ 30 g /10 litres water	2.47 (5.60)	1.68 (2.32)	1.58 (2.00)	1.23 (1.01)	1.50 (1.74)	1.34 (1.30)	1.34 (1.30)	1.34 (1.30)	1.34 (1.31)	1.42^{ef} (1.52)
T6:	*M. anisopliae* @ 40 g /10 litres water	2.54 (5.95)	1.46 (1.63)	1.34 (1.30)	1.05 (0.60)	1.29 (1.15)	1.23 (1.01)	1.05 (0.60)	1.05 (0.60)	1.11 (0.73)	1.20^{cd} (0.94)
T7:	*N. rileyi* @ 30 g /10 litres water	2.46 (5.55)	1.86 (2.96)	1.85 (2.92)	1.68 (2.32)	1.80 (2.73)	1.77 (2.63)	1.70 (2.39)	1.58 (2.00)	1.69 (2.34)	1.74^{g} (2.53)
T8:	*N. rileyi* @ 40 g /10 litres water	2.54 (5.95)	1.77 (2.63)	1.68 (2.32)	1.46 (1.63)	1.64 (2.18)	1.68 (2.32)	1.46 (1.63)	1.34 (1.30)	1.50 (1.74)	1.57^{f} (1.96)
T9:	Recommended insecticide (Thiamethoxam 25 WG @ 20 g/ 10 litres water)	2.60 (6.26)	1.23 (1.01)	0.91 (0.32)	0.88 (0.27)	1.00 (0.51)	0.88 (0.27)	0.88 (0.27)	0.88 (0.27)	0.88 (0.27)	0.94^{a} (0.38)
T10:	Control (water spray)	2.66 (6.58)	2.74 (7.01)	2.85 (7.62)	2.85 (7.62)	2.81 (7.39)	2.79 (7.28)	2.86 (7.68)	3.03 (8.68)	2.89 (7.85)	2.85^{h} (7.62)
S. Em. ±	**Treatment (T)**	0.15	0.12	0.12	0.11	0.07	0.12	0.14	0.15	0.08	0.05
	Spray (S)	-	-	-	-	0.05	-	-	-	0.05	0.03
	Period (P)	-	-	-	-	-	-	-	-	-	0.02
	T x S	-	-	-	-	0.04	-	-	-	0.04	0.04
	T x P	-	-	-	-	-	-	-	-	-	0.09
	S x P	-	-	-	-	-	-	-	-	-	0.07
	T x S x P	-	-	-	-	-	-	-	-	-	0.13
C. D @ 5 %	**T**	NS	0.35	0.34	0.34	0.19	0.35	0.42	0.44	0.22	0.15
	S	-	-	-	-	0.21	-	-	-	-	0.11
	P	-	-	-	-	-	-	-	-	-	0.07
	T x S	-	-	-	-	NS	-	-	-	NS	NS
	T x P	-	-	-	-	-	-	-	-	-	NS
	S x P	-	-	-	-	-	-	-	-	-	0.21
	T x S x P	-	-	-	-	-	-	-	-	-	NS
C. V. (%)		10.42	12.25	13.04	14.56	13.20	14.32	17.54	19.06	16.98	15.37

Note: Figures in parentheses are retransformed values; those outside are $\sqrt{X+0.5}$ transformed values; Figures in Letter(s) in common are statistically at par as per DNMRT

Table 62. Bio-efficacy of microbial insecticides against whitefly infesting *Bt* cotton

Treatments		No. of whitefly/ leaf									
		Before spray	3 days after spray				7 days after spray				Pooled
			1st spray	2nd spray	3rd spray	Pooled	1st spray	2nd spray	3rd spray	Pooled	
T1:	*B. bassiana* @ 30 g /10 litres water	2.70 (6.79)	2.18 (4.25)	1.86 (2.96)	1.58 (2.00)	1.87 (3.00)	1.94 (3.26)	1.67 (2.29)	1.46 (1.63)	1.69 (2.36)	1.78^{bcd} (2.67)
T2:	*B. bassiana* @ 40 g /10 litres water	2.97 (8.32)	2.11 (3.95)	1.68 (2.32)	1.49 (1.72)	1.76 (2.60)	1.80 (2.74)	1.59 (2.03)	1.31 (1.22)	1.56 (1.93)	1.66^{b} (2.26)
T3:	*V. lecanii* @ 30 g /10 litres water	2.70 (6.79)	2.31 (4.84)	1.95 (3.30)	1.77 (2.63)	2.01 (3.54)	2.00 (3.50)	1.77 (2.63)	1.56 (1.93)	1.78 (2.67)	1.89^{cd} (3.07)
T4:	*V. lecanii* @ 40 g /10 litres water	3.02 (8.62)	2.04 (3.66)	1.77 (2.63)	1.58 (2.00)	1.80 (2.74)	1.86 (2.96)	1.58 (2.00)	1.46 (1.63)	1.63 (2.16)	1.72^{bc} (2.46)
T5:	*M. anisopliae* @ 30 g /10 litres water	2.58 (6.16)	2.27 (4.65)	2.03 (3.62)	2.04 (3.66)	2.11 (3.95)	1.87 (3.00)	1.86 (2.96)	1.68 (2.32)	1.80 (2.74)	1.96^{d} (3.34)
T6:	*M. anisopliae* @ 40 g /10 litres water	2.76 (7.12)	2.16 (4.17)	1.76 (2.60)	1.68 (2.32)	1.87 (3.00)	1.87 (3.00)	1.68 (2.32)	1.58 (2.00)	1.71 (2.42)	1.79^{bcd} (2.70)
T7:	*N. rileyi* @ 30 g /10 litres water	3.03 (8.68)	2.74 (7.01)	2.41 (5.31)	2.35 (5.02)	2.50 (5.75)	2.27 (4.65)	2.27 (4.65)	2.12 (3.99)	2.22 (4.43)	2.36^{e} (5.07)
T8:	*N. rileyi* @ 40 g /10 litres water	2.91 (7.97)	2.61 (6.31)	2.25 (4.56)	2.17 (4.21)	2.34 (4.98)	2.17 (4.21)	2.11 (3.95)	1.95 (3.30)	2.08 (3.83)	2.21^{e} (4.38)
T9:	Recommended insecticide (Thiamethoxam 25 WG @ 20 g/ 10 litres water)	2.85 (7.62)	1.77 (2.63)	1.34 (1.30)	1.46 (1.63)	1.53 (1.84)	1.46 (1.63)	1.05 (0.60)	1.23 (1.01)	1.25 (1.06)	1.39^{a} (1.43)
T10:	Control (water spray)	2.88 (7.79)	2.91 (7.97)	3.44 (11.33)	3.44 (11.33)	3.26 (10.13)	2.98 (8.38)	3.19 (9.68)	3.48 (11.61)	3.21 (9.80)	3.24^{f} (10.00)
S. Em. ±	**Treatment (T)**	0.22	0.18	0.13	0.10	0.08	0.14	0.13	0.12	0.08	0.05
	Spray (S)	-	-	-	-	0.03	-	-	-	0.03	0.03
	Period (P)	-	-	-	-		-	-	-		0.02
	T x S	-	-	-	-	0.05	-	-	-	0.04	0.04
	T x P	-	-	-	-		-	-	-		0.09
	S x P	-	-	-	-		-	-	-		0.08
	T x S x P	-	-	-	-		-	-	-		0.13
C. D @ 5 %	**T**	NS	0.54	0.39	0.31	0.23	0.43	0.37	0.36	0.21	0.15
	S	-	-	-	-	0.13	-	-	-	0.13	0.10
	P	-	-	-	-		-	-	-		0.07
	T x S	-	-	-	-	NS	-	-	-	NS	0.12
	T x P	-	-	-	-		-	-	-		NS
	S x P	-	-	-	-		-	-	-		NS
	T x S x P	-	-	-	-		-	-	-		NS
C. V. (%)		13.56	13.74	10.97	9.22	11.75	12.38	11.60	11.66	11.93	11.63

Note: Figures in parentheses are retransformed values; those outside are $\sqrt{X+0.5}$ transformed values; Figures in Letter(s) in common are statistically at par as per DNMRT

Table 63. Bio-efficacy of microbial insecticides against aphid infesting *Bt* cotton

Treatments		No. of aphid/ leaf									
		Before spray	3 days after spray				7 days after spray				Pooled
			1st spray	2nd spray	3rd spray	Pooled	1st spray	2nd spray	3rd spray	Pooled	
T1:	*B. bassiana* @ 30 g /10 litres water	3.97 (15.26)	3.21 (9.80)	2.83 (7.51)	2.54 (5.95)	2.86 (7.68)	3.11 (9.17)	2.47 (5.60)	2.07 (3.78)	2.55 (6.00)	2.70^{d} (6.79)
T2:	*B. bassiana* @ 40 g /10 litres water	4.09 (16.23)	2.93 (8.08)	2.59 (6.21)	2.32 (4.88)	2.62 (6.36)	2.41 (5.31)	2.26 (4.61)	1.93 (3.22)	2.20 (4.34)	2.41^{bc} (5.31)
T3:	*V. lecanii* @ 30 g /10 litres water	4.35 (18.32)	3.21 (9.80)	2.97 (8.32)	2.56 (6.05)	2.91 (7.97)	3.15 (9.42)	2.50 (5.75)	2.20 (4.34)	2.61 (6.31)	2.76^{d} (7.12)
T4:	*V. lecanii* @ 40 g /10 litres water	4.27 (17.73)	3.03 (8.68)	2.50 (5.75)	2.28 (4.70)	2.61 (6.31)	2.22 (4.43)	2.20 (4.34)	2.06 (3.74)	2.16 (4.17)	2.38^{b} (5.16)
T5:	*M. anisopliae* @ 30 g /10 litres water	4.10 (16.31)	3.25 (10.06)	3.02 (8.62)	2.61 (6.31)	2.96 (8.26)	3.28 (10.26)	2.61 (6.31)	2.34 (4.98)	2.74 (7.01)	2.85^{de} (7.62)
T6:	*M. anisopliae* @ 40 g /10 litres water	3.93 (14.94)	3.17 (9.55)	2.74 (7.01)	2.34 (4.98)	2.75 (7.06)	3.08 (8.99)	2.41 (5.31)	2.13 (4.04)	2.54 (5.95)	2.64^{cd} (6.47)
T7:	*N. rileyi* @ 30 g /10 litres water	4.12 (16.47)	3.46 (11.47)	3.29 (10.32)	3.08 (8.99)	3.27 (10.19)	3.48 (11.61)	3.02 (8.62)	2.89 (7.85)	3.13 (9.30)	3.20^{f} (9.74)
T8:	*N. rileyi* @ 40 g /10 litres water	4.02 (15.66)	3.34 (10.66)	3.25 (10.06)	2.95 (8.20)	3.18 (9.61)	3.43 (11.26)	2.72 (6.90)	2.75 (7.06)	2.96 (8.26)	3.07^{ef} (8.92)
T9:	Recommended insecticide (Thiamethoxam 25 WG @ 20 g/ 10 litres water)	4.33 (18.25)	2.61 (6.31)	2.04 (3.66)	1.68 (2.32)	2.11 (3.95)	1.95 (3.30)	1.77 (2.63)	1.46 (1.63)	1.73 (2.49)	1.92^{a} (3.19)
T10:	Control (water spray)	4.27 (17.73)	4.36 (18.51)	4.42 (19.04)	4.74 (21.97)	4.51 (19.84)	4.70 (21.59)	4.70 (21.59)	4.71 (21.68)	4.70 (21.59)	4.61^{g} (20.75)
S. Em. ±	**Treatment (T)**	0.29	0.17	0.16	0.14	0.10	0.21	0.14	0.14	0.09	0.07
	Spray (S)	-	-	-	-	0.05	-	-	-	0.05	0.04
	Period (P)	-	-	-	-		-	-	-	-	0.03
	T x S	-	-	-	-	0.10	-	-	-	0.09	0.05
	T x P	-	-	-	-		-	-	-	-	0.12
	S x P	-	-	-	-		-	-	-	-	0.10
	T x S x P	-	-	-	-		-	-	-	-	0.17
C. D. at 5 %	**T**	NS	0.52	0.48	0.42	0.28	0.61	0.43	0.42	0.27	0.19
	S	-	-	-	-	-	-	-	-	0.15	0.17
	P	-	-	-	-	-	-	-	-	-	0.09
	T x S	-	-	-	-	NS	-	-	-	NS	0.15
	T x P	-	-	-	-	-	-	-	-	-	NS
	S x P	-	-	-	-	-	-	-	-	-	NS
	T x S x P	-	-	-	-	-	-	-	-	-	NS
	C. V. (%)	12.14	9.30	9.34	9.09	9.92	11.63	9.32	10.06	10.37	10.31

Note: Figures in parentheses are retransformed values; those outside are $\sqrt{X+0.5}$ transformed values; Figures in Letter(s) in common are statistically at par as per DNMRT

Table 64. Bio-efficacy of microbial insecticides against thrips infesting *Bt* cotton

Treatments		No. of thrips/ leaf									
		Before spray	3 days after spray				7 days after spray				Pooled
			1st spray	2nd spray	3rd spray	Pooled	1st spray	2nd spray	3rd spray	Pooled	
T1:	*B. bassiana* @ 30 g /10 litres water	2.41 (5.31)	2.04 (3.66)	1.77 (2.63)	1.34 (1.30)	1.72 (2.46)	1.46 (1.63)	1.46 (1.63)	1.23 (1.01)	1.38 (1.40)	1.55^{cd} (1.90)
T2:	*B. bassiana* @ 40 g /10 litres water	2.34 (4.98)	1.86 (2.96)	1.46 (1.63)	1.34 (1.30)	1.55 (1.90)	1.23 (1.01)	1.32 (1.24)	1.05 (0.60)	1.20 (0.94)	1.38^{bc} (1.40)
T3:	*V. lecanii* @ 30 g /10 litres water	2.27 (4.65)	1.95 (3.30)	1.68 (2.32)	1.46 (1.63)	1.70 (2.39)	1.34 (1.30)	1.34 (1.30)	1.36 (1.35)	1.35 (1.32)	1.52^{bcd} (1.81)
T4:	*V. lecanii* @ 40 g /10 litres water	2.54 (5.95)	1.76 (2.60)	1.36 (1.35)	1.23 (1.01)	1.45 (1.60)	1.23 (1.01)	1.23 (1.01)	1.05 (0.60)	1.17 (0.87)	1.31^{b} (1.22)
T5:	*M. anisopliae* @ 30 g /10 litres water	2.41 (5.31)	2.13 (4.04)	2.04 (3.66)	1.58 (2.00)	1.92 (3.19)	1.58 (2.00)	1.58 (2.00)	1.34 (1.30)	1.50 (1.75)	1.71^{de} (2.42)
T6:	*M. anisopliae* @ 40 g /10 litres water	2.20 (4.34)	1.95 (3.30)	1.60 (2.06)	1.34 (1.30)	1.63 (2.16)	1.34 (1.30)	1.34 (1.30)	1.23 (1.01)	1.30 (1.19)	1.47^{bc} (1.66)
T7:	*N. rileyi* @ 30 g /10 litres water	2.67 (6.63)	2.39 (5.31)	2.26 (4.61)	1.77 (2.63)	2.14 (4.08)	1.86 (2.96)	1.84 (2.89)	1.58 (2.00)	1.76 (2.60)	1.95^{f} (3.30)
T8:	*N. rileyi* @ 40 g /10 litres water	2.41 (5.31)	2.24 (4.52)	2.12 (3.99)	1.66 (2.26)	2.01 (3.54)	1.77 (2.63)	1.77 (2.63)	1.48 (1.69)	1.68 (2.32)	1.84^{ef} (2.89)
T9:	Recommended insecticide (Thiamethoxam 25 WG @ 20 g/ 10 litres water)	2.32 (4.88)	1.29 (1.16)	0.88 (0.27)	0.88 (0.27)	1.02 (0.54)	1.05 (0.60)	1.05 (0.60)	0.88 (0.27)	0.99 (0.48)	1.01^{a} (0.52)
T10:	Control (water spray)	2.71 (6.84)	2.66 (6.58)	2.88 (7.79)	3.08 (8.99)	2.88 (7.79)	2.89 (7.85)	2.94 (8.14)	3.20 (9.74)	3.01 (8.56)	2.94^{g} (8.14)
S. Em. ±	**Treatment (T)**	0.13	0.15	0.10	0.10	0.07	0.10	0.10	0.12	0.06	0.05
	Spray (S)	-	-	-	-	0.03	-	-	-	0.01	0.02
	Period (P)	-	-	-	-	-	-	-	-	-	0.02
	T x S	-	-	-	-	0.04	-	-	-	0.03	0.04
	T x P	-	-	-	-	-	-	-	-	-	0.08
	S x P	-	-	-	-	-	-	-	-	-	0.07
	T x S x P	-	-	-	-	-	-	-	-	-	0.11
C. D @ 5 %	**T**	NS	0.46	0.30	0.30	0.20	0.28	0.30	0.34	0.17	0.13
	S	-	-	-	-	0.11	-	-	-	0.06	0.06
	P	-	-	-	-	-	-	-	-	-	0.06
	T x S	-	-	-	-	NS	-	-	-	NS	0.10
	T x P	-	-	-	-	-	-	-	-	-	0.23
	S x P	-	-	-	-	-	-	-	-	-	0.18
	T x S x P	-	-	-	-	-	-	-	-	-	NS
	C. V. (%)	9.465	13.09	9.61	11.25	11.63	10.46	10.96	13.88	11.74	11.85

Note : Figures in parentheses are retransformed values; those outside are $\sqrt{X+0.5}$ transformed values; Figures in Letter(s) in common are statistically at par as per DNMRT

Table 65. Impact of microbial insecticides on yield

Treatments		Seed cotton yield (q/ha)
T1:	*B. bassiana* @ 30 g /10 litres water	23.40^{bcde}
T2:	*B. bassiana* @ 40 g /10 litres water	25.98^{abc}
T3:	*V. lecanii* @ 30 g /10 litres water	22.93^{cde}
T4:	*V. lecanii* @ 40 g /10 litres water	28.96^{ab}
T5:	*M. anisopliae* @ 30 g /10 litres water	21.83^{cde}
T6:	*M. anisopliae* @ 40 g /10 litres water	25.29^{bcd}
T7:	*N. rileyi* @ 30 g /10 litres water	19.80^{def}
T8:	*N. rileyi* @ 40 g /10 litres water	18.13^{ef}
T9:	Recommended insecticide (Thiamethoxam 25 WG @ 20 g/ 10 litres water)	31.26^{a}
T10:	Control (water spray)	15.14^{f}
S. Em. ±		1.65
C. D. @ 5%		4.89
C.V. (%)		12.25

Note: Figures in Letter(s) in common are statistically at par as per DNMRT

5. Biological suppression of sap sucking pests of *Bt* cotton (MPKV, PJTSAU and UAS-R)

MPKV, Pune

Bt cotton var. Jai, Bollgard II was raised separately on the research farm of Agril. Entomology section, College of Agriculture, Pune. Seeds were sown on 24th July 2015 on ridges and furrows at 90 x 60 cm spacing in 40 x 40 m^2 size plots. Sprays were given at fortnightly interval. The sucking pests were recorded from randomly selected 5 plants per plot and tagged as replicate before treatment and 10 days after each treatment. The pest population was recorded from three leaves (terminal shoots)/ plant. Recorded Seed cotton yield

It was seen from the table 4 that the treatments with dimethoate @ 0.05% and *L. lecanii* (1 x 10^8 conidia/g) @ 5 g/litre were significantly superior over all other treatments in reducing sucking pests, *viz*., aphids, jassids, thrips and white flies population and was at par with each other. The highest seed cotton yield (18.01 q/ha) was recorded in dimethoate @ 0.05% which was at par with *L. lecanii* @ 5 g/litre with 17.71 q/ha of seed cotton yield **(Table 66)**.

Table 66. Effect of biopesticides against sucking pest complex in cotton

Treatments	Average number of sucking pest population / 3 leaves								Yield of seed cotton (q/ha)
	Aphids		Jassids		Thrips		White-flies		
	Pre count	Post count	Pre count	Post count	Pre count	Post count	Pre count	Post count	
T_1: *Metarhizium anisopliae*	24.30 (4.97)	9.45 [b] (3.15)	7.22 (2.77)	2.71 [b] (1.79)	12.64 (3.62)	3.44 [b] (1.98)	5.43 (2.43)	2.26 [b] (1.66)	15.73 [b]
T_2: *Lecanicillium lecanii*	24.06 (4.95)	7.42 [a] (2.80)	7.09 (2.75)	1.62 [a] (1.46)	11.89 (3.52)	2.58 [a] (1.74)	5.84 (2.52)	1.41 [a] (1.38)	17.71 [a]
T_3:*Beauveria bassiana*	25.97 (5.13)	13.34 [c] (3.71)	7.11 (2.76)	4.35 [c] (2.20)	12.66 (3.62)	4.65 [c] (2.27)	5.61 (2.47)	2.62 [b] (1.76)	14.04 [b]
T_4: NSKE @ 5 %	24.21 (4.95)	10.78 [b] (3.35)	6.98 (2.73)	3.75 [b] (2.06)	12.93 (3.66)	4.28 [b] (2.18)	5.00 (2.34)	2.77 [b] (1.81)	15.42 [b]
T_5: Diamethoate @ 0.05 %	23.94 (4.94)	5.34 [a] (2.42)	6.74 (2.69)	1.14 [a] (1.28)	11.97 (3.53)	1.71 [a] (1.50)	6.17 (2.58)	0.99 [a] (1.22)	18.01 [a]
T_6: Untreated control	23.31 (4.87)	31.45 [d] (5.65)	6.83 (2.70)	9.68 [d] (3.19)	12.68 (3.63)	16.09 [d] (4.07)	5.90 (2.53)	12.55 [c] (3.61)	10.48 [c]
CD (p = 0.05)	(NS)	(0.40)	(NS)	(0.30)	(NS)	(0.25)	(NS)	(0.19)	(2.15)

Figures in parentheses are √ n+ 0.5 transformed values

PJTSAU-Hyderabad

No report received

UAS-Raichur

Variety: KCH-14K59 (Jadoo) BG II
DOS: 21-08-2015
Spraying: 07-10-2015, 16-10-2015 and 02-11-2015

In each treatment five plants were randomly selected to record the incidence of leafhoppers, whitefly and aphids at one day before spray, 10 days and 20 days after each spray. The seed cotton yield was recorded in each treatment and subjected for statistical analysis.

Leafhoppers: Ten days after spray among the biocontrol agents minimum leafhopper population of 4.82 per leaf was noticed in *Beauveria bassiana* @ 5 gm/l and it was followed by *Lecanicillium lecanii* @ 5 gm/l.

Whitefly: *Beauveria bassiana* @ 5gm/l recorded lowest population of whitefly (2.16/leaf) and it was followed by *Lecanicillium lecanii* @ 5gm/l.

Aphids: Among the bioagents, *Beauveria bassiana* @ 5 gm/l recorded lowest population of aphids (4.06/leaf) followed by *Lecanicillium lecanii* @ 5 gm/l.

Yield: The highest seed cotton yield 17.04 q/ha was noticed *Beauveria bassiana* @ 5 gm/l followed by *Lecanicillium lecanii* @ 5 gm/l. Untreated control recorded minimum seed cotton yield of 12.62q/ha **(Table 67)**.

Table 67. Biological suppression of sap sucking pests on *Bt* cotton.

Sl. No.	Treatments	Dosage g/ml/lit	No of leafhoppers per leaf			No. of whitefly per leaf			No. of aphids per leaf			Seed Cotton Yield (q/ha)
			IDBS	10 DAS	20 DAS	IDBS	10 DAS	20 DAS	IDBS	10 DAS	20 DAS	
1	*Metarhizium anisopliae* 1 x 10^8 conidia/g	5.00	10.16 (3.26)	6.48 (2.64)	4.60 (2.26)	5.32 (2.41)	3.18 (1.92)	3.06 (1.89)	15.36 (3.98)	12.04 (3.54)	9.36 (3.14)	14.89
2	*Lecanicillum lecanii* 1 x 10^8 conidia/g	5.00	9.92 (3.23)	5.14 (2.37)	3.84 (2.08)	5.48 (2.45)	3.04 (1.88)	2.84 (1.83)	15.02 (3.94)	9.84 (3.22)	5.32 (2.41)	16.38
3	*Beauveria bassiana* 1 x 10^8 conidia/g	5.00	10.06 (3.25)	4.84 (2.31)	3.04 (1.88)	5.64 (2.48)	2.16 (1.63)	1.98 (1.57)	15.98 (4.06)	8.32 (2.97)	4.06 (2.14)	17.04
4	NSE 5%	3.00	9.98 (3.24)	3.68 (2.04)	2.12 (1.62)	5.18 (2.38)	1.74 (1.50)	1.42 (1.39)	16.14 (4.08)	6.14 (2.58)	3.18 (1.92)	18.96
5	Dimethoate 36 EC	1.75	10.14 (3.29)	2.18 (1.64)	1.98 (1.57)	5.44 (2.44)	1.58 (1.44)	1.36 (1.36)	15.36 (3.98)	5.98 (2.55)	2.84 (1.83)	19.02
6	Untreated Control	-	10.32 (2.96)	10.08 (3.25)	9.94 (3.23)	5.26 (2.40)	5.18 (2.38)	5.22 (2.39)	15.14 (3.95)	14.04 (3.81)	13.82 (3.78)	12.62
S Em ±			**0.13**	**0.09**	**0.05**	**0.16**	**0.03**	**0.07**	**0.18**	**0.02**	**0.08**	**0.23**
CD (P=0.05)			**NS**	**0.28**	**0.16**	**0.48**	**0.10**	**0.21**	**0.52**	**0.07**	**0.25**	**0.68**
CV %			**10.18**	**11.46**	**10.78**	**10.06**	**11.46**	**10.14**	**13.18**	**12.06**	**12.18**	**10.76**

DBS: Day before spray DAS: Day after spray
Figures in parentheses are square root transformed values

2.5. Tobacco

1. Bio-intensive integrated management of tobacco aphid, *Myzus nicotianae* Blackman in central black soils of Andhra Pradesh (CTRI-Guntur)

Treatments

T1. Maize border (two rows) + two sprays of *Lecanicillium lecanii* @ 10^{13} spores/ha at 45and 65 days after planting (DAP)
T2. Maize border (two rows) + one spray of *Lecanicillium lecanii* @ 10^{13} spores /ha at 45DAP and one spray of imidacloprid 0.03% at 65 DAP
T3. Maize border (two rows) + one spray of imidacloprid 0.03% at 55 DAP and one spray of thiomethaxam 0.02% at 65 DAP
T4. Maize border (two rows)
T5. Two sprays of *Lecanicillium lecanii* @ 10^{13} spores /ha at 55 and 65 days of planting
T6. One spray of *Lecanicillium lecanii* @ 10^{13} spores /ha at 55 DAP and one spray of imidacloprid 0.03% at 65 DAP
T7. One spray of imidacloprid 0.03% at 55 DAP and one spray of thiomethaxam 0.02% at 65 DAP
T8. Control (no border crop and no spray)

Replications : 3
Design : RBD
Variety : Siri (FCV)
Plot size : 15 X 15 m^2

Observations

- Per cent aphid infested plants
- Aphid population (score) on 5 infested plants (top and middle leaf)
- Per cent sooty mold incidence (low, medium and high)
- Yield parameters of tobacco (green leaf, cured leaf, bright grade, medium grade and low grade)

Aphid infestation: The first year data revealed that all the treatments were significantly superior over control in reducing aphid infestation after 10 days of second spray **(Table 68)**. The per cent reduction of infestation over control ranged from 35.78 to 100. Cent per cent reduction of infestation was recorded in chemical control plot with and without maize border. In control plot (no border and no spray), the per cent aphid infested plants were 31.83. Among other treatments, border crop sprayed with *L. lecanii* @ 10^{13} spores/ha at 55 days and imidacloprid 0.03% at 65 days was superior with 95.85% reduction of aphid infestation followed by the same treatments without border crop (91.64%). The bio-intensive IPM module with two rows of maize border as barrier crop, one spray of *Lecanicillium lecanii* @ 10^{13} spores /ha at 55 DAP and one spray of imidacloprid @ 0.03% at 65 DAP exhibited 95.85% reduction of infestation by tobacco aphid, which was on par with recommended chemical control practice **(Table 68)**.

Aphid population: The aphid population on infested plants in each treatment showed similar trend after ten days of second spray (75 DAP), aphid population was nil in chemical control plot with and without border crop. Border row of maize with 2 sprays of bio-agent and maize border with one spray of bio-agent and one spray of insecticide also did not show aphid population. The population was also less in plot sprayed with *L. lecanii* twice at 55 and 65 DAS with 0.83 and 0.33 scores on top and middle leaves, respectively **(Table 69)**.

Sooty mold incidence

Sooty mold incidence was zero in the plots received either two sprays or one spray of pesticide in combination with maize border or entomopathogenic fungus or both **(Table 70)**.

Yield

Highest yields of 13950, 2022 and 1247 kg/ha of green leaf, total cured leaf and bright leaf, respectively were recorded in chemical control plot, whereas, lowest yields of 13250, 1908 and 979 kg/ha were recorded in control plot. In all the remaining treatments, green leaf and total cured leaf yields varied from 13510 to 13912 and 1949 to 2018 kg/ha, respectively **(Table 71)**.

Table 68. Integrated management of aphid infestation

Sl. No	Treatments	Aphid infested plants (%)			Per cent reduction of infestation over control at 75 days
		Pre count (55 days)	10 days after 1st spray (65 days)	10 days after 2nd spray (75 days)	
1	Maize border (2 rows) + *L. lecanii* @10^{13} spores/ha at 55 & 65 days	12.00	10.66	7.33	74.05
2	Maize border + *L. lecanii* @10^{13} spores/ha at 55 days+ imidacloprid 0.03% at 65days	11.83	10.66	1.00	95.85
3	Maize border + imidacloprid 0.03% at 55days + thiomethaxam 0.02% at 65 days	12.66	2.33	0.00	100.00
4	Maize border (2 rows)	11.33	16.33	19.83	35.78
5	*L. lecanii* @ 10^{13} spores/ha at 55 & 65 days	17.83	14.00	10.33	63.19
6	*L. lecanii* @ 10^{13} spores/ha at 55 days + imidacloprid 0.03% at 65days	16.66	12.00	2.66	91.64
7	Imidacloprid 0.03% at 55days + thiomethaxam 0.02% at 65 days	16.50	4.00	0.00	100.00
8	Control (no border & no spray)	16.33	24.50	31.83	-----
	S.Em±	1.10	0.76	0.49	2.19
	C.D at 5%	3.17	2.20	1.41	6.34
	C.V (%)	7.15	5.83	6.08	7.86

Table 69. Integrated management of aphid infestation

Sl. No	Treatments	Aphid population (score)					
		Pre count (55 days)		10 days of 1st spray (65 days)		10 days of 2nd spray (75 days)	
		Top leaf	Middle leaf	Top leaf	Middle leaf	Top leaf	Middle leaf
1	Maize border (2 rows) + *L. lecanii* @ 10^{13} spores/ha at 55 & 65 days	1.66	0.66	0.83	0.33	0.66	0.00
2	Maize border + *L. lecanii* @ 10^{13} spores/ha at 55 days + imidacloprid 0.03% at 65days	1.33	1.00	1.00	0.33	0.33	0.00
3	Maize border + imidacloprid 0.03% at 55days + thiomethaxam 0.02% at 65 days	1.66	1.00	1.00	0.33	0.00	0.00
4	Maize border (2 rows)	1.66	1.00	2.33	1.33	3.00	1.66
5	*L. lecanii* @ 10^{13} spores/ha at 55 & 65 days	2.33	0.83	1.00	0.33	0.83	0.33
6	*L. lecanii* @ 10^{13} spores/ha at 55 days + imidacloprid 0.03% at 65days	2.66	1.00	1.33	0.66	0.83	0.33
7	Imidacloprid 0.03% at 55days + thiomethaxam 0.02% at 65 days	2.66	1.00	1.66	0.66	0.00	0.00
8	Control (no border & no spray)	2.33	1.00	3.00	1.66	3.83	2.00
	S.Em±	0.12	0.15	0.05	0.09	0.06	0.04
	C.D at 5%	0.3	NS	0.14	0.26	0.18	0.11
	C.V (%)	10.17	15.85	6.08	9.70	12.80	9.50

Aphid score

Score	Aphid population / leaf
0	0
1	1-50
2	51-250
3	251-500
4	501-1000
5	>1000

Table 70. Integrated management of aphid infestation - sooty mold incidence

Sl. No	Treatments	Per cent sooty mold infested plants			
		Total	Low	Medium	High
1	Maize border (2 rows) + *L. lecanii* @ 10^{13} spores/ha at 55 & 65 days	5.33 (13.34)	3.66 (11.02)	1.66 (7.33)	0.00 (0.00)
2	Maize border + *L. lecanii* @ 10^{13} spores/ha at 55 days+ imidacloprid 0.03% at 65 days	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
3	Maize border + imidacloprid 0.03% at 55days + thiomethaxam 0.02% at 65 days	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
4	Maize border (2 rows)	13.66 (21.67)	2.33 (8.74)	7.00 (15.32)	4.33 (12.00)
5	*L. lecanii* @ 10^{13} spores/ha at 55 & 65 days	7.00 (15.27)	4.33 (11.89)	2.66 (9.36)	0.00 (0.00)
6	*L. lecanii* @ 10^{13} spores/ha at 55 days + imidacloprid 0.03% at 65 days	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
7	Imidacloprid 0.03% at 55days + thiomethaxam 0.02% at 65 days	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
8	Control (no border & no spray)	23.00 (28.63)	4.66 (12.42)	5.00 (12.88)	13.33 (21.40)
	S.Em±	0.40	0.30	0.86	1.12
	C.D at 5%	1.16	0.86	2.50	3.25
	C.V (%)	8.85	7.50	18.37	24.10

Figures in parentheses are arc sine transformed values

Table 71. Integrated management of aphid infestation - yield parameters (kg/ha)

Sl. No	Treatments	Green leaf	Cured leaf	Bright grade	Medium grade	Low grade
1	Maize border (2 rows) + *L. lecanii* @10^{13} spores/ha at 55 & 65 days	13510	1960	1168	528	264
2	Maize border + *L. lecanii* @ 10^{13} spores/ha at 55 days+ imidacloprid 0.03% at 65 days	13582	1983	1182	556	245
3	Maize border + imidacloprid 0.03% at 55days + thiomethaxam 0.02% at 65 days	13912	2018	1259	610	149
4	Maize border (2 rows)	13885	1937	1040	486	411
5	*L. lecanii* @ 10^{13} spores/ha at 55 & 65 days	13534	1949	1085	510	354
6	*L. lecanii* @ 10^{13} spores/ha at 55 days + imidacloprid 0.03% at 65days	13810	1975	1143	553	279
7	Imidacloprid 0.03% at 55 days + thiomethaxam 0.02% at 65 days	13950	2022	1247	602	173
8	Control (no border & no spray)	13250	1908	979	471	458
	S.Em±	64.12	9.03	7.10	5.27	3.59
	C.D at 5%	185.94	26.12	19.83	15.21	10.45
	C.V (%)	8.25	6.91	7.30	7.54	7.83

2.6. Rice

1. Seasonal abundance of predatory spiders (PAU)

The seasonal abundance of spiders was recorded on rice variety PR 114 at Punjab Agricultural University (PAU), Ludhiana under unsprayed conditions. The population of spiders was recorded using pit fall traps, sweep net and visual method. The population of spiders varied from 0.1 to 0.9 spiders per plant during the season with maximum population (0.9 spiders/plant) during 38th SMW (3rd week of September) **(Table 72)**.

Regular surveys were conducted to collect spiders from rice growing areas (Ludhiana, Patiala, Sangrur, Fazilka) of Punjab. A total of 10 species were recorded from the rice fields **(Table 73)**. *Neoscona* sp. was the predominant species (78.11%) at all the locations followed by *Tetragnatha* sp (14.98%). Species diversity (0.867) was calculated as per Shannon-Weiner index of diversity. Species evenness (0.377) and dominance index (0.623) was worked out as per formulae given by Krebs and Southwood, respectively.

Table 72. Seasonal abundance of sucking insect pests and their natural enemies in rice under unsprayed conditions at Ludhiana during 2015

Standard Met. Weeks	Leaf folder Damage		Stem borer damage		Plant hoppers population / plant		No. of Grass hoppers/ plant	Predators population/plant			Pitfall collection
	No. of larvae /plant	Damaged leaves (%)	DH (%)	WE (%)	BPH	WBPH		Dragonfly	Damselfly	Spiders	Spiders/ trap
32	0.3	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
33	0.0	0.4	1.5	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.6
34	0.1	0.4	1.4	0.0	0.0	0.0	0.0	0.1	0.0	0.5	0.8
35	0.0	0.2	2.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.5
36	0.0	0.4	1.9	0.0	0.0	0.0	0.0	0.0	0.8	0.4	1.0
37	0.2	1.0	1.7	0.0	0.0	0.0	0.0	0.2	1.3	0.0	7.2
38	0.0	0.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.9	6.6
39	0.0	0.5	2.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.4
40	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	1.6

Table 73. Diversity of spiders in rice during 2015

Sl. No.	Species	Family	Relative abundance (%)
1	*Neoscona* sp.	Araneidae	78.11
2	*Tetragnatha maxillosa*	Tetragnathidae	10.37
3	*T. javana*	Tetragnathidae	4.61
4	*Argiope catenulata*	Araneidae	2.76
5	*Leucage venusta*	Tetragnathidae	1.61
6	*Oxyopes salticus*	Oxyopidae	0.92
7	*Thomisus* sp.	Thomisidae	0.46
8	*Dolomedes fimbriatus*	Pisauridae	0.46
9	*Bianor* sp.	Salticidae	0.46
10	*Plexippus paykulli*	Salticidae	0.23
H (diversity index) : 0.867116 Species evenness : 0.376584 Dominance index : 0.623416			

2. Diversity of insect pests and their natural enemies in organic and conventional rice (PAU)

The mean incidence of insect pests and natural enemies in organically as well as conventionally (chemical control) grown basmati rice was recorded at village Sahauli (Patiala). The overall incidence of rice stem borer and leaf folder was less in conventionally managed fields as compared to organic fields. The mean dead heart incidence over a period of months was 3.63 and 3.13 per cent in organic and conventional fields, respectively. The mean incidence of white ears was 3.05 and 2.56 per cent in organic and conventional fields, respectively. Similarly, leaf folder damage in organic fields was 2.37 as compared to 1.09 per cent in conventional fields. The population of spiders on whole plant basis was 0.54 and 0.44 spiders per hill in organic and conventional fields, respectively. The population of spiders in pitfall collection was high in organic fields (1.63 spiders/trap) during the season as compared to conventional fields (1.17 spiders/trap). The similar trend was observed in sweep net collection wherein the mean population of spiders (6.78/plot), dragonflies (3.00/plot) and damselflies (5.50/plot) were higher than in conventional plots. The corresponding figures in conventional plots were 3.89, 0.00 and 4.75 per plot, respectively.

Natural parasitism of major insect pests in organically as well as conventionally grown rice revealed that parasitism in the eggs, larvae and pupae of stem borer and leaf folder ranged from 1.79 to 12.15 and 0.88 to 3.47% in organic and conventional rice, respectively **(Table 74)**. Parasitoids like *T. chilonis*, *T. japonicum, Telenomus* sp were recorded from the eggs of *S. incertulas. Telenomus* sp was most dominant with highest parasitism in organic (12.15%) and conventional fields (3.47%). Larval parasitoids namely, *Stenobracon nicevillei*, *Bracon* sp and *Cotesia* sp were recorded from stemborer and leaf folder larvae. Pupal parasitoids, *Tetrastichus* sp, *Brachymeria* sp and *Xathopimpla* sp were recorded from stem borer and leaf folder pupae with per cent parasitism ranging from 1.79 to 3.82 and 0.88 to 2.22 in organic and conventional fields, respectively.

Table 74. Parasitism level of rice stem borer and leaf folder in organic and conventional *basmati* rice at Sahauli during 2015

Parasitoids	Host	Parasitism (%)	
		Organic	Conventional
a. Egg Parasitoids			
- *Trichogramma chilonis*	*S. incertulas*	6.07	1.86
- *T. japonicum*	*S. incertulas*	4.46	1.23
- *Telenomus* sp	*S. incertulas*	12.15	3.47
B. Larval Parasitoids			
- *Stenobracon nicevillei*	*S. incertulas*	4.93	2.15
- *Bracon* sp	*S. incertulas* & *C. medinalis*	3.62	2.49
- *Cotesia* sp	*C. medinalis*	4.88	1.94
C. Pupal Parasitoids			
- *Tetrastichus* sp	*S. incertulas* & *C. medinalis*	3.82	2.22
- *Brachymeria* sp	*S. incertulas* & *C. medinalis*	2.28	1.03
- *Xathopimpla* sp	*S. incertulas*	1.79	0.88

3. Field evaluation of fungal pathogens on gundhi bug, *Leptocorisa oratorius* (KAU)

Two entomopathogenic fungi, namely, *Beauveria bassiana* (local isolate) and *Metarhizium anisopliae*, identified as superior in the laboratory trials in 2014-15 were evaluated at three different doses each in the field at College of Horticulture, Vellanikkara during the period from December, 2015 to January, 2016.

Treatments: 8
Replication: 3
Plot size: 5x4 m^2
Location: Vellanikkara

Treatment details

T1: *Beauveria bassiana* @ $2x10^7$ spores/ml
T2: *Beauveria bassiana* @ $2x10^8$ spores/ml
T3: *Beauveria bassiana* @ $2x10^9$ spores/ml
T4: *Metarhizium anisopliae* @ $2x10^7$ spores/ml
T5: *Metarhizium anisopliae* @ $2x10^8$ spores/ml
T6: *Metarhizium anisopliae* @ $2x10^9$ spores/ml
T7: Malathion @ 500 g a.i ha^{-1}
T8: Untreated control

The treatments were applied twice at 15 days interval starting from 87 days after transplantation after recording the average bug population/ m^2.

Beauveria bassiana applied at the rate of $2x10^9$ spores/ml registered the lowest population of 0.67 bugs/ m^2 ten days after treatment, followed by Malathion @ 500 g a.i/ha with a mean value of 1.07 bugs/ m^2. The two treatments were at par with *Metarhizium anisopliae* @ 2 x 10^8 spores/ml as well as *B. bassiana* @ 2 x 10^7spores/ ml with mean populations of 1.33 and 2.0 bugs/ m^2 respectively.

All the treatments were at par with each other and significantly superior over control in reducing rice bug populations at 15 days after treatment. Plots treated with *Metarhizium anisopliae* @ $2x10^8$ spores/ ml and *Beauveria bassiana* @ 2 x 10^9 spores/ ml, recorded mean values (0.33 and 1.00 bugs/ m^2 respectively) followed by chemical treatment (1.28 bugs/ m^2).

Plots treated with Malathion @ 500 g a.i/ha had the lowest number of bugs, at 0.33/m^2 ten days after second spray.

There was no significant difference between the treatments in terms of yield, though the highest value of 1.23 kg/m^2 was recorded in case of *B. bassiana* @ 2 x 10^9 spores/ ml, followed by malathion @ 500 g a.i/ha with a mean yield of 1.16 kg/m^2 **(Table 75)**.

The local isolate of the fungus *B. bassiana* @ 2 x 10^9 spores/ml proved its potential in the management of this pest which was evident by the occurance of fungal epizootics. This was also confirmed by the epizootic level infection of rice bug by the fungus when applied in a rice field of one acre at Kuruvai Padasekharam in Vadekkencherry Panchayat of Palghat district.

Table 75. Effect of entomopathogenic fungi on rice bug (*Leptocorisa oratorius*) population

Treatment	Pre count	5DAT	10 DAT	15 DAT	5 DAT	10 DAT	Yield (kg/m^2)
T1: *Beauveria bassiana* (local isolate) @ $2x10^7$ spores/ ml	9.67 (3.14)	17.67 (4.06)	2.00 (1.32)	7.33 (2.27)	10.67 (2.94)	6.67 (2.50)	0.81 (2.80)
T2: *Beauveria bassiana* @ $2x10^8$ spores/ml	7.00 (2.69)	12.00 (3.53)	7.00 (2.47)	5.33 (2.16)	1.00 (1.17)	2.00 (1.52)	1.03 (2.89)
T3: *Beauveria bassiana* @ $2x10^9$ spores/ml	11.00 (3.36)	12.00 (3.52)	0.67 (1.05)	1.00 (1.10)	1.00 (1.17)	2.33 (1.64)	1.23 (2.88)
T4: *Metarhizium anisopliae* @ $2x10^7$ spores/ ml	12.67 (3.592)	10.67 (3.33)	4.00 (2.03)	4.67 (2.22)	3.00 (1.67)	2.33 (1.68)	0.39 (2.57)
T5: *Metarhizium anisopliae* @ $2x10^8$ spores/ ml	19.33 (4.24)	10.67 (3.244)	1.33 (1.27)	0.33 (0.88)	3.67 (1.91)	1.33 (1.27)	0.50 2.48)
T6: *Metarhizium anisopliae* @ $2x10^9$ spores/ml	7.00 (2.68)	14.67 (3.88)	6.33 (2.51)	2.00 (1.56)	3.33 (1.55)	2.67 (1.76)	0.19 (2.35)
T7: Malathion @ 500 g a.i/ha	9.67 (3.19)	10.45 (3.31)	1.07 (1.20)	1.28 (1.29)	1.28 (1.29)	0.33 (0.88)	1.16 (2.99)
T8: Control	22.33 (4.78)	11.89 (3.52)	12.11 (3.55)	14.33 (3.82)	15.67 (4.00)	26.34 (5.10)	1.01 (2.91)
CD at 5%	NS	NS	1.36	1.62	1.79	1.2	NS

Values in parentheses are transformed values

2.7. Maize

1. Bio-suppression of *Chilo partellus* with *Trichogramma chilonis* on rabi maize (ANGRAU-Anakapalle)

Date of planting : 04.01.2016
Crop : Maize
Variety : DHM 117

Treatments imposed

Main plot treatments: T1, T2, T3

T1: Release of *Trichogramma chilonis* beginning from 15 Days After Emergence (DAE)
T2: Release of *Trichogramma chilonis* beginning from 20 DAE
T3: Release of *Trichogramma chilonis* beginning from 25 DAE

Sub plot treatments: S1, S2, S3

S1 : at the rate of 50,000/ha, thrice at 7-10 days interval
S2 : at the rate of 75,000/ha , thrice at 7-10 days interval
S3 : at the rate of 1,00,00/ha , thrice at 7-10 days interval

Filed release of *Trichogramma chilonis* (@ 75,000 and 1,00,000 parasitoids per ha) at 15 Days after seedling emergence, three times at weekly interval was found effective in reducing the stem borer damage. Three releases of *T. chilonis* @ 1,00,000 /ha recorded lowest dead hearts (1.05%) followed by three releases of *T. chilonis* @ 75,000 /ha from 15 DAE at weekly interval (1.27% DH) **(Table 76)**.

.

Table 76. Bio suppression of *Chilo partellus* with *Trichogramma chilonis* on rabi Maize

Treatment	% DH upto 60 DAE
M1 S1 : Release of *Trichogramma chilonis* beginning from 15DAE @ 50,000/ha ,thrice at 7-10 days interval	2.3
M1S2 : Release of *Trichogramma chilonis* beginning from 15DAE @ 75,000/ha ,thrice at 7-10 days interval	1.27
M1S3 : Release of *Trichogramma chilonis* beginning from 15DAE @ 1,00,00/ha ,thrice at 7-10 days interval	1.05
M2S1 : Release of *Trichogramma chilonis* beginning from 20 DAE @ 50,000/ha ,thrice at 7-10 days interval	2.15
M2 S2: Release of *Trichogramma chilonis* beginning from 20 DAE @ 75,000/ha , thrice at 7-10 days interval	1.47
M2S3 : Release of *Trichogramma chilonis* beginning from 20 DAE @ 1,00,00/ha , thrice at 7-10 days interval	1.36
M3S1 : Release of *Trichogramma chilonis* beginning from 25 DAE @ 50,000/ha , thrice at 7-10 days interval	5.72
M3S2 : Release of *Trichogramma chilonis* beginning from 25 DAE @ 75,000/ha ,thrice at 7-10 days interval	4.79
M3S3 : Release of *Trichogramma chilonis* beginning from 25 DAE @ 1,00,00/ha ,thrice at 7-10 days interval	3.12
Control	13.03

2. Evaluation of NBAIR entomopathogenic strains against maize stem borer (ANGRAU-Anakapalle)

The evaluation was carried out on maize variety DH117 with the following treatments.

Treatment details

T1 : Bb -5a @ 5 ml/lt
T2 : Bb -7 @ 5 ml/lt
T3 : Bb-14 @ 5 ml/lt
T4 : Bb -19 @ 5 ml/lt
T5 : Bb-23 @ 5 ml/lt
T6 : Bb-45 @ 5 ml/lt

T7 : Ma -35 @ 5 ml/lt
T8 : Untreated control

Two sprays were imposed at one month after seedling emergence. First spray at 25 days after emergence and second spray at 40 days after emergence. Thirty second instar larvae were released 5 days after first spray. Lowest stem borer damage was recorded in Bb -7 (0.57 % DH) followed by Bb -5a (0.87 % DH) and Bb -19 (1.29 % DH) compared to untreated control (8.53 % DH) **(Table 77)**.

Table 77. Evaluation of NBAIR entomopathogenic strains against maize stem borer

Treatment	Stem borer damage (% DH) at 30 DAE	Stem borer damage (% DH) upto 60 DAE
T1 : Bb -5a @ 5 ml/lt	0.73	0.87
T2 : Bb -7 @ 5 ml/lt	0.28	0.57
T3 : Bb-14 @ 5 ml/lt	0.77	1.34
T4 : Bb -19 @ 5 ml/lt	0.38	0.94
T5 : Bb-23 @ 5 ml/lt	0.5	1.29
T6 : Bb-45 @ 5 ml/lt	0.4	1.8
T7 : Ma -35 @ 5 ml/lt	0.43	1.49
T8: Untreated control	0.46	8.53

PJSTAU-Hyderabad

The yield of the trial was harvested recently during last week of March, 2016. The cobs are being dried for shelling. The outcome of the experiment will be submitted within week after getting yield data recorded.

2.8. Sorghum

1. Field evaluation of NBAII entomopathogenic strains against sorghum stem borer, *Chilo partellus* (Swinhoe) in kharif sorghum (IIMR and UAS-R)

IIMR-Hyderabad

An experiment was conducted at the farm of Indian Institute of Millets Research, Hyderabad, Telangana, during Kharif 2015. The experimental material consisted of sorghum variety C 43 sown on 15.07.2015 for evaluation of entomofungal formulation against spotted stem borer (*Chilo partellus*) in sorghum. Three strains each of *Metarrhizium anisopliae* and *Beauveria bassiana* were evaluated. The trial was laid in randomized block design with eight treatments and three replications. Lab reared *Chilo partellus* neonates were released to each experimental plot using bazooka applicator @ 5-7 larvae/ plant at 20 DAE. Entomofungal formulations received from NBAIR, Bangalore were sprayed at 22, 35 DAE at recommended dose. The carbofuran 3G also applied as one of the treatments. The observations were recorded on plants with deadhearts at 45 DAE, number of exit holes/plant, stem tunneling and seed yield / plot

Deadhearts (%): The deadhearts caused by *C. partellus* at 45 DAE following application of entomofungal formulation indicated that the strain Ma 35, Ma 36, Ma 52, caused significant reduction in deadhearts (9.8, 10.1 11.3%) respectively as compared to control which recorded 20.1% deadhearts. Whorl application of carbofuran @ 8 kg/ha was significantly better (7.7%) over the entomofungal formulations **(Table 78)**.

Stem tunneling (%): The data on stem tunneling caused by *C partellus* indicated that the strain Ma 52, Ma 36 and Ma 35 resulted significant reduction in stem tunneling (10.2, 11.5, 12.6%), respectively as compared to control which recorded 23.5% deadhearts. Carbofuran whorl application @ 8 kg/ha was significantly best (4.9%) and was significantly superior over other treatments.

Exit holes (no/stalk): The data on exit holes/ stalk revealed that formulation Ma 35, Ma 36, Ma 52 recorded significantly less damage (2.5, 2.6, 2.8 exit holes/ stalk) respectively over the control (9.1 exit holes/ stalk) and the damage was on par with carbofuran application (2.0 exit holes/ stalk) indicating their effectiveness **(Table 78)**.

Grain yield (kg/plot): The grains harvested from the experimental plot (19.2 m^2) indicated that the strain Ma 35 and Ma 36 caused significant increase in grain yield (4.16 and 4.25 kg/ plot), respectively as compared to control which recorded 2.85 kg/plot. Carbofuran whorl application @ 8 kg/ha was significantly superior (4.32 kg/plot and was on par with the strain Ma 36 and Ma 35 **(Table 78)**.

Table 78. Efficacy of Entomofungal pathogens against sorghum stem borer

Treatment	DH %	ST %	EHS	GY/Kg plot
(Beauveria bassiana) Bb-23*	14.8 ^{e}	17.3 ^{c}	4.0 ^{b}	3.07 ^{d}
(Beauveria bassiana) Bb-45	15.6 ^{ef}	16.8 ^{c}	4.3 ^{b}	3.69 ^{c}
(Beauveria bassiana) Bb-14	13.2 ^{de}	16.1 ^{c}	4.7 ^{b}	3.82 ^{c}
(Metrahizum anisopliea) Ma-35	9.6 ^{ab}	12.6 ^{b}	2.5 ^{a}	4.16 ^{ab}
(Metrahizum anisopline) Ma-36	10.1 ^{ab}	11.5 ^{b}	2.6 ^{a}	4.25 ^{ab}
(Metrahizum anisopline) Ma-52	11.3 ^{bcd}	10.2 ^{b}	2.8 ^{a}	4.13 ^{b}
Carbofuran 3G#	7.7 ^{a}	4.9 ^{a}	2.0 ^{a}	4.32 ^{a}
Control	20.1 ^{g}	23.5 ^{d}	9.1 ^{c}	2.85 ^{e}

Means followed by same letter are significantly not different (p= 0.05) by LSD
* Entomofungal formulations were sprayed at 22, 35 DAE; # whorl application @ 8 kg/ha at 20 DAE
Dose: 5 ml/lt; Var: C 43; Plot size 19.2 Sqm
DH %- Deadhearts at 45 DAE; ST %- Stem tunneling at maturity; EHS- Exit holes/stalk; GY- Grain yield

UAS-Raichur

The evaluation was carried out on sorghum variety M 35-1 in RBD during rabi 2015 with six treatments and control. The treatments imposed include six NBAII strains of *B. bassiana* (Bb-5a, Bb-7, Bb-14, Bb-23 and Bb-45) and *M. anisoplae* (Ma-35). Two sprays were given @ 1 x 10^8 conidia/g at 25 and 40 days after germination. In each treatment number of dead hearts was counted before spray, 10 days and 20 days after each spray. Post harvest observations were recorded on the length of tunneling, number of exit holes, number of larvae and pupae. Grain and fodder yield were recorded in each treatment and analyzed statistically.

Dead hearts: On 10 days after spray, Bb -7 was recorded minimum dead hearts (7.58/ plot) which was at par with Bb - 23 which recorded 7.88 dead hearts per plot. Untreated control recorded 12.16 per plot dead hearts which was statistically inferior. Similar trend was noticed on 20 days after spray. On second spray also, Bb -7 recorded minimum dead hearts and there was no significant increase in number of dead hearts compared to untreated control which recorded 18.36 dead hearts per plot on ten days after second spray **(Table 79.)**

Post harvest observation: Minimum tunneling of 12.78 cm was noticed in Bb-7 and it was at par with Ma-35 which recorded 15.83 cm tunneling while untreated control recorded the highest tunneling of 64.17 cm. The number of exit holes were low (0.72/ plot) in Bb-7 and it was at par with Ma-35 which recorded 0.83 exit holes per plot while untreated control recorded 2.28 exit holes per plot. Over all the presence of larvae and pupae were negligible in all the treatments. However, Bb-7 recorded minimum population of larvae and pupae compared to untreated control **(Table 80)**.

Yield: The highest grain yield of 10.05 q/ha was recorded in Bb-7 and it was at par with Ma-35 which recorded 9.88 q/ha grain yield. Untreated control recorded 7.46 grain yield. Bb-7 recorded 4.07 t/ha fodder yield and it was followed by Ma-35 which recorded 3.92 t/ha. Untreated control recorded lowest fodder yield of 2.11 t/ha **(Table 80)**.

Table 79. Evaluation of NBAII entomopathogenic strains against sorghum stem borer, *Chilo partellus* (Swinhoe)

Sl. No.	Treatments	Dosage gm/ml/l	Number of dead hearts per plot				
			I Spray			II Spray	
			1DBS	10 DAS	20 DAS	10 DAS	20 DAS
1	*Beauveria bassiana* - 5a (1×10^8 conidia/g)	1.50	7.25 (2.78)	8.14 (2.94)	8.56 (3.01)	8.98 (3.08)	9.04 (3.09)
2	*Beauveria bassiana* - 7 (1×10^8 conidia/g)	1.50	7.44 (2.82)	7.58 (2.84)	7.92 (2.90)	7.92 (2.90)	7.92 (2.90)
3	*Beauveria bassiana* - 14 (1×10^8 conidia/g)	1.50	7.38 (2.81)	8.94 (3.07)	9.06 (3.09)	9.12 (3.10)	9.16 (3.11)
4	*Beauveria bassiana* - 23 (1×10^8 conidia/g)	1.50	6.98 (2.73)	7.88 (2.89)	8.14 (2.94)	8.22 (2.95)	8.26 (2.96)
5	*Beauveria bassiana* - 45 (1×10^8 conidia/g)	1.50	7.02 (2.74)	9.38 (3.14)	10.14 (3.26)	10.96 (3.39)	11.08 (3.40)
6	*Metarhizium anisopliae*-35 (1×10^8 conidia/g)	1.50	7.16 (2.77)	10.02 (3.24)	11.98 (3.53)	12.14 (3.56)	12.36 (3.59)
7	Untreated control	--	7.12 (2.76)	12.16 (3.56)	16.48 (4.12)	18.36 (4.34)	19.84 (4.51)
S Em ±			0.23	0.03	0.02	0.05	0.06
CD (P=0.05)			NS	0.09	0.07	0.16	0.18
CV %			11.10	14.02	10.02	11.72	13.97

DBS: Day before spray DAS: Day after spray

* Figures in parentheses are square root transformed values

Table 80. Effect of NBAII entomopathogenic strains on the sorghum stem borer damage caused by sorghum stem borer (stem tunnelling, exit holes and yield)

Sl. No.	Treatments	Dosage gm/ml/l	TLM	NEH	No. of larvae	No. of pupae	Seed yield (q/ha)	Fodder yield (t/ha)
1	*Beauveria bassiana* - 5a (1×10^8 conidia/g)	1.50	30.00 (5.52)	1.15 (1.26)	0.17 (0.82)	0.06 (0.75)	8.96	3.64
2	*Beauveria bassiana* - 7 (1×10^8 conidia/g)	1.50	12.78 (3.64)	0.72 (1.10)	0.00 (0.71)	0.00 (0.71)	10.05	4.07
3	*Beauveria bassiana* - 14 (1×10^8 conidia/g)	1.50	25.00 (5.05)	1.00 (1.22)	0.05 (0.74)	0.05 (0.74)	8.89	3.40
4	*Beauveria bassiana* - 23 (1×10^8 conidia/g)	1.50	24.04 (4.95)	0.83 (1.15)	0.04 (0.77)	0.01 (0.74)	9.33	3.87
5	*Beauveria bassiana* - 45 (1×10^8 conidia/g)	1.50	28.55 (5.39)	1.10 (1.22)	0.16 (0.81)	0.05 (0.78)	8.89	2.37
6	*Metarhizium anisopliae*-35(1×10^8 conidia/g)	1.50	15.83 (4.04)	0.83 (1.15)	0.04 (0.73)	0.01 (0.71)	9.88	3.92
7	Untreated control	--	64.17 (8.04)	2.28 (1.66)	0.22 (0.84)	0.11 (0.78)	7.46	2.11
S Em ±			0.49	0.07	0.03	0.02	0.29	0.09
CD (P=0.05)			1.43	0.22	0.10	0.07	0.91	0.28
CV %			12.34	11.30	13.21	12.32	11.10	14.14

DBS: Day before spray DAS: Day after spray

* Figures in parentheses are square root transformed values

2.9. Pulses

1. Demonstration of NBAIR liquid formulation (PDBC BT1 AND NBAII BTG4) against pigeon pea pod borer (*Helicoverpa armigera*) (AAU and UAS-R)

AAU-Anand

Three farmers were selected for large scale demonstration at village Dhavat in Taluka. Karjan for management of *H. armigera* in pigeon pea using PDBC-BT1 and NBAII BTG4 at 2%. Lower incidence of *H. armigera* larvae (0.52-0.56/ plant) with pod damage (6.79-7.60%) and grain damage (8-10%) was noticed in the treatment with NBAIR liquid formulation as against farmer's practices.

UAS-Raichur

Large scale demonstration of NBAII BTG 4 *Bt* was done in a Kurdi village of Raichur taluka over an area of 5 ha. Totally ten farmers were selected to demonstrate the effectiveness of NBAII BTG 4 *Bt* in comparison with farmers practice. The results indicated that NBAII BTG 4 *Bt* recorded 12.18% damage compared to farmers practice which recorded 8.34% pod damage. Similarly the grain damage was 1.98 was noticed in NBAII BTG 4 *Bt* compared to farmers practice (chemical treatment) which recorded 9.94 q/ha grain yield **(Table 81)**.

Table 81. Performance of NBAII BTG 4 *Bt* in comparison with farmers practice at Kurdi village, Raichur

Sl. No.	Particulars	% Pod damage	% Seed damage	Grain Yield (q/ha)
1.	NBAII BTG 4 *Bt*	12.18	1.98	8.06
2.	Farmers Practice	8.34	1.31	9.94
T test		0.12*	0.23*	0.08*

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

The experiment was conducted on moong bean (variety PAU 911) sown at Entomological Research Farm, Punjab Agricultural University, Ludhiana in a plot size of 20 sq m in Randomized block design during 2015. There were twelve treatments with three replications. Among these treatments were four formulations of *Bacillus thuringiensis* at different doses Bt1 (1%), Bt 1 (2%), NBAII BT G4 (1%), NBAII Bt G4 (2%), Delfin @ 1 Kg/ha, Delfin @ 2 Kg/ha, PAU Bt @ 1 Kg/ha, PAU *Bt* @ 2 Kg/ha, one formulation of *Beauveria bassiana* (Mycojal) (@ 1.5 Kg/ha and 2 Kg/ha), chemical control (chlorpyriphos 20 EC 1.5 l/acre) and untreated control. Three sprays of bioagents were given at ten days interval and two sprays of chlorpyriphos 20 EC was applied at fifteen days interval.

Per cent pod damage was recorded per month and yield was recorded on whole plot basis. During the month of September and first fortnight of October per cent pod damage was non-significant in all the treatments. During second fortnight of October, lowest percent pod

damage (11.23%) was recorded in chemical control and was at par with PDBC *Bt1* (2%), NBAII *Bt* G4 (1% and 2%) and Delfin (@ 1 and 2 Kg/ha) which recorded 13.43, 12.22, 11.80, 13.92 and 12.05 per cent, respectively **(Table 82)**. Highest per cent pod damage (21.73%) was recorded in untreated control. Highest yield (3.81 q/ac) was recorded in chemical control and was at par with both doses of Delfin and NBAII *Bt* G4 and at higher dose of PDBC Bt1 (2%). However, lowest yield (2.51 q/ac) was recorded in untreated control.

Table 82. Evaluation of microbial agents for the management of lepidopteran pests on Moong bean

Sl. No	Treatment	Percent pod damage			Yield (q/acre)
		After First Spray	After Second Spray	After Third Spray	
1	PDBC *Bt1* (1%)	10.91 (18.71)	13.66 (21.59)	14.10^{b} (22.00)	3.17^{b}
2	PDBC *Bt1* (2%)	10.31 (18.67)	13.46 (21.38)	13.43^{a} (21.48)	3.56^{a}
3	NBAII *Bt* G4 (1%)	13.86 (21.79)	13.93 (21.86)	12.22^{a} (20.43)	3.52^{a}
4	NBAII *Bt* G4 (2%)	12.88 (20.91)	11.93 (20.16)	11.80^{a} (20.08)	3.58^{a}
5	PAU *Bt* @ 1 Kg/ha	12.01 (19.78)	11.39 (19.67)	15.76^{b} (23.37)	3.06^{b}
6	PAU *Bt* @ 2 Kg/ha	12.48 (20.44)	10.56 (18.90)	14.65^{b} (22.42)	3.16^{b}
7	Delfin @ 1 Kg/ha	10.29 (18.51)	12.76 (20.81)	13.92^{a} (21.87)	3.61^{a}
8	Delfin @ 2 Kg/ha	11.54 (19.73)	12.43 (20.62)	12.05^{a} (20.26)	3.73^{a}
9	*Beauveria bassiana* (1.5 Kg/ha)	11.85 (!9.91)	16.08 (23.57)	19.16^{cd} (25.88)	2.52^{c}
10	*Beauveria bassiana* (2.0 Kg/ha)	11.43 (19.58)	15.30 (23.01)	18.13^{c} (25.16)	2.53^{c}
11	Chlorpyriphos 20 EC @ 1.5 l/acre	11.71 (19.59)	10.96 (19.21)	11.23^{a} (19.56)	3.81^{a}
12	Control	13.56 (21.57)	17.43 (24.62)	21.73^{d} (27.73)	2.51^{c}
	C D (0.05)	NS	NS	2.38	0.25
	CV	19.26	10.17	6.25	4.71

3. Evaluation of IPM Modules of Green gram (MPUAT)

The BIPM practice was found to be superior over control. The yield obtained was 8.58 q/ha compared 6.48 q/ha in untreated control.

4. Evaluation of biocontrol agents against pod borers of cowpea (KAU)

Design: RBD
Variety: Lola
Treatments: 6
Replications: 3

Treatment details

T1: Three sprays of *Beauveria bassiana* (1 x 10^8 spores/ ml) @ 5g/l at 7 days interval
T2: Three sprays of *Beauveria* bassiana (1 x 10^8 spores/ ml) @ 5g/l at 15 days interval
T3: Three sprays of *Bacillus thuringiensis* NBAIR formulation @ 1 kg/ha at 7 days interval
T4: Three sprays of *B. thuringiensis* NBAIR formulation @ 1 kg/ha at 15 days interval
T5: Quinalphos 25 EC @ 250 g a.i/ha
T6: Control

The experiment was laid out at College of Horticulture, Vellanikkara. However, the infestation was very low as the crop suffered collar rot immediately after the first round of spray and the experiment was discontinued. The experiment need to be repeated.

2.10. Oil seeds

Biological suppression of mustard aphid, *Lipaphis erysimi* (MPKV)

Mustard trial was conducted on Research farm of College of Agriculture, Pune on the variety- Sita. The Experiment trial was conducted but there was no incidence of mustard aphid, *Lipaphis erysimi* observed on Mustard.

2.11. Coconut

Bio-suppression of red palm weevil through entomopathogenic nematodes (CPCRI)

Filter-paper delivery technique using a botanical cake was developed by ICAR-CPCRI in order to dispense the chemical, imidacloprid with the *H. indica* infected *G. mellonella* cadavers. Prophylactic delivery of filter paper sachets containing 10 *Heterorhabditis indica* infected *G. mellonella* cadavers in combination with tablet-shape botanical cake on the leaf axils reduced 35-85% rhinoceros beetle attack and safeguarded palms from red palm weevil invasion during monsoon period. This field delivery of filter paper sachets containing botanical cake and *H. indica* infected *G. mellonella* cadavers will be further refined for sustainable pest management.

Entomopathogenic nematode belonging to *Heterorhabditis indica* was found effective in the bio-suppression of red palm weevil grubs in synergy with imidacloprid. Placement of three filter paper sachets containing 12-15 *H. indica* infected *G. mellonella* cadavers on the leaf axils after application of 0.002% imidacloprid could recover 60% of infested palms.

2.12. Tropical Fruits

1. Field evaluation of *Metarhizium anisopliae* formulations against mango hoppers (KAU and TNAU)

KAU-Thrissur

Different formulations of *M. anisopliae* along with chemical and botanical insecticides were evaluated against mango hoppers. The details of experiment are as follows.

Location : **Instructional farm, Madakkathara**
Season : **January – March, 2016**
Design : **RBD**
Cultivar : **Kalapady**
Treatments : **6**
Replications : **5**

Treatment details

T1: *Metarhizium anisopliae* oil formulation @ 1 ml/2l
T2: *M. anisopliae* liquid formulation @ 1 ml/2l
T3: *M. anisopliae* talc formulation @ 10 g/l
T4: Chemical insecticides- Imidacloprid @ 0.3 ml/l
T5: Botanical insecticides - Nimbicidine @ 0.3%
T6: Control

The treatments were applied twice at fortnightly intervals. The hoppers population in each treatment was recorded before and after treatment at five and ten days interval. The results are presented in **Table 83**.

Table 83. Effect of *Metarhizium anisopliae* formulations against mango hoppers

Treatments	Mean number of hoppers per panicle		
	Pre-treatment	Post treatment count	
		5 DAT	10 DAT
M. anisopliae oil formulation @ 1 ml/2l	11.17 (3.40)	31.50 (5.38)	2.17 (1.55)
M. anisopliae liquid formulation @ 1 ml/2l	18.33 (4.32)	11.00 (3.19)	1.50 (1.31)
M. anisopliae talc formulation @ 10 g/l	19.17 (4.37)	39.17 (6.06)	10.67 (3.14)
Imidacloprid @ 0.3ml/l	10.80 (3.36)	0.833 (0.09)	0.67 (0.94)
Nimbicidine @ 0.3 %	25.50 (4.95)	37.00 (6.03)	1.33 (1.17)
Control	26.17 (5.12)	7.00 (2.72)	0.50 (0.94)
CD at 5%	0.85	1.53	0.91

Figures in parenthesis are sinearc transformed values

The results were inconclusive owing to the low post treatment hopper populations in untreated control. In case of inflorescence, that received no treatments, the panicles were totally bare and were covered with sooty mould typical of hopper infestation. The insects having migrated to other inflorescences or trees could be the reason for low population levels in untreated control. This discrepancy apart, spraying with Imidacloprid @ 0.3 ml/l recorded the lowest mean hopper population both at fifth and tenth day after treatment. Among the different formulations of *M. anisopliae*, the liquid formulation registered the lowest hopper count. The hopper population was negligible in all treatments after the second spray, with four out of five treatments recording zero values.

TNAU-Coimbatore

Treatment details

T1- Liquid formulation 1 ml/2 L
T2- Oil formulation 1 ml/2 L
T3- Talc formulation 1 kg/100 L
T4- Neem oil @ 1%
T5- Untreated check
T6- Imidacloprid 17.8 SL @ 0.4 ml/L

Replications	: Five
Location of the field trial	: ARS, Bhavanisagar, TNAU
Cultivar	: Salem Bengalura
Date of spraying	: 1.3.2016, 10.3.2016 & 21.3.2016

Field evaluation of *Metarhizium anisopliae* against mango hoppers was carried out with IIHR formulations during February to March 2016 at Agricultural Research Station, Bhavanisagar. Three different formulations *viz*., liquid, oil and talc formulations of *Metarhizium anisopliae* were evaluated in comparison with neemoil 1% and insecticide (Imidacloprid 17.8 % SL @ 0.4 ml /l of water) treatment. Three rounds of spray were given to mango trees after the initiation of inflorescence and incidence of hoppers. The initial population of hoppers in mango inflorescence in different treatments ranged between 5 and 7 hoppers/inflorescence. Three rounds of treatments were imposed at 10 days interval with the help of tree sprayer. The hopper population was assessed at 7 days after each round of spray indicated that the liquid formulation of *M. anisopliae* @ 1 ml/2L was more efficacious than talc and oil formulations. The population reduction achieved in imidacloprid spray was maximum as compared to all other treatments. Maximum fruit set of 3.2 / inflorescence was recorded in liquid formulation of *M. anisopliae* treatment **(Table 84)** whereas the least fruitset of 1.6 / inflorescence was noted in untreated check. Though superior performance in checking the hopper population was noted in imidacloprid treatment, the fruit set of 2.5 /inflorescence was comparable with *M. anisopliae* liquid formulation. The *M. anisopliae* spray recorded a fruit set of 2.3 to 3.2 fruits / inflorescence in different formulations tested. The order of efficacy among the different formulations of *M. anisopliae* in checking the hopper population was liquid formulation > talc formulation > oil formulation.

Table 84. Field evaluation of *Metarhizium anisopliae* formulations (IIHR) against mango hoppers

Treatments	Pre-treatment count of hoppers/ inflorescence	Mango hopper population /inflorescence, 7 days after each spray			Per cent reduction over control	Fruit set / Inflorescence
		I	II	III		
Liquid formulation @ 1 ml/2L	5.4[a]	2.8[b]	2.0[b]	1.3[b]	89.21	3.2
Oil formulation @ 1 ml/2L	5.9[a]	4.6[c]	3.9[c]	3.0[c]	77.22	2.3
Talc based formulation @ 10 g/L	7.2[a]	4.8[c]	3.6[c]	2.7[c]	83.20	2.5
Neem oil @ 1%	6.4[a]	5.2[c]	3.7[c]	3.0[c]	79.00	2.3
Imidacloprid @ 0.3 ml/L	6.8[a]	0.4[a]	0.0[a]	0.0[a]	100.00	2.5
Untreated check	5.6[a]	7.5[d]	9.2 [d]	12.5 [d]	-	1.6

Means followed by a common letter(s) are not significantly different by DMRT (P = 0.05)

2. Survey, collection, Identification and Mass culturing of Trichogrammatids and Entomopathogenic nematodes from mango ecosystem in Uttar Pradesh and Uttarakhand for evaluation against mango leaf webber, *Orthaga euadrusalis* (CISH)

During the year 2015-16 five species of Coccinellids *viz., Coccinella septempunctata, Cheilomenes sexmaculata, Serangium parcesetosum, Chilocorus rubidus, Scymnus sp.* has been observed feeding on mango hoppers and mealybugs. Most abundant predator was *Coccinella septempunctata* followed by *Cheilomenes sexmaculata.* Natural infestation of entomapathogenic fungi *Beverria bassiana* was observed on guava bark eating caterpillar, *Inderbela quadrinotata* and infested cadavers were collected from 8 locations and pure culture of the *B.bassiana* is being maintained **(Table 85)**. Entomopathogenic fungi *Beverria bassiana* infesting mango mealybug was collected from the experimental farm of CISH, Rehmankhera. The strain named CISH-MMB-Bb1 was isolated and pure culture is being maintained. Entomopathogenic fungi infesting mango hopper was collected from Ranchi and Malda. The identities of the fungi isolated are yet to be ascertained. Four parasitoids belongs to family Ichneomonidae, Braconidae were collected from the mango and guava ecosystem.

Table 85. Entomopathogenic fungi *Beverria bassiana* infesting guava bark eating caterpillar, *Inderbela* sp. from different locations in Uttar Pradesh.

Sl. No.	Location	Strain Name
1	Rehmankhera(Lucknow)	CISH-BEC-1
2	*Sukhrakhera (Unnoa)*	*CISH-BEC-2* *CISH-BEC-3*
3	*Asaravekela (Allahabad)*	*CISH-BEC-5* *CISH-BEC-6*
4	*Hingopur (Kanpur)*	*CISH-BEC-7*
5	*Tikanpur (Kanpur)*	*CISH-BEC-8*
6	*Koulaha (Kausambhi)*	*CISH-BEC-9*
7	*Bheta (Kausambhi)*	*CISH-BEC-10*
8	*Bamrauli (Allahabad)*	*CISH-BEC-11*

3. Monitor and record of incidence of papaya mealybug and its natural enemies on papaya and other alternate host (AAU, MPKV, KAU, TNAU and NBAIR)

AAU-Anand

Survey was made in 5 randomly selected villages in each district of middle Gujarat region to determine the infestation of papaya mealybug, *P. marginatus*. Farmers' fields were visited at fortnightly interval. Percentage of plants infested with mealybug was assessed by observing 25 randomly selected plants and intensity of damage (grade in the scale of 1-5) was determined.

Grade	Population
0	No infestation (0%)
1	very low (1-5%)
2	low (6-10%)
3	medium (11-30%)
4	high (31-80%)
5	very high (>80%)

Survey for ascertaining the outbreak of mealybug was carried out in agriculture campus as well as in farmers' fields in Anand and Kheda district during entire year. Only stray incidence has been reported in campus and in few farmers's fields. The samples of mealybug infested papaya fruits were brought to the laboratory and were reared on sprouted potato. The parasitoid *viz*., *Acerophagus papayae* was noticed parasitizing mealybug in laboratory condition **(Table 86)**.

Table 86. Survey and monitoring of papaya mealybug, *Paracoccus marginatus*

Sl. No.	Date of survey	Name and full address of the farmer	Crop plants infested.	Non hosts crop and weeds infested	Chemical pesticides if any used with dose	Existing natural enemies in 25 randomly selected plants	Grade
1	21.09.15	Mahendrabhai Patel Por Ta-Vadodara, Dist- Vadodara	Papaya	-	Profenophos 50 EC @ 20 ml/ 10 L water	No	2
2	21.09.15	Gunvant Ramjibhai Patel Karena Ta-Amod, Dist-Bharuch	Papaya	-	-	*A. papayae*	1
3	21.09.15	Akshay Muljibhai Patel Adas Ta- Anand Dist- Anand	Papaya	-	-	*A. papayae*	1
4	21.09.15	Manusinh K. Mahida Alarsa Ta- Borsad Dist- Anand	Papaya	-	-	*A. papayae*	2
5	21.09.15	Radheshambhai Gosai Alarsa Ta- Borsad Dist- Anand	Papaya	-	Chloropyriphos 20 EC @ 20 ml/ L water	No	2
6	30.09.15	Mahendrabhai Patel Vaghasi Ta- Anand Dist- Anand	Papaya	-	Profenophos 50 EC @ 20 ml/ 10 L water	No	2
7	30.09.15	Hasmukhbhai Patel Vaghasi Ta- Anand Dist- Anand	Papaya	-	Profenophos 50 EC @ 20 ml/ 10 L water	No	2
8	30.09.15	Sureshbhai Patel Sandesar Ta- Anand Dist- Anand	Papaya	-	-	*A. papayae*	1
9	30.09.15	Jigneshbhai Ambalal Patel Sihol Ta- Petlad Dist- Anand	Papaya	-	Profenophos 50 EC @ 20 ml/ 10 L water	No	2

MPKV-Pune

The papaya orchards were surveyed for the incidence of Papaya mealybug (PMB) in various agro-ecological zones of western Maharashtra and recorded its associated natural enemies as well as alternate hosts. The intensity rating of mealybug was recorded in 1-5 scale (1= very low; 2=low; 3=medium; 4=high; 5= very high population) from 5 plants/ orchard. Besides, the natural enemies in mealybug colonies and alternate hosts of PMB in the vicinity of papaya orchards were also recorded.

The data presented in **Table 87** revealed that the incidence of (PMB) was noticed to the extent of 1.0 to 13.3% in all districts of western Maharashtra. The highest incidence of PMB was recorded in Sahada and Taloda tahsils of Nandurbar district. Shirpur and Sakri in tahsils of Dhule district and Chopada and Yawal tahsils of Jalgaon district were also recorded PMB infested orchards. Overall this year incidence is low as compared to previous year. However, PMB incidence was recorded along with *Acerophagus papayae* and *Pseudleptomastix mexicana.*The average pest population density was relatively low during this year (3.97% incidence).

Table 87. Survey and record of papaya mealybugs in western Maharashtra

Districts surveyed	PMB incidence (%)	Pest intensity rating	*A. papayae* population /leaf
Pune	2.0	1.0	1.2
Ahmednagar	1.3	1.0	1.0
Jalgaon	6.3	1.0	3.4
Dhule	10.6	1.0	5.8
Nandurbar	13.3	1.0	6.2
Nashik	1.0	1.0	0.8
Solapur	1.6	1.0	1.2
Kolhapur	1.3	1.0	0.8
Satara	1.0	1.0	0.6
Sangli	1.3	1.0	1.2
Average	**3.97**	1.0	**2.22**
Range	**1.0 – 13.3**	**1.0**	**0.6 – 6.2**

Natural enemies recorded in the papaya mealybug colonies

i. Encyrtid parasitoid, *Acerophagus papayae* N. & S.
ii. *Pseudleptomastix mexicana* N. & S.
iii. *Spalgius epius* (Westwood)
iv. *Coccinella septempunctata* (Linn).
v. *Scymnus nubilus* (Mulsant)
vi. *Monochilus sexmaculatus* (F)
vii. *Illeis cincta* (Fabricius)
viii. *Berginus maindroni* (Grouvelle)
ix. *Hyperaspis maindroni* (Sicard)
x. *Cybocephalus* sp.
xi. *Phrynocaria perrotteti* (Mulsant)
xii. Anthocorids

xiii. *Mallada* sp.
xiv. *Brumoides* sp.
xv. Syrphids
xvi. Spiders

Alternate hosts of papaya mealybug in Maharashtra

During the survey, the mealybug stages were observed on following weeds as well as other plants as alternate hosts in the vicinity of papaya orchards.

1. Parthenium (*Parthenium hysterophorus* L.)
2. Safed chafa (*Plumeria alba*)
3. Mulberry (*Morus alba*)

KAU

Random surveys were carried out in different districts of Kerala. The papaya mealybug incidence was low in all areas. Survey showed that the parasitoid established very well in Kerala. Stray incidences of PMB infestations were observed in two locations in Thrissur district. However, the population was very low and the parasitoid was observed at both the locations.

TNAU

Survey was conducted in eight districts of Tamil Nadu *viz*., Coimbatore, Erode, Tiruppur, Salem, Dingigul, Ariyalur, Tiruchi and Kanyakumari during the period under report. The survey on the occurrence of PMB was carried out for twelve months from April 2015 to March 2016. The incidence was noticed in the month of April 2015 which escalated to a maximum of 8.6% **(Table 88)** in August 2015 (Erode) followed 7.4% in September 2015 (Erode). The occurrence of mealybug was absent in November and December 2015. Among the eight districts surveyed, maximum incidence and prevalence was noted in Erode district followed by Tirupur and Coimbatore

In all the districts, the natural enemies such as, *Acerophagus papayee*, *Anagyrus lockii*, *Cryptolaemus* and *Spalgis* were observed. The population of these parasitoids and predators were present almost throughout the year. The association of *Acerophagus papayee, Anagyrus lockii* and *Cryptolaemus* with PMB was more and these natural enemies were more prevalent during the months of August and September where the population of mealybug was also high. The spatial and temporal distribution of parasitoids, *Acerophagus papayee, Anagyrus sp.* and predator, *Cryptolaemus* coincided with the population of mealybug. This might be reason for effective containment of the mealybug in subsequent months of observation where in the mealybug population was absent in November and December 2015.

Table 88. Incidence of papaya mealybug and its natural enemies on papaya during 2015-16

Districts / no. of villages	Observation recorded	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan' 16	Feb' 16	Mar' 16
Coimbatore	Per cent incidence	2.4	3.2	1.4	2.8	5.3	4.8	2.5	0	0	0	1.3	2.8
	Natural enemy population / 5 leaves	4	6	0	5	9	11	3	0	0	0	0	3
Tirupur	Per cent incidence	1.3	3.6	2.3	1.6	4.8	7.3	3.2	0	0	1.8	2.5	2.8
	Natural enemy population / 5 leaves	2	2	5	1	8	12	4	0	0	0	3	5
Erode	Per cent incidence	3.2	3.8	2.6	5.3	8.6	7.4	3.1	0	0	0	1.8	2.5
	Natural enemy population / 5 leaves	4	6	2	3	12	14	5	0	0	0	0	4
Salem	Per cent incidence	0	0	0	0	3.4	0	0	0	0	1.3	0	0
	Natural enemy population / 5 leaves	0	0	0	0	2	0	0	0	0	2	0	0
Dindigul	Per cent incidence	0	2.4	0	0	1.5	0	1.8	0	0	0	0	0
	Natural enemy population / 5 leaves	0	1	0	0	1	0	1	0	0	0	0	0
Ariyalur	Per cent incidence	3.2	0	0	1.6	0	0	0	0	0	0	0	0
	Natural enemy population / 5 leaves	2	0	0	2	0	0	0	0	0	0	0	0
Kanyakumari	Per cent incidence	0	0	0	0	0	2.3	0	0	0	0	0	0
	Natural enemy population / 5 leaves	0	0	0	0	0	2	0	0	0	0	0	0
Trichy	Per cent incidence	0	0	0	3.4	0	0	0	0	0	0	0	0
	Natural enemy population / 5 leaves	0	0	0	0	0	0	0	0	0	0	0	0

NBAIR

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

Table 89. Incidence of papaya mealy bug and its natural enemies on papaya and other alternate hosts

Location	Area of plantation(ha)	No of plants with Papaya mealybug	damage
Mandya	8.00	12	Trace
Raichur	1.50	2	Trace
Shimoga	0.50	Nil	
Hassan	1.50	Nil	
Gulbarga	0.50	Nil	
Bangalore	0.5	2	Trace
Maddur	2.75	Nil	
Ramnagar	0.50	7	Severe in one
Chamrajnagar	5.50	2	Trace
Chitradurga	0.50	Nil	
Tumkur	1.00	Nil	
Nelamangala	2.00	2	Trace
Coimbatore	0.50	2	Trace
Nashik	1.25	Nil	
Nagpur	0.50	Nil	
Hosur	2.50	7	Severe in 2 trees
Andaman Islands	0.50	15	Severe

Parasitization: A high level of parasitization was recorded in all the samples collected. *Acerophagus papayae* was the predominant parasitod exercising control; in addition *Pseudleptomastix mexicana* was recorded in all the samples with parasitization ranging from 5-20%. None of the samples recorded from any area was free from parasites showing the wide spread of the parasitoids and their survival in Indian conditions

Hyper parasitization: Parasitization of Acerophagus papayae by hyper parasitoids is increasing in Karnataka. The samples collected from Nelamangala, Chamarajnagar, and Maddur had 6-7% hyperparasitization by *Chartocerus sp*. and 2-3% by *Marietta leopardina*.

Supply of host insects and natural enemies: *Acerophagus papayae* and *Pseudleptomastix mexicana* cultures were sent to OUAT Bhuvaneshwar, Andaman Islands, Hosur, Madhurai, New Delhi, Gujarat, Pondicherry, Ananthpur, in addition to local supplies in Karnataka. Cultures of *Aenasius arizonensis*, Zygogramma bicolorata and *Neochetina* sp. were sent to the requested researchers and organizations.

4. Bio-efficacy of EPNs against citrus trunk borer, *Pseudonemophas (=Anoplophora) versteegi* (CAU)

Bio-efficacy of EPNs against citrus trunk borer, *Pseudonemophas versteegi* was carried out at two locations *viz.* Pasighat and Rengging of Arunachal Pradesh. Fourteen treatments *i.e.*, treatments with EPN strains CAU-1, CAU-2, CAU-3, CAUH-1, CAUH-2 and NBAII-1 as stem injection @ 50 IJs/ml of water and as cadaver application (wrapping two cadaver by muslin cloth and binding at one meter height from the ground level) separately, a check (stem injection with dichlorvos 0.05%) and an untreated control were maintained. In each location, three orchards were selected to serve as three replications per treatments. For each treatment, ten infested plants were selected (140 infested plants/ orchard) and the numbers of holes with fresh frass materials were counted before applications of the treatments. The treatments were applied in two months, one during the last week of April and the second application at second week of May. The efficacy of the treatments were recorded at monthly interval starting from 2nd fortnight of May upto 2nd fortnight of August (4 observations) by checking the presence of fresh frass materials at the holes. Among the four observations, the highest numbers of holes with fresh frass material were considered as the population of trunk borer after application of the treatments. In both the locations, all the treatments recorded a significant reduction in the trunk borer infestation than the untreated control. Stem injection with Dichlorvos gave the highest reduction of 82.06 and 76.30% at Pasighat and Rengging, respectively. Among the EPN treatments, CAU-1 stem injection (38.00% reduction) was observed as the best treatment and it was closely followed by CAUH-1 stem injection (32.50% reduction), NBAII-01 stem injection (31.69% reduction) and CAUH-2 stem injection (29.06% reduction) at Pasighat. However, at Rengging, CAUH-1 stem injection gave the highest reduction in trunk borer infestation among the EPNs with 34.22% reduction and followed by CAU-1 stem injection (33.45% reduction), NBAII-01 stem injection (33.17% reduction) and CAUH-2 stem injection (31.20% reduction) **(Table 90)**. The stem injections of the EPNs were found more effective than their respective cadaver treatments.

Table 90. Bio-efficacy of entomopathogenic nematodes against citrus trunk borer applied as stem injection and cadaver against *Pseudonemaphas versteegi* in *Citrus reticulata*

Treatments	Pasighat (average of three orchard)			Rengging (average of three orchard)		
	Trunk borer/10 plants before treatment	Trunk borer/10 plants after treatment	Per cent reduction after treatment	Trunk borer/10 plants before treatment	Trunk borer/10 plants after treatment	Per cent reduction after treatment
CAU-1 Stem injection	12.90 (21.05)	8.00 (16.43)	38.00 (38.06)	12.30 (20.53)	8.20 (16.64)	33.45 (35.34)
CAU-2 Stem injection	10.43 (18.84)	7.60 (16.00)	27.20 (31.44)	12.32 (20.55)	8.98 (17.44)	29.30 (32.77)
CAU-3 Stem injection	11.21 (19.56)	8.19 (16.63)	26.96 (31.28)	9.70 (18.15)	6.79 (15.10)	30.02 (33.22)
CAUH-1 Stem injection	10.22 (18.64)	6.90 (15.23)	32.50 (34.76)	12.92 (21.07)	8.50 (16.95)	34.22 (35.80)
CAUH-2 Stem injection	10.84 (19.22)	7.69 (16.10)	29.06 (32.62)	10.40 (18.81)	7.16 (15.52)	31.20 (33.96)
CAU-1 Cadaver application	7.60 (16.00)	7.35 (15.73)	23.50 (29.00)	10.25 (18.67)	8.63 (17.08)	15.85 (23.46)
CAU-2 Cadaver application	11.30 (19.64)	8.90 (17.36)	21.30 (27.49)	11.28 (19.62)	8.76 (17.22)	22.36 (28.22)
CAU-3 Cadaver application	11.04 (19.41)	8.13 (16.57)	19.70 (26.35)	11.95 (20.22)	9.90 (18.34)	17.16 (24.47)
CAUH-1 Cadaver application	11.86 (20.14)	8.98 (17.44)	24.30 (29.53)	12.12 (20.37)	9.23 (17.69)	23.89 (29.26)
CAUH-2 Cadaver application	13.15 (21.26)	10.01 (18.44)	23.89 (29.26)	12.11 (20.36)	8.90 (17.36)	26.86 (31.22)
NBAII-01 Stem injection	10.97 (19.34)	7.50 (15.89)	31.69 (34.26)	11.97 (20.24)	8.00 (18.43)	33.17 (35.17)
NBAII-01 Cadaver application	10.94 (19.31)	8.30 (16.74)	24.16 (29.44)	12.06 (20.32)	9.98 (18.42)	17.26 (24.55)
Dichlorvos Stem injection	31.07 (33.88)	5.50 (13.56)	82.06 (64.94)	28.22 (32.09)	6.69 (14.99)	76.30 (60.87)
Untreated control	8.73 (17.19)	9.23 (17.69)	6.89 (15.22)	11.02 (19.39)	10.23 (18.65)	7.20 (15.56)
SE(m)±	0.56	1.27	0.77	0.34	0.36	0.34
CD 0.05	1.66	3.78	2.31	1.02	1.08	1.03

CV%	4.79	13.50	4.15	2.86	3.73	1.90

Figures in the parentheses are angular transformed values.

5. Field evaluation of Entomopathogens against banana pseudostem weevil, *Odoiporus longicollis* (KAU)

Design : RBD
Treatments : 6
Replication : 4 (4 plants /replication)

The treatments were as follows:

T1: *Metarhizium anisopliae* (10^8 spores/ ml) - leaf axil filling
T2: *M. anisopliae* (10^8 spores/ ml) – spraying
T3: *Beauveria bassiana* (10^8 spores/ ml) - leaf axil filling
T4: *B. bassiana* (10^8 spores/ ml) – spraying
T5: Chlorpyriphos spraying @ 2.5 ml/l
T6: Control

Field evaluation of two entomopathogenic fungi, namely, *Metarhizium anisopliae* and *Beauveria bassiana* for the management of the banana pseudostem borer *Odoiporus longicollis* was carried out from June 2015 to December 2016 in a farmer's field at Perumbavoor in Ernakulam District. Treatments were applied from fifth month onwards at monthly interval either through spaying on the pseudostem or through leaf axil filling. Destructive sampling was done at the time of bunch harvest to record the pest incidence. The results are presented in **Table 91**.

Table 91. Effect of entomopathogenic fungi on infestation by banana pseudostem borer

Sl. No.	Treatment	Mean infestation (%)	Mean Yield (Kg/plant)
1	*Metarhizium anisopliae* (10^8 spores/ ml) - leaf axil filling	0	12.5
2	*M. anisopliae* (10^8 spores/ ml) – spraying	0	12.8
3	*Beauveria bassiana* (10^8 spores/ ml) – leaf axil filling	0	13.2
4	*B. bassiana* (10^8 spores/ ml) – spraying	0	12.9
5	Chlorpyriphos leaf axil filling @ 2.5 ml/l	0	13.4
6	Chlorpyriphos spraying @ 2.5 ml/l	0	12.6
7	Control	2.5	12.6

As the results show, the infestation of the weevil was low even in control (2.5%). In all the treatments, banana pseudostem infestation was nil.

6. Field evaluation of entomopathogens against pineapple mealybug, *Dysmicoccus brevipes* (KAU)

Design : RBD
Treatments : 5

Replications : 15 (1 plant/replication)
Location: Pineapple Research Station, Vellanikkara

The experiment was carried out in Pineapple Research Station of Kerala Agricultural University, Vellanikkara during December, 2015. The treatments were applied twice at fifteen days interval by spraying as well as drenching the root zone with relevant treatment. Observations were recorded at weekly intervals by uprooting three plants at random from each treatment and counting the mealybug population. The results are presented in **Table 92**.

Table 92. Field evaluation of *Lecanicillium lecanii* against mealybug *Dysmicoccus brevipes*

Treatments	Count of mealybug / plant					
	Precount	**7 DAT**	**14 DAT**	**7 DAT**	**14 DAT**	**21 DAT**
L. lecanii @ 10^7 spores/ml	52.00 (6.85)	22.00 (4.30)	87.33 (8.97)	62.00 (7.71)	59.67 (7.30)	15.67 (3.33)
L. lecanii @ 10^8 spores/ml	55.67 (7.24)	36.67 (5.68)	54.00 (6.91)	3.67 (2.04)	8.67 (2.83)	12.67 (3.36)
L. lecanii @ 10^9 spores/ml	72.33 (8.06)	30.00 (5.37)	18.00 (3.56)	41.00 (5.82)	4.67 (1.94)	28.67 (4.08)
Imidacloprid @ 0.3 ml/l	99.67 (8.97)	87.67 (7.12)	3.0 (1.86)	0.33 (0.88)	1.00 (1.17)	0.33 (0.88)
Control	74.33 (8.14)	10.33 (3.20)	58.33 (6.89)	27.00 (5.07)	19.00 (4.21)	38.33 (5.75)
CD at 5%	NS	NS	5.66	3.32	3.61	NS

Figures in parenthesis are transformed values. DAT- Days After Treatment

There was no significant variation in the mealybug population at seven days after treatment. Fourteen days after treatment, the lowest mean population of 3.0 bugs/plant was recorded in case of plants treated with imidacloprid @ 0.3 ml/l, followed by 18 bugs/plant in case of plants treated with *Lecanicillium lecanii* @ 10^9 spores/ml. All the treatments, however, were at par except *L. lecanii* applied @ 10^7 spores/ml, which recorded the highest mean population of 87.33 bugs/plant.

Imidacloprid (0.3 ml/l) with mean bug population of 1.0/plant recorded the lowest population at fifteen days after second round of treatment application and was on par with *L. lecanii* @ 10^9 spores/ml (4.67 bugs/per plant).

The above trend was discernable during subsequent observations as well. The average bug population of 0.33/plant recorded as a lowest population at seven days after second round of Imidacloprid 0.3 ml/l treatment application. This was however, at par with *L. lecanii* @ 10^8 spores/ml (3.67 bugs/per plant). The treatments did not differ significantly in terms of mealybug count 21 days after treatment.

7. Laboratory and field evaluation of entomopathogenic fungi against banana root mealybug, *Geococcus citrinus* (KAU)

Surveys were carried out in Thrissur, Eranakulam and Kozhikode districts for collection of banana root mealybug. No pest incidence was observed in either Thrissur or Ernakulam districts. However, infestation was observed at Thamarassery area of Kozhikode

district towards end of February. The mealybugs have been collected and are used for building adequate population for evaluation.

8. Laboratory evaluation of entomopathogenic fungi against pepper root mealybug, Formicoccus *polysperes* (KAU)

Survey was carried out at Wayanad for the collection of the mealybug. Incidence was observed only towards late January. The mealybug is being reared in laboratory for further evaluation.

9. Field evaluation of *Beauveria bassiana* liquid formulation against tea mosquito bug in Guava (TNAU)

Cultivar	:	Lucknow 49
No of trees selected	:	10
No. of sprays	:	4
Location	:	Agricultural Research Station, Bhavanisagar
Date of spraying	:	22.2.16, 1.3.2016, 10.3.2016 and21.3.2016

A field trial was conducted to evaluate IIHR liquid formulation of *Beauveria bassiana* at ARS, Bhavanisagar during March 16. As per the requirement ten guava trees were marked. Liquid formulation of *Beauveria bassiana* @ 1ml/ lit was sprayed four times using tree sprayer. The fruit damage by tea mosquito bug, *Helopeltis antonii* before spraying ranged 14.6 to 17.2% **(Table 93)**. After four sprays, the fruit damage in the newly harvested fruits was 9.3% in treated trees. But in unsprayed trees, the fruit damage recorded 28.7% at the same period of observation.

Table 93. Field evaluation of *Beauveria bassiana* liquid formulation (IIHR) against tea mosquito bug in guava

Particulars	Mean fruit damage by *Helopeltis antonii* (%)	
	Treated plot	Untreated plot
Pretreatment	14.6	17.2
Post treatment (*B.bassiana* @ 1 ml/l)	9.3	28.7

10. Incidence of tamarind fruit and seed borer in Chhattisgarh state with their natural enemies.

Survey was conducted in Chhattisgarh for the incidence of tamarind fruit and seed borer during 2014-15 and 2015-16 and the results are present in Table 3. Population of fruit borer and seed borer was found to be maximum during second fortnight of August and first fortnight of September during 2014 and 2015. With regard to population of seed weevil, *Sitophilus* sp, it was found to be maximum during February- March 2015 and 2016. Approximate per cent of fruit loss by fruit borer is expected to be 27-35% and per cent of seed loss by *Sitophilus* sp. is expected to be 15-20% **(Table 94)**.

Table 94. Fortnightly population of fruit and seed borer of tamarind

Date of observation	Mean population Fruit borer (per m^2) 2014--15	*Sitophilus* sp (Seed feeder) No. of insect (per m^2) 2014--15	Date of observation	Mean population Fruit borer (per m^2) 2015--16	*Sitophilus* sp (Seed feeder.) No of insect (per m^2) 2015--16
01/07/2014	**1.97**	**0**	01/07/2015	2.05	**0**
15/07/2014	**5.63**	**0**	15/07/2015	5.24	**0**
01/08/2014	**11.35**	**0**	01/08/2015	9.90	**0**
15/08/2014	**29.95**	**0**	15/08/205	27.95	**0**
01/09/2014	**30.08**	**0**	01/09/2015	25.39	**1.06**
15/09/2014	**20.54**	**0**	15/09/2015	35.24	**1.66**
01/10/2014	**15.45**	**1.02**	01/10/2015	16.61	**2.66**
15/10/2014	**17.55**	**2.68**	15/10/2015	15.81	**4.95**
01/11/2014	**14.82**	**4.71**	01/11/2015	13.47	**5.31**
15/11/2014	**14.55**	**4.05**	15/11/2015	12.46	**5.99**
01/12/2014	**9.88**	**6.56**	01/12/2015	8.50	**6.94**
15/12/2014	**8.99**	**8.81**	15/12/2015	6.96	**10.05**
01/01/2015	**5.99**	**6.5**	01/01/2016	4.88	**11.27**
15/01/2015	**2.55**	**8.88**	15/01/2016	3.90	**13.55**
01/02/2015	**2.44**	**10.57**	01/02/2016	2.71	**14.51**
15/02/2015	**2.58**	**13.91**			
01/03/2015	**1.91**	**15.5**			
15/03/2015	**1.55**	**15.66**			

2.13. Temperate Fruits

1. Evaluation of entomopathogenic fungi and EPNs for the suppression of Apple root borer, *Dorystheneshugelii* under field conditions (YSPUHF-Solan)

Entomopathogenic fungi, *Metarhizium anisopliae* and *Beauveria bassiana* (10^6 conidia/ cm² each), entomopathogenic nematodes, *Steinernema carpocapsae* and *Heterorhabditis indica* (80 IJ/ cm² each) and chlorpyriphos (0.06%) along with untreated control were evaluated for the control of apple root borer, *Dorysthenes hugelii* at Seobagh of district Kullu, Himachal Pradesh. The experiment was conducted on fully grown bearing trees of apple (cv. Royal Delicious) in randomized block design with four replications. The treatments were applied during the month of August, 2015 and the observations were recorded during November, 2015. While recording the data number of live and dead grubs of *D. hugelii* were counted and pooled to get total number of larvae present in the tree basin for calculation of per cent mortality. Among different biopesticides, *Metarhizium anisopliae* (10^6 conidia/ cm²) was the most effective resulting in 70.4% mortality of the grubs and there is no significant difference between *M. anisopliae* and chlorpyriphos (0.06%) treatment. In chlorpyriphos (0.06%) treated plot, 85.8 per cent grub mortality was recorded **(Table 95)**. Other bio-pesticides *viz*., *Beauveria bassiana* @ (10^6 conidia/cm²), *Heterorhabditis indica* and *Steinernema carpocapsae* @ (80 IJ/cm² each) were moderately effective and there is no significant difference between these treatments. The mortality of the grubs in the control plot was 8.1%.

Table 95. Evaluation of entomopathogenic fungi and EPNs for the suppression of Apple root borer, *Dorysthenes hugelii* under field conditions

Sl. No.	Treatment	Larval mortality (%)
1	*Steinernema carpocapsae* @ (80 IJ/cm²)	27.9 (31.6)^b
2	*Heterorhabditis indica* @ (80 IJ/cm²)	42.9 (40.4)^b
3	*Beauveria bassiana* @ (10^6 conidia/cm^2)	42.7 (40.6)^b
4	*Metarahizium anisopliae* @ (10^6 conidia/cm²)	70.4 (57.1)^a
5	Chlorpyriphos @ (0.06%)	85.8 (66.5)^a
6	Control (Untreated)	8.1 (11.6)^c
	CD (p=0.05)	(13.2)
	CV (%)	28.9

Figures in parentheses are angular transformed values

2. Survey for identification of suitable natural enemies of Codling moth, *Cydia pomonella* (SKUAST)

Two different approaches were made to investigate the natural enemies associated with Codling moth, *Cydia pomonella* infesting apple in Kargil during 2015. 1. Installation of Sentinel cards with *Corcyra* eggs in untreated orchards. 2. Observations on naturally

occurring larval and pupal parasitism in overwintered larvae. Natural parasitism was detected by unwrapping of old trunk bands used on apple, in late May to early June. Presence of minute cocoons of parasitoids under the trunk bands or on the apple trunk itself indicated natural parasitism. Samples of overwintering larvae (N= 100) from each of the six locations were also collected during the month of October- November and stored in plastic jars along with leaves and plant parts, and reared in Laddakh itself (there being strict quarantine for the pest), for the emergence of parasitoids. The samples were examined during June for the emergence of parasitoids and per cent parasitism calculated for each location.

Out of total 1751 overwintering larvae observed from all the six locations, average parasitism was worked out as 0.63% ranging 0.0 to 1.5%. No parasitoids were found to occur at Bagh-e- Khomini and Mingy as per collected samples, whereas, 1.11, 0.77, 0.44 and 1.5% parasitism was found at Shanigund, Mangmore, Kharrol and Gond, respectively. The reason for negligible occurrence of parasitism is probably due to large scale pesticide used on apple, in past, for the management of Codling moth. Sentinel cards used in all the orchards during beginning of June and mid of July did not reveal occurrence of any indigenous *Trichogramma*.

3. Field evaluation of *Trichogramma embryophagum* and *T. cacoeciae* against Codling moth, *Cydia pomonella* on apple (SKUAST)

The experiment was carried out in six selected orchards of apple at Kargil during 2015. The study was based on a total of five different treatments compared with untreated check. The details of treatments orchard wise are tabulated as below:

Orchards	Detail of treatments
Shani gund (T1)	Chlorpyriphos + *T.embryophagum*
Mangmore (T2)	Chlorpyriphos + *T. cacoeciae*
Bagh-e- khomini (T3)	Pheromone traps + *Trichogramma* spp.
Kharrol (T4)	Trunk banding + disposal of infested fruits
Mingy (T5)	Neem + all the treatments (1-4)
Gond (T6)	Untreated Check

Approximately 50 apple trees of 10-20 years of age were selected for this study and data was collected from ten randomly selected trees. One spray of Chlorpyriphos (20 EC) @ 1.5 ml/litre of water was applied during pea stage of the fruit, followed by two sequential releases of laboratory reared *Trichogramma cacoeciae* and *T. embryophagum* (received from NBAIR) @ 5000 adults/tree, ten days after the chemical spray. Similar gap between chemical spray and one spray of NSKE @ 3.0 ml/ litre of water was also maintained. Trunk banding in ten trees of each orchard was done with 1-2 meter of gunny bags, in the last week of August' 2015, when the larvae start overwintering. The bands were unwrapped during late October for counting the number of larvae overwintering, followed by mechanical killing or their storage for further study. Larval density was determined by untying the trunk bands and counting the larvae, dead or alive, parasitized or healthy during the month of October-November 2015, for each orchard. Delta traps @ 4.0/orchard was installed twice during ending May to first week of June and mid July 2015, corresponding to emergence of first and second generation of adult moths. Data on adult moths trapped in Pheromone traps were

based on 4 traps. Thorough disposal of infested dropped fruits were done throughout the crop season.

Data on fruit damage, both for fruits on trees as well as dropped fruits were recorded by examining individual fruits of a sample for larval damage. The damage is represented as per cent damage for the observations. Mean of these two parameters represented average fruit damage for the season of an orchard.

For recording data on trunk banding and pheromone trap catches, the experiments were laid in same orchards to observe the effect of treatments. Data was statistically analyzed through Minitab.

Average fruit damage during 2015 in treated orchards of Kargil, varied from 35.91 to 52.28%, when compared with untreated control (76.55%) **(Table 96)**. Differences in fruit damage on tree (F= 26.63**; d.f.=5,45), dropped fruits (F=6.89**, d.f.= 5,45) as well as overall fruit damage (F= 24.58**;d.f.= 5,45) were found statistically significant among treatments, when data was analyzed through one way ANOVA. Per cent reduction in damage over control ranged between 24.65-52.92. Average damage during 2015 was recorded comparatively lesser than 2014 as obtained from comparison of two years' data through Student's *t*- test **(Table 96)**. Overall difference in fruit damage during the two years was statistically significant (*t*= 7.03**, d.f.= 115). This was also verified by the interaction between treatments and years through two way ANOVA (*F*= 11.27**, d.f.= 4,90). Overall per cent reduction in fruit damage over control when compared with data of 2014, yielded statistically significant difference, when analyzed through Student's *t*- test (*t*= 7.19**, d.f.= 95). As also verified by the interaction between treatments and year (*F*= 9.57**, d.f.= 4,90). Use of one spray of Chlorpyriphos @ 1.5 ml/ lit. of water during pea stage of the fruit i.e. during May in Shanigund, Mangmore and Mingy played significant role in reducing the overall fruit infestation considerably, thereby observed increase in per cent reduction in fruit damage over control **(Table 96)**. Two year investigation also confirmed superiority of *Trichogramma cacoeciae* (T2) over *T. embryophagum* (T1). Combination of *Trichogramma* spp. along with pheromone traps (T3) and trunk banding with disposal of infested fruits (T4) however were found statistically on par, both for over all fruit damage and per cent reduction in damage over control. A combination of all the approaches (T5) was found statistically significant over all the treatments during 2015 reflecting significant differences both in terms of fruit damage (*t*= -6.28** d.f.= 18) as well as per cent reduction in damage over control (*t*= 6.32** d.f.= 9), when compared for two years' data through Student's *t*- test.

Average catch of overwintering larvae of Codling moth, *Cydia pomonella* in the trunk bands used during late August of 2015, ranged 17.2- 48.7 per tree **(Table 97)** statistically different between orchards (*F*= 15.39**; d.f.= 5,45). Two years data on larval catch/ trunk band when compared through Student's *t*- test indicated a non significant difference in the orchards except at Bagh-e- Khomini and Mingy **(Table 97)**. An increase in larval density was observed in the former whereas a significant decline in the latter, probably due to use of Chlorpyriphos.

Average adult moths trapped in pheromone traps ranged 25.62 to 91.25 / trap in different orchards, differing significantly when analyzed through ANOVA (*F*= 26.73**; d.f.=5,15) **(Table 97)**. Two years' data on adult catches when compared through Student's *t*- test indicated a significant decline in moths when orchards treated with Chlorpyriphos. A non significant negative correlation was however found to exist between treated orchards and

moth catches in July, 2015 (r= -0.138 NS; d.f.= 20) that alluded the role of chemical spray in suppression of the pest.

Trunk banding, disposal of infested fruits and mass trapping of adult moths in combination with other treatments showed better result in managing the Codling moth, *Cydia pomonella* at Kargil.

Table 96. Effect of different treatments on apple fruit damage by Codling moth, *Cydia pomonella* in Kargil, during 2015

	Damage on tree (%)	**Dropped fruits (%)**	**Overall fruit damage (%)**	**% reduction in damage over control**	**average damage during 2014 & 2015 (*t*- test)**	**% reduction in damage over control during 2014 & 2015 (*t*- test)**
Shanigund (T1)	22.61 (28.06)^{b}	77.2 (62.18)^{b}	49.93 (44.96)^{b}	34.54 (35.81)^{bc}	*t*= -8.70** df= 18	*t*= 6.00** df = 15
Mangmore (T2)	16.02 (16.02)^{a}	72.27 (59.13)^{a}	44.15 (41.59)^{b}	42.19 (40.39)^{c}	*t*= 8.38** df = 18	*t*= 7.43** df = 13
Bagh-e-Khomini (T3)	30.57 (33.17)^{c}	84.55 (67. 21)^{b}	57.56 (49.43)^{c}	24.65 (28.77)^{a}	*t*= 0.17NS df = 18	*t*= -0.51 NS df = 11
Kharrol (T4)	24.69 (29.43)^{b}	79.87 (63.75)^{b}	52.28 (46.32)^{bc}	31.70 (34.0)^{a}	*t*= -5.97** df = 18	*t*= 5.40** df = 17
Mingy (T5)	6.05 (13.53)^{a}	65.76 (54.51)^{a}	35.91 (36.68)^{a}	52.92 (46.74)^{d}	*t*= -6.28** df = 18	*t*= 6.32** df = 9
Gond (T6) (Untreated check)	60.91 (47.2)^{d}	92.1 (72.32)^{bc}	76.55 (58.24)^{d}	--	--	--
C.D @ 5%	**5.09**	**5.58**	**3.49**	**5.33**	**Over all *t*= -7.03** df= 115**	**Over all *t*= 7.19 df= 95**
CV (0.05)	**72.51**	**16.89**	**27.29**	**37.24**		

Figures in each column represent mean of 10 observations

Values in parentheses are arc sin transformations

Similar alphabets in a column indicate values statistically on par

Where; T1= One spray of Chlorpyriphos +Two sequential releases of *T. embryophagum*;
T2= one spray of Chlorpyriphos + Two sequential releases of *T. cacoeciae*;
T3= Pheromone traps + *Trichogramma* spp.;
T4= Trunk banding & destruction of larvae;
T5= 2 sprays of Chlorpyriphos + Two sequential releases of Trichogramma + trunk banding + pheromone traps

Table 97. Average catch of larvae and adults of Codling moth, *Cydia pomonella* through trunk banding and pheromone traps during 2015

	Av. Larvae/ burlap	Av. adults / trap during May' 2015	Av. adults / trap during July' 2015	Average moths/ trap during 2015	Comparison for larval catch during 2014 & 2015 (*t*-test)	Comparison for adult moth catch during 2014 & 2015 (*t*-test)
Shanigund	26.7 (5.02)[a]	16.25 (3.99)[a]	48.0 (6.88)[b]	32.12 (5.66)[b]	*t* = -1.67 NS df= 15	*t* = -4.72** df = 4
Mangmore	22.3 (4.66)[a]	14.25 (3.73)[a]	58.0 (7.57)[c]	36.12 (6.01)[c]	*t* = -1.39 NS df = 17	*t*= -2.14* df = 3
Bagh-e-Khomini	40.1 (6.27) [bc]	42.25 (6.48)[b]	85.5 (9.23)[d]	63.87 (7.99)[e]	*t* = 2.75** df = 17	*t* = 2.87** df = 4
Kharrol	36.1 (5.96)[b]	41 (6.37)[b]	62.75 (7.89)[c]	51.87 (7.20)[d]	*t* = -0.29 NS df = 17	*t* = 1.34 NS df = 5
Mingy	17.2 (4.09)[a]	13.5 (3.64)[a]	37.75 (6.11)[a]	25.62 (5.06)[a]	*t* = -3.92** df = 17	*t* = -6.92** df = 4
Gond	48.7 (6.94)[c]	63.5 (7.77)[c]	119 (10.88)[e]	91.25 (9.55)[f]	*t* = 1.67 NS df = 17	*t* = -0.65 NS df = 5
CD @ 5%	**0.64**	**0.72**	**0.64**	**0.51**	**Overall *t*= -0.78** NS P=0.44 df = 104	**Overall *t*= -** 2.65** df = 45
CV(0.05)	44.8	70.7	43.3	49.3		

Figures in first column represent mean of 10 observations; figures in column 2-4 represent men of 4 replications
Values in parentheses are √n; t= Student's *t*; DF= degree of freedom; ** significant at 5.0 and 1.0 per cent; NS= Non significant
Similar alphabets in a column indicate values statistically on par

4. Evaluation of predatory bug, *Blaptostethus pallescens* against European red mite, *Panonychus ulmi* on apple (SKUAST)

Predatory potential of *B. pallescens* (received from NBAIIR) against the eggs of European red mite (ERM) infesting apple leaves was evaluated in laboratory during 2015. Infested leaves with eggs were collected from apple orchards of district Srinagar during June-July 2015. The leaves were brought to laboratory and observed under stereoscopic binocular for the presence of eggs of ERM. Fresh eggs on leaves were encircled with black ink to observe their fate after exposure to the predators. Extra eggs, nymphs and adults of ERM and other mites were removed. A fixed number of ERM eggs *i.e.*, 5, 20, 45 and 80 were exposed to predation for 24 hours, in a predator: prey ratio of 1:5, 1:10, 1:15 and 1:20. The experiment was continued for three days, replenishing the old eggs after every 24 hours and average of the three days fecundity determined for each predator/ prey ratio. Both 8-days old nymphs and adult females of the anthocorid bugs were evaluated separately in plastic boxes (21 X 15 X 5 cm). Water soaked cotton was kept around the petiole of each leaf to prevent desiccation. Twenty four hours after exposure to predation, the samples were kept separately for observations on the hatching of eggs. Number of unhatched eggs indicated feeding effect of the bugs during the given period. The experiment was replicated thrice, in BOD maintained at 27± 1 ^{o}C, 65 ± 5% relative humidity and 12: 12 photoperiod. An untreated check, both for nymphs as well as adults, was also studied for comparison of data.

Per cent failure of hatching of eggs of ERM was calculated from the number of hatched eggs, for each sample. Corrected (%) mortality was calculated by using Abbott's formula. Data was statistically analyzed using Minitab.

Average failure of egg hatching of ERM eggs caused by 8 days' old nymphs was worked out as 93.33, 61.66, 59.50 and 45.97% in relation to predator: prey ratio of 1:5, 1:10, 1:15 and 1: 20, respectively. Corrected mortality of the eggs was calculated as 92.12, 54.71, 52.16 and 36.18, respectively. Average consumption/ nymph/day were calculated as 4.66, 6.16, 8.92 and 9.19 **(Table 98)**. Similarly, adult predators caused 100.0, 86.66, 77.3 and 59.58% failure of egg hatch in relation to predator/prey ratio of 1:5, 1:10, 1:15 and 1: 20 respectively. Average prey consumption by an adult female during three days was worked out as 5.00, 8.66, 11.62 and 11.91 corresponding to above mentioned predator/prey ratio. Differences in per cent failure of egg hatch in relation to predator/ prey ratio, caused both by nymphs (F= 30.96; d.f.= 4, 16; P= 0.000) as well as adults (F= 173.67; d.f.= 4, 16; P= 0.000) was found statistically significant when analyzed using one way ANOVA. Rate of feeding both for nymphs (r= 0.99**) and adults (r= 0.99**) was found correlated with prey density. Fecundity potential between nymphs and adults when compared through Student's *t*-test was found statistically significant **(Table 98)**.

Table 98. Predatory potential of *Blaptostethus pallescens* against eggs of European red mite, *Panonychus ulmi*

Predator : Prey ratio	No. of predators used	No. of ERM eggs used/ day	8 days old nymphs			Adult females			Student's *t*-test for consumption
			% failure of egg hatch*	Corrected % mortality	Av. Eggs consumption/ nymph /day	% failure of egg hatch*	Corrected % mortality	Av. Eggs consumption/ adult/day	
1:5	01	05	93.33 (81.14)^{c}	92.12	4.66	100.00 (90.00)^{e}	100.00	5.00	t = 2.00NS; df=8
1:10	02	20	61.66 (51.81)^{b}	54.71	6.16	86.66 (70.52)^{d}	84.37	8.66	t = 5.02; df=11
1:15	03	45	59.50 (50.51)^{b}	52.16	8.92	77.53 (62.30)^{c}	73.68	11.62	t= 4.34 df=11
1:20	04	80	45.97 (42.68)^{b}	36.18	9.19	59.58 (44.65)^{b}	52.66	11.91	t = 7.10; df=13
Control	--	--	15.33 (22.69)^{a}		r= 0.99	14.6 (22.19)^{a}		r= 0.99	t = 0.18 NS
CD (0.01)	--	--	11.05			5.62			Overall t = 3.11; df =69
CV (%)			**29.27**			**20.42**			

* Each figure represents mean of 5 replications; values in parentheses are arc sin transformations; similar alphabets in a column indicate values statistically on par

5. Field evaluation of anthocorid bug, *Blaptostethus pallescens* against Two spotted spider mite, *Tetranychus urticae* on apple (SKUAST)

Because of insufficient population density of *Tetranychus urticae* on apple in field condition during 2015, due to intermittent rains, field releases could not be made. Laboratory evaluation on the efficacy of anthocorid bugs, both nymphs and adults. Field collected 10, 30, 60 and 100 eggs of spider mites were exposed to nymphs and adults of anthocorid bugs for 24 hrs, in a predator: prey ratio of 1:10, 1:15: 1:20 and 1:25, respectively. The experiment was carried out for three days and average of three days predation was determined for each predator/prey ratio. The experiment was replicated thrice. Total number of eggs of spider mites consumed by given number of nymphs as well as adult females in each replication during a period of three days was counted and calculated average daily consumption/individual. Statistical analyses were made using Minitab.

On an average, single nymph of *B. pallescens* was found to consume 7.66, 9.11, 10.77 and 10.86 eggs/day in relation to predator: prey ratio of 1:10, 1:15: 1:20 and 1:25 respectively. Per cent failure of egg hatch of spider mite, *Tetranychus urticae* however was noticed to decline from 76.66 to 43.44 when prey density was increased from 10 to 100 eggs. Similarly, a single adult female was recorded to consume 9.66, 11.77, 13.11 and 13.55 eggs/ day in relation to identical predator prey ratio as mentioned in **(Table 99)**.

One way ANOVA indicated statistically significant difference in feed by the nymphs as well as adult in relation to both density of predators (F= 122.87; P= 0.000; d.f.= 1, 23), as well the prey density(F = 57.71; P = 0.000; d.f.= 3, 23). A positive correlation between feeding and predator density was observed both in nymphs (r= 0.91**) as well as adult females (r= 0.89**). Rate of consumption between nymphs and adults was worked out to be statistically significant (t= 4.04**; d.f.= 21), when data was compared using Student's t-test. Per cent failure of egg hatching caused by nymphs as well as adults when compared through one way ANOVA indicated non significant difference (F = 1.73 NS; P = 0.20; d.f.= 1, 26).

Table 99. Predatory potential of anthocorid bugs, *Blaptostethus pallescens* against spider mite, *Tetranychus urticae* on apple

Predator: prey	No. of predators used	No. of prey eggs used	Av. egg consumption/ individual / day*	% failure of egg hatching*	Corrected failure of hatching (%)
Nymphs 1:10	1.0	10.00	7.66±0.86 (2.76)[a]	76.66 (61.45)[b]	71.67
1:15	2.0	30.0	9.11±0.92 (3.01)[a]	60.74 (51.25)[a]	52.12
1:20	3.0	60.0	10.77±0.83 (3.28)[a]	53.88 (46.91)[a]	43.75
1:25	4.0	100.0	10.86±0.89 (3.29)[a]	43.44 (41.22)[a]	31.02
Check	--	100.00	--	18.00 (25.01)[a]	--
Adult females 1:10	1.0	10.00	9.66±0.5 (3.10)[a]	96.66 (83.85)[b]	96.14
1:15	2.0	30.0	11.77±1.30 (3.42)[b]	78.51 (62.73)[b]	75.20
1:20	3.0	60.0	13.11±1.26 (3.61)[b]	65.55 (54.13)[a]	60.25
1:25	4.0	100.0	13.55±0.88 (3.68)[b]	54.22 (47.42)[a]	47.17
Check	--	100.00	--	13.33 (21.26)[a]	--
CD(0.01)	-	-	0.53	36.54	--
CV(%)	-	-	19.24	23.13	--

Figures in columns represent mean of 3 observations; figures in parentheses 4th and 5th columns are √n and arc sin transformations respectively; similar alphabetical superscripts indicate the values statistically on par

2.14. Vegetables

1. Demonstration of BIPM package for management of key pests of tomato (AAU-J, MPUAT, TNAU and YSPUHF)

AAU-Johrat

Location : Farmers' Field (Uttar garumora, Jorhat)
Target pest : Tomato fruit borer, *Helicoverpa armigera*
Variety : Namdhari
Area : 0.5 ha/treatment
Date of planting: 5.10.2015
N:P:K : 120:200:200 kg/ha
Treatment : 3

T1= BIPM package comprised of;

- Seedling root dip treatment with *Pseudomonas* 2% solution
- Installation of yellow sticky trap @ 50 /ha
- Installation of bird perches @ 10 /ha
- Spray of NSKE @ 5 % against sucking pests
- Use of pheromone traps @ 5 /ha against *Helicoverpa armigera*
- Six releases of *Trichogramma chilonis* @ 1,00,000 /ha from flower initiation stage at weekly intervals
- Need based spray of Bt @ 1 kg/ha (two rounds of spray)
- Rouging of leaf curl disease affected plants.
- Regular collection and destruction of damage fruits
- Need based spray of *Ha*NPV / *Bt*

T2 = Chemical control plots (Indoxacarb @ 75 g a.i/ha

T3= Untreated control

The field experiment on biocontrol based IPM package of tomato was evaluated in comparison with farmers' practice (chemical control) and untreated check in the farmers' field located at Uttar Garumora, Jorhat. The treatment blocks were raised at 50 m isolation distance. Each block was divided into 8 sub plots as replicates. Application of bio agents; releases of parasitoids and spraying of *Bt*, NSKE were made at 10 days interval starting from 35 days after transplanting, where as four rounds of indoxacarb @ 75 g a.i. /ha was sprayed at fortnightly interval, starting from 35 DAP in farmers practice. No pest management practice was followed in control.

Observations on post treatment count for larvae of *H. armigera* and sucking pests were made on 10 randomly selected plants per plot after each spray/release of parasitoids. Per cent fruit damage and weight of the marketable tomato fruits per plot were recorded at the time of harvesting.

The results of the experiment **(Table 100 & 101)** indicated that, in majority cases BIPM package and chemical control were equally effective in reducing the larval population

of *H. armigera*. The mean population of *H. armigera* / plants was 2.23 in BIPM, whereas it was 3.02 in chemical control plot. Maximum number of larval population (6.38/ plants) was recorded in untreated check. Similarly, same trend of result was observed in case of whitefly infestation. Both the treatment (BIPM package and chemical control) was on par in their efficacies in reducing the whitefly infestation as against untreated check. The mean population of whitefly was 1.83 and 1.68 in BIPM package and chemical control plot, respectively, as against 10.77/10 leaves in control after 65 DAT. However, plots with BIPM package had minimum fruit damage (13.5%) with higher yield of 291.78 q/ha compared to 16.12% fruit damage with 287.0 q/ha in chemical control plots. Both the treatments were significantly differed with each other. Highest fruit damage of 25.37% and minimum yield of 201.5 q/ha was recorded in untreated control plot. In general, maximum numbers of coccinelids were observed in BIPM in comparison to chemical control plot throughout the cropping season.

Table 100. Effect of BIPM packageon incidence against *Helicoverpa armigera* on tomato

Treatment	Post treatments* (larval population/plant)	% fruit damage	Yield (q/ha)
BIPM	2.23[b]	13.5[c] (31.46)	291.8[b]
Chemical Control	3.02[b]	16.12[b] (31.97)	287.0[b]
Untreated control	6.38[a]	25.37[a] (40.29)	201.5[a]
CD (=0.05)	1.46	0.27	9.40
CV %	35.30	5.74	3.37

*Mean of three observations
Figures in parenthesis are transformed angular values
Means followed by the same letter in a column are not significantly different

Table 101. Effect of BIPM package on incidence against *Bemisia tabaci* on tomato

Treatment	*Bemisia tabaci* / 10 leaves*			Mean
	35 DAT	50 DAT	65 DAT	
BIPM	3.33[c]	2.85[b]	1.83[b]	2.67
Chemical Control	4.02[b]	3.61[b]	1.68[b]	3.37
Untreated control	5.88[a]	7.73[a]	10.77[a]	8.11
CD (=0.05)	0.53	1.18	0.82	-
CV %	11.40	23.36	16.14	-

*Mean of three observations
Means followed by the same letter in a column are not significantly different

MPUAT-Udaipur

Location **:** Farmers' field
Experiment Details **:** Five treatments

Replications **:** 4
Design : RBD
Crop of Variety : Tomato, Dev

Treatment details

1. Installation of pheromone traps @ 5/ha.
2. One spray of *Ha* NPV @ 250 LE at flowering stage.
3. Two sprays of *Bt* @ 1 kg/ha first at flowering stage and second after 15 days of first spray.
4. Two sprays of *Ha* NPV first at flowering stage and second after 15 days of first spray.
5. Farmers' practices (chemical control)

Sl. No.	Name of farmer	Village	Area (ha)
1	Ramesh Pushkarna	Navania, Vallabhnagar	0.4
2	Govindlal s/o Kalu	Gandhipura, Sarada	0.1
3	Hiralal s/o Ganga	Gandhipura, Sarada	0.1
4	Pannalal s/o Rupa	Gandhipura, Sarada	0.1
5	Dolatram s/o Hakra	Gandhipura, Sarada	0.1
6	Kashna s/o Punja	Gandhipura, Sarada	0.1

The results of the experiment showed that two sprays of *Ha*NPV was as good as farmers' practice with per cent infested fruits being 3.5 and 4.08 respectively, compared to 7.22 and 10.95 in single spray of *Ha*NPV and untreated control respectively. The yields of uninfested fruits were highest in two sprays of *Ha*NPV plots which are as good as other treatments and untreated control **(Table 102)**.

Table 102. Validation of *Ha*NPV against *H. armigera* in tomato in farmers' field (Average of 6 farmers)

Sl. No.	Treatments	Per cent infested fruit	Yield in (Q/ha)	
			Infested	Uninfested
1	One spray of *Ha*NPV @ 250 LE at flowering stage and followed by one spray of Azadirachtin	7.22 $(15.59)^{b}$	38.52	158.23
2	Two sprays of *Ha*NPV @ 250 LE first at flowering stage and second after 15 days of first spray	3.5 $(10.78)^{d}$	29.65	165.27
3	Farmers' Practices	4.08 $(11.65)^{c}$	48.62	134.25
4	Control	10.95 $(19.32)^{a}$	68.56	128.52
	SEm±	0.26	-	-
	CD 5%	0.71	-	-

MPUAT

Nursery Raising: Well prepared nursery beds were mixed with *Trichoderma* enriched FYM.
Date of Nursery: 10 Nov. 2015
Date of Transplanting: 1-10 Dec. 2015

IPM module comprises of 5 weekly releases of *T. chilonis* @ 1,00,000/ha followed by 2 sprays of *Ha*NPV, when 3-4 adult moths are captured in the pheromone trap and second spray @ 15 days after first spray.

The data revealed that the fruit damage was reduced in IPM modules in comparison to farmers practices (*i.e.,* the application of 3 sprays of insecticides) and also resulted in higher fruit yield.

Treatments	Percent Fruit Damage	Yield (Q/ha)	C:B Ratio
IPM Module	11.52	232.34	1:1.11
Farmers practices	20.04	215.46	

TNAU-Coimbatore

Variety : Lakshmi
Spacing : 60 x 45 cm
Date of transplanting of Tomato :26.8.2015
Date of transplanting of Marigold :10.8.2015

T_1 BIPM package

- Seedling root dip with *Pseudomonas* 2% solution :26.8.2015
- Raising African Marigold as trap crop
- Installation of yellow sticky trap @ 50 No's /ha. :10.9.2015
- Installation of bird perches @ 10/ha. :10.9.2015
- Installation of Pheromone trap 12/ha :25.9.2015
- Release of *Trichogramma pretiosum*@50,000 /ha :04.10.2015,11.10.15 and 18.10.2015
- Release of *Chrysoperla* larvae @ 50,000 No's /ha. :20.9.2015
- Sucking pests management through Azadirachtin spray :13.9.2015

T_2 Farmer's practice – Dimethoate 0.06% spray at 30 days, imidacloprid 17.8 SL @ 0.4ml/l, chlorpyriphos 0.04% and indoxacarb 14.5 SC 0.8 ml/l @ at 60, 75 and 90 days after planting.
Plot size : One acre/treatment

The observations on insect pests in plots of BIPM demonstration along with farmers practice and control showed the presence of sucking pests like thrips and whiteflies. During fruiting period the incidence of *Helicoverpa armigera* was also noted. The population of thrips 2-4 nos. recorded per plant and whiteflies 2-5 nos. per plant in BIPM plots were low as compared to farmer's practice which recorded 9-15 thrips/ plant and 7-11 whiteflies/plant.

The BIPM package was able to maintain the sucking pests population up to 60 DAT better than the farmer's practice which had insecticide spray alone **(Table 103)**. The fruit damage due to *H. armigera* was higher in plots of farmer's practice with a mean per cent fruit damage of 12-15% as compared to 6-8% in BIPM plots. The population of sucking pests and fruit borer damage were significantly low in BIPM plot as compared to plots of farmer's practice with four insecticide sprays. Untreated plots recorded maximum population of thrips and whiteflies on 30, 45 and 60 DAP.

The occurrence of predators like green lacewings and coccinellids were found higher in plots which received the BIPM package and lower in plots of farmer's practice. The highest fruit yield was recorded in BIPM package 31.2 t/ha compared to 26.9 t/ha in farmer's practice. The untreated plot showed a fruit yield of 24.8 t/ha **(Table 104)**. The cost to benefit ratio recorded 1:3.2 in BIPM plot was superior as compared to farmer's practice which involved four insecticide sprays and showed 1: 2.7. This has clearly indicated that the results of the BIPM demonstration module were able to contain the pests to below economic injury level, realising higher yield and protecting the crop from diseases also.

Table 103. Field demonstration of BIPM package for the management of sucking pests of Tomato

Treatments	Population of sucking pests /plant					
	Thrips			whiteflies		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
BIPM	3.6 [a]	3.2[a]	2.4[a]	5.2[a]	2.4 [a]	4.0[a]
Farmer's practice	9.4[b]	11.8[b]	14.4[b]	10.8[b]	10.4[b]	7.8[b]
Control	11.8[c]	17.4[c]	19.4[c]	19.4[c]	26.4[c]	26.6[c]

Means followed by a common letter in a column are not significantly different by DMRT

Table 104. Field demonstration of BIPM package for the management of fruit borer in Tomato (*Helicoverpa armigera*)

Treatments	Fruit damage (%)			Population of natural enemies/ 5 plants						Fruit yield (t/ha)	Cost Benefit Ratio
				75 DAT		90 DAT		105 DAT			
	75 DAT	90 DAT	105 DAT	*Chrysopa*	*Coccinellid*	*Chrysopa*	*Coccinellid*	*Chrysopa*	*Coccinellid*		
BIPM	6.45[a]	8.00[a]	6.55[a]	4.0[a]	2.4[a]	4.8[a]	3.0[a]	3.6[a]	4.5[a]	31.2[a]	1:3.2
Farmers practice	12.2[b]	15.00 [b]	13.1[b]	0.0[c]	1.0[c]	0.0[c]	0.0[c]	0.8[c]	1.6[c]	26.9[b]	1:2.7
Control	14.3[c]	23.2[c]	18.1[c]	2.3[b]	1.6[b]	1.8[b]	1.5[b]	3.2[ab]	3.8[b]	24.8[c]	-

Means followed by a common letter in a column are not significantly different by DMRT

YSPUHF-Solan

An experiment for bio-intensive management of greenhouse whitefly, *Trialeurodes vaporariorum* and two spotted spider mite, *Tetranychus urticae* was laid at experimental farm of Department of Entomology, Dr YS Parmar University of Horticulture and Forestry Nauni, Solan (HP). For the management of the greenhouse whitefly, biocontrol agents/bio-pesticides like *Chrysoperla zastrowi sillemi* (1 larva/plant), *Lecanicillium lecanii* (NBAIR strain) at 5 g/L of 10^8 conidia/g formulation, Azadirachtin (1500 ppm; 3 ml/L) were evaluated in comparison with imidacloprid @ 0.0075% (chemical control) and untreated control. For the control of the mite, predatory mite, *Neoseiulus longispinosus* (5 and 10 mites/plant) and Azadirachtin (1500 ppm; 3 ml/L) were evaluated and compared with fenazaquin (0.0025%) and untreated control. The experiment was laid in a randomized block design with five replications. All the treatments were applied three times at ten days interval and the data on whitefly population and mite population density were recorded before first application and seven days after final application of the treatments. The data were then converted to percent reduction in the pest population over pretreatment counts which were further converted to percent reduction over control by applying Abbott's correction and the results are presented in **Tables 105 and 106**. Among different biocontrol agents/bio-pesticide evaluated against the greenhouse whitefly, Azadirachtin (1500 ppm; 3 ml/L) was the most effective resulting in 60.2 per cent reduction in the whitefly nymph population over control which was, however, statistically on par with *Lecanicillium lecanii* (5 g/L of 10^8 conidia/g) and *Chrysoperla* (1 larva/plant) where the reduction was 57 and 50%, respectively **(Table 105)**. However, none of these treatments could match the efficacy of imidacloprid (0.0075%) which reduced the whitefly population to the tune of 94.1% over control. As for as the control of *T. urticae* is concerned, all the tested bioagents were only moderately effective resulting in the population reduction of the mite over control in the range of 47.9 to 54.5% as compared to 89.9% by fenazaquin (0.0025%) **(Table 106)**.

Table 105. Evaluation of some biocontrol agents against *T. vaporariorum* on tomato under field conditions

Sl. No.	Treatment	Whitefly population reduction over control (%)
1	*Chrysoperla* (1 larva/plant)	50.0 (45.0)[b]
2	*Lecanicillium lecanii* (5 g/L of 10^8 conidia/g)	57.0 (49.1) [b]
3	Azadirachtin (1500 ppm; 3 ml/L)	60.2 (51.2) [b]
4	Imidacloprid (0.0075%)	94.1 (77.8)[a]
	CD (p=0.05)	(10.3)
	CV (%)	13.3

Table 106. Evaluation of some biocontrol agents against *T. urticae* on tomato under field conditions

Sl. No.	Treatment	Reduction (%) in mite population over control
1	*Neoseiulus longispinosus* (5 predatory mites/plant)	47.9 (43.8) [b]
2	*Neoseiulus longispinosus* (10 predatory mites /plant)	54.5 (47.7) [b]
3	Azadirachtin (1500 ppm; 3 ml/L)	48.8 (44.3) [b]
4	Fenazaquin @ (0.0025%)	89.9 (72.1)[a]
	CD (p=0.05)	(5.5)
	CV (%)	7.6

AAU-Anand

Large scale demonstration was carried out in 50 farmer's fields at Runaj village near Sojitra (Dist. Anand) for management of *H. armigera* in tomato using pheromone traps, neem oils spray and Trichocards. The results indicated lower (3.25-7.5%) damage of fruit in BIPM module as against 9.5% fruit damage in the farmer's practice of insecticidal spray. **Detailed data/tables were not provided.**

2. Survey and surveillance of pinworm, *Tuta absoluta* on tomato (AAU-A, AAU-J, KAU, MPKV, PAU, PJTSAU, SKUAST, YSPUHF, UAS-R, IIVR, TNAU and IGKV)

AAU-Anand

Survey was made in 5 randomly selected villages in each district of middle Gujarat region to determine the infestation of *T. absoluta*. Percentage of plants infested with *T. absoluta* was assessed by observing 10 randomly selected plants in every 100 sq m crop area and leaves were observed for the presence of leaf mines caused by larvae and fruits was also observed for the presence of pin head sized holes. The incidence of *T. absoluta* in other field crop *viz*., potato, brinjal, chili, and tobacco were surveyed and observations were recorded.

Survey for ascertaining the outbreak of *T. absoluta* was carried out in agriculture campus as well as in farmers' fields in Anand, Kheda, Vadodara and Sabarkantha districts during entire year. Incidence of *T. absoluta* has been reported in campus and in farmers's fields to the tune of 8-90% **(Table 107)**. The samples of *T. absoluta* infested tomato leaves as well as fruits were brought to the laboratory and examined.

Table 107. Survey and surveillance of pinworm, *T. absoluta* on tomato

Sl. No.	Place	Crop plants infested	Non hosts crop and weeds infested	Existing natural enemies in 25 randomly selected plants	Grade
1	Bodeli	Tomato	Nil	Nil	4 (50-60%)
2	Ajarpura	Tomato	Nil	Nil	1 (8-12%)
3	Runaj	Tomato	Nil	Nil	1 (10-14%)
4	MVRS farm, AAU Campus	Tomato	Nil	Nil	1 (10-12%)
5	Idar	Tomato	Nil	Nil	5 (80-90%)

AAU-Jorhat

Survey was conducted in different tomato growing pockets (village: Alengmora, Dangdhara, Uttar garumora and Morangaon) of Jorhat districts. No Pinworm infestation was observed in those surveyed areas. The survey programme will be continued during 2016 -17 covering districts of upper Assam.

IIVR-Varnasi

Extensive surveys were conducted in and around Varanasi to know the occurrence of pinworm, *Tuta absoluta* (Lepidoptera: Gelechiidae) on tomato. Different plant parts *viz*., green leaves and fruits were observed for the incidence of pin worm. However, no incidence of pin worms on tomato was observed throughout the tomato growing period in and around Varanasi, Uttar Pradesh.

IGKV-Raipur

Female pheromone lure of *Tuta absoluta* was purchased from the PCI unit at Raipur. The lure was placed in Wota T traps in tomato, Chilli, brinjal and potato fields. Daily records of the male moths trapped were recorded and the weakly total and mean was computed in all the four above mentioned crop eco-systems. The data are presented in the **(Table 108)**.

Table 108. Weekly collection of adults of *Tuta absoluta* males in Wota T traps on different hotspot

WEEKLY COLLECTION OF WOTA T- TRAPS ON DIFFERENT HOSTS

SN	SMW	DATE	TOMATO	BRINJAL	POTATO	CHILLI	Tempreture MIN. TEMP.	MAX. TEM.	RH% morning	evening	RAIN FALL	Sun Shine (hour
1	33	13-19	0	0			25.3	31.7	94	73	126.4	4.1
2	34	20-26	1	1			25.9	32.3	87	65	23.6	6.5
3	35	27-02	1	1			25	30.8	94	80	37.9	1.2
4	36	Sep 03-09	0	1			25.5	33	93	64	10	6.9
5	37	10-16	1	0			25.4	33.5	93	62	68.4	6.8
6	38	17-23	2	0			25.1	30.1	94	78	135.4	3.1
7	39	24-30	0	1			24.6	32.5	92	57	0	7.2
8	40	Oct 01-07	0	0			24.4	33.7	92	51	0	7.7
9	41	08-14	0	0			22.2	33.9	89	47	0	8.7
10	42	15-21	0	0			22.8	33.4	91	45	0	8.7
11	43	22-28	1	0			21.3	33.7	90	37	0	8.2
12	44	29-04	4	2			19.4	30	90	55	0	6.7
13	45	Nov 05-11	0	1			18.8	31.7	91	37	0	7.8
14	46	12-18	1	1		0	16.3	31.7	89	33	0	7.5
15	47	19-25	2	1		0	15.5	30.6	88	36	0	8.3
16	48	26-02	1	3		0	16.7	31.9	87	34	0	7.5
17	49	Dec 03-09	1	1		0	14.8	31.2	88	31	0	8
18	50	10-16	0	1		0	17.3	30.1	77	46	4.4	4.4
19	51	17-23	0	0		1	16.6	27.7	85	52	9.4	2
20	52	24-31	0	1	0	0	10.8	26.9	87	29	0	6.2
21	1	junv. 1-7	1	0	0	0	10.7	26.6	91	35	0	6.2
22	2	8-14	1	0	0	0	10.8	26.7	88	33	0	6.1
23	3	15-21	0	0	1	0	10.9	22.5	90	34	0	6.0
24	4	22-23	2	0	3	0	10.9	22.1	85	31	0	4.0
25	5	24-30	27	6	6	1	11.0	23.4	84	29	0	5.1
26	6	Feb.31-6	37	1	11	3	11.1	24.3	86	31	0	5.9
27	7	7-13	26	0	7	2	10.6	24.1	83	27	0	5.8
28	8	14-20	11		5	2	11.2	25.3	82	26	0	6.0
29		21-27			9		11.3	25.6	84	28	0	6.1
30	10	Mrch.28-3			1		11.4	26.1	81	23	0	6.2
31	11	4-11			1		11.5	24.9	79	21	0	5.9

The data in **(Table 108)** reveals that the activity of *T. absoluta* moths in the field was observed from 34 SMW on tomato and brinjal, but mean maximum number of moths were trapped during 6th SMW on tomato and potato while 5th SMW showed maximum population in brinjal.

Monitoring crop damage:

Leaf damage: Ten plants were selected and fortnightly observations were recorded on three randomly selected leaves from each plant. Similar observations were recorded on stem, terminal buds, flower and fruits.

Fruit damage: Observations on fruit damage was recorded at the time of fruit set in all the above mentioned crops. The data is presented in **(Table 109)**.

Table 109. Average number of mines observed at various plant parts due to *T. absoluta*

	Tomato					Brinjal				
SMW	**Leaf**	**Stem**	**Terminal buds**	**Flower**	**fruit**	**Leaf**	**Stem**	**Terminal buds**	**Flower**	**fruit**
33	0.22	0	0	-	-	0	0	-	-	-
34	0.2	0	0	-	-	0	0	-	-	-
35	0.57	0.017	0	-	-	0.00095	0	-	-	-
36	0.38	0	0.01	-	-	0.02	0	0	-	-
37	0.17	0	0	-	-	0.25	0	0	0	-
38	0.006	0	0	-	-	0.25	0	0	0	-
39	0.09	0	0	-	-	0.18	0	0	0	-
40	0.05	0.01	0	-	-	0.34	0	0	0	-
41	0.01	0	0	0	-	0.37	0	0	0	-
42	0	0	0	0	-	0.5	0	0	0	-
43	0	0	0	0	-	0.38	0	0	0	-
44	0.01	0	0	0	-	0.31	0	0	0	0
45	0.01	0	0	0	0	0.32	0	0	0	0
46	0.02		0	0	0	0.1	0	0	0	0
47	0.03	0	0	0	0	0.66	0	0	0	0
48	0.05	0.02	0	0	0	0.65	0	0	0	0
49	0.03	0	0	0	0	0.53	0	0	0	0
50	0.02	0	0	0	0.026	0.54	0	0	0	0
51	0.1	0	0	0	0.0066	0.51	0	0	0	0
52	0.02	0	0	0.01	0.013	0.53	0	0	0	0
1	0.06	0	0	0	0	0.5	0	0	0	0
2	0.22	0.01	0	0	0.02	0.51	0	0	0	0
3	0.2	0	0	0	0.033	0.47	0	0	0	0
4	0.37	0	0	0	0.026		0	0	0	0

The data in **Table 109** shows that the appearance of damage symptoms due to *T. absoluta* in the form of mines was observed from the 33rdSMW on tomato. Damage symptoms on brinjal appeared during the 35th SMW and no symptoms were noticed on chilli crop. In potato being Kharif crop, symptoms appeared on the leaves from 46th SMW onwards.

One hymenopterous larval parasitoid and a predator were recorded during the present studies. The larval parasitoid is being sent NBAIR, for identification.

KAU-Thrissur

Surveillance visits were carried out at Koshinjampara and Vadakarapathy panchayats of Palghat district during the crop season for recording incidence of *T. absoluta*, as well as for collection of their natural enemies. However, no incidence of the pin worm was observed in any of the plots surveyed.

MPKV-Pune

The Survey and surveillance of natural enemies of pinworm, *Tuta absoluta* on tomato was conducted during July to March, 2016. The incidence of this pest was observed in

Yedagan, Umbraj and Pipmpalwandi and Manjarwadi villages of Junnar tahsil Avasari village of Ambegaon Tahsil of Pune district.

The leaf damage ranged between 10 and 20 trifoliate/ 10 plants with an average of 14.28 trifoliate / 10 plants. The leaf damage percentage due to pin worm was 28.56 % and fruit damage ranged between 20-29 with an average of 22.57 fruits / 10 plants. The fruit damage percentage due to pin worm was 12.53 %. The Maximum incidence of the pin worm was recorded in the months of March, 2016 **(Table 110).**

Table 110. Survey and incidence of pinworm, *Tuta absoluta* on tomato

Month	Leaf damage 5 trifoliate/ plant (10 plants)	Fruit damage/ 10 plants
September, 2015	10	21
October, 2015	12	21
November, 2015	15	23
December, 2015	10	20
January, 2016	12	20
February, 2016	18	24
March, 2016	20	29
Average	**14.28**	**22.57**
Range	**10 to 20**	**20-29**
% damage	**28.56 %**	**12.53 %**

PAU-Ludhiana

Surveys were conducted for the incidence of pinworm, *Tuta absoluta* in tomato growing areas at Fatehgarh Sahib, Patiala, Ludhiana and Amritsar on tomato. No incidence was observed at any of the locations.

PJTSAU-Hyderabad

The vegetable growing areas of Telangana were surveyed for infestation and intensity of *Tuta absoluta* incidence. The overall scenario showed marginal incidence of this pest. The surveys are in progress and quantification of the incidence levels will be finalized after completion of surveys.

SKUAST-Srinagar

Preliminary survey was conducted in tomato fields of three districts *viz*., Budgam, Ganderbal and Srinagar of Kashmir for the presence of pinworm, *Tuta absoluta* However, leaves and fruits of tomato and brinjal at all stages of their maturity were thoroughly examined for the presence of leaf miners on leaves or their specific damage symptoms on fruits. Although no signs of the presence of said pest were seen in the surveyed areas, nevertheless, intensive surveys will be conducted during current year for the presence of the pest and its natural enemies on tomato, potato, brinjal and capsicum/chilli.

TNAU-Coimbatore

The prevalence of tomato pinworm, *Tuta absoluta* was monitored in Coimbatore and Erode districts. In Coimbatore district, four tomato growing locations were selected *viz*., Thondamuthur, Madukkarai, Thudiyalur and Annur block for monitoring the activity of tomato pinworm. Pheromone lures were obtained both from Ponalab, Bengaluru and PCI, Coimbatore for the study. The lures were kept in sleeve traps during the cropping period with periodical replacement of lures at 30 days interval.

The observation on number of adults collected through traps, per cent leaf damage and per cent fruit damage were recorded periodically **(Table 111)**. In Thondamuthur block, the damage to leaf was observed upto 30.2% where as the fruit damage was noted in 10.6% fruits and mean adult catch per trap per week was 24 adults. The crop did not show any damage from seedling up to three weeks. The incidence of leaf damage by pinworm was observed (35.4%) in Madukarai also whereas it was absent in Thudiyalur and Annur block.

- The occurrence of pinworm in other crops like potato, brinjal, chilli and tobacco was not observed in any of the survey locations.
- The incidence of pinworm was noted in tomato crop from October 2015 onwards whereas the crop stand during earlier months did not show the presence of pinworm.
- The pinworm incidence was absent in Erode, Perambulur, Cuddalore, Tiruvannamalai districts during random survey.

Table 111. Monitoring the incidence of tomato pinworm, *Tuta absoluta*

Locations	Particulars	Oct 2015	Nov 2015	Dec 2015	Jan 2016	Feb 2016	Mar 2016
Coimbatore district Thondamuthur	% leaf damage	*3.6	6.2	10.4	18.2	30.2	24.6
	% fruit damage	0.0	2.3	3.6	4.8	10.6	8.3
	No. of adults trapped	4.0	6.0	8.0	15.0	24.0	18.0
Thudiyalur	% leaf damage	0.0	0.0	0.0	0.0	0.0	0.0
	% fruit damage	0.0	0.0	0.0	0.0	0.0	0.0
	No. of adults trapped	0.0	0.0	0.0	0.0	0.0	0.0
Madukkarai	% leaf damage	0.0	4.2	9.5	23.6	35.4	28.5
	% fruit damage	0.0	0.0	2.5	4.6	8.6	6.8
	No. of adults trapped	0.0	2.0	5.0	26.0	42.0	31.0
Annur	% leaf damage	0.0	0.0	0.0	0.0	0.0	0.0
	% fruit damage	0.0	0.0	0.0	0.0	0.0	0.0
	No. of adults trapped	0.0	0.0	0.0	0.0	0.0	0.0
Erode district Bhavanisagar	% leaf damage	0.0	0.0	0.0	0.0	0.0	0.0
	% fruit damage	0.0	0.0	0.0	0.0	0.0	0.0
	No. of adults trapped	0.0	0.0	0.0	0.0	0.0	0.0

*Mean of four observations

YSPUHF-Solan

A survey was conducted during May to December 2015 in different tomato growing areas of mid-hills, major tomato growing area, of Himachal Pradesh. The incidence of *Tuta absoluta* was not seen in any of the location upto October 2015. During November, 2015, the pest was recorded for the first time feeding on tomato leaves, flowers, terminal shoots and fruits at the experimental farm of Department of Entomology, Dr YS Parmar University of Horticulture and Forestry, Solan (HP) and later on in the farmers' fields in the adjacent village. Since tomato crop is generally removed from the field during November, one plot was retained at the experimental farm till December end to monitor the pest incidence. Nearly 60% of plants were infested and the number of larvae varied from 5 to 17/infested plant. The identity of the miner was confirmed by Dr V. Shridhar, Principal Scientist, Indian Institute of Horticultural Research, Hessaraghatta, Karnataka, India. During the study mirid bug, *Nesidiocoris tenuis* (Reuter) (Hemiptera: Miridae) was found predating on eggs and early instars of *T. absoluta*. Hymenopteran parasitoid, *Neochrysocharis formosa* was also reared from the collected leaves, but, its association with *T. absoluta* remained doubtful and needs further verification as the serpentine leafminer, *liriomyza trifolii* (Burgess) was also present on the leaves. The pest appeared late towards the end of tomato cropping season, however, during 2016 a more comprehensive survey will be carried out to determine the status of this invasive pest in the state on different hosts as well as the natural enemies associated with the pest.

UAS-Raichur

Survey and Surveillance of Natural enemies of pinworm*, Tuta absoluta* on Tomato

1.	Crop	: Tomato
2.	Hybrid	: Mahyco 401
3.	Date of Transplanting	: 06-09-2015
4.	Area	: 100sqm
5.	Situation	: Unprotected
6.	Observation	: Two traps were installed
7.	Pheromone source	: BCRL, Bangalore
8.	Loading type	: Water pan/yellow sticky trap
9.	Number of traps to be installed	: Two
10.	Period of operation	: Seedling stage to last harvest
11.	Placement in field	: Place the traps at canopy level
12.	Observations	: Count the moth catches at weekly interval
13.	Replacement of pheromone septa	: Every 4-6 weeks.

The incidence of pin worm was noticed from second fortnight of September onwards and continued till the harvest of the crop. The peak activity of pinworm during second fortnight of January month with a highest moth traps of 2413.57 and 2221.14 moths/trap, respectively **(Table 112)**.

Table 112. Survey and Surveillance of Natural enemies of pinworm, *Tuta absoluta* on Tomato

Sl. No.	Year 2015	Std Week	No of moths trapped per trap	
			Trap 1	Trap 2
1	Sep 24-Sep30	39	5.29	3.00
2	Oct 01-Oct 07	40	5.86	1.00
3	Oct 08-Oct 14	41	4.71	2.29
4	Oct 15-Oct 21	42	5.14	4.29
5	Oct 22-Oct 28	43	6.00	6.71
6	Oct 29-Nov 04	44	7.29	6.43
7	Nov 05-Nov 11	45	11.71	7.57
8	Nov 12-Nov 18	46	24.14	12.43
9	Nov 19-Nov 25	47	125.14	30.71
10	Nov 26-Dec 02	48	293.14	77.00
11	Dec 03-Dec 09	49	559.86	113.43
12	Dec 10- Dec 16	50	645.29	160.86
13	Dec 17- Dec 23	51	890.47	268.12
14	Dec 24- Dec 31	52	1093.86	254.57
15	Jan 01-07	1	1480.86	381.00
16	Jan 8-14	2	1536.43	271.43
17	Jan 15-21	3	2221.14	362.00
18	Jan 22-28	4	2413.57	313.86
19	Jan 29-Feb 4	5	2106.00	215.29
20	Feb 5 - 11	6	1868.29	210.43
21	Feb12 - 18	7	1828.57	179.29
22	Feb 19- 25	8	1348.29	118.57
23	Feb 26- Mar 4	9	428.14	98.00
24	Mar 5-11	10	434.29	33.14
25	Mar 12-18	11	317.76	31.88

3. Biological suppression of American pinworm, *Tuta absoluta* on tomato (AAU-A, IIHR, MPKV, PJTSAU, UAS-R and YSPUHF-Solan)

AAU-Anand

Location : Village-Runaj, Dist: Anand.

Experimental details

1. Treatments : 8
2. Replication : 3
3. Design : Randomized Block Design (RBD)
4. Crop / variety : Tomato (Alankar)
5. Plot size : 3 x 2 m^2
6. Spacing : 90 x 60 cm

Details of treatments

T_1 : *Trichogramma achaeae* @ 50000 per release (6 releases)
T_2 : *Trichogramma pretiosum* @ 50000 per release (6 releases)
T_3 : *Metarhizium anisopliae* @ 4 g/ litre ($2x10^8$ cfu g^{-1})
T_4 : *Verticillium lecanii* @ 4 g/ litre ($2x10^8$ cfu g^{-1})
T_5 : *Beauveria bassiana* @ 4 g/ litre ($2x10^8$ cfu g^{-1})
T_6 : Azadirachtin 1500 ppm @ 4 ml/ litre
T_7 : Indoxacarb 15.8 EC 0.032% @ 2 ml/ litre (125 g a.i./ha)
T_8 : Control (water spray)

Note: Isolation distance of 500 meters was maintained between *Trichogramma* treatments.

The treatment application was started at initial appearance of American pinworm and sprays were given during evening hours at fortnightly interval.

1. Randomly selected 10 plants/ 100 m^2 crop area and observed all the leaves for presence of leaf mines caused by larva.
2. Observations were recorded at fortnightly interval from seedling to last harvest.
3. Worked out the leaf damage percentage.
4. Randomly selected 10 plants/ 100 m^2 crop area and observed all the fruits for presence of pin head sized holes/ damage caused by larva.
5. Observations were recorded at fortnightly interval from fruit formation to last harvest.
6. Worked out the fruit damage percentage.
7. Yield of healthy marketable fruits at each picking

IIHR

An experiment was laid out at IIHR, Bangalore to evaluate the biological control agents against *Tuta absoluta* on tomato. The experiment included five treatments replicated five times in RBD design.

Observation details

No.of mines/plant (5 leaves/ plant)
No of fruits damaged
No of healthy fruits
Yield

Treatments

Egg parasitoid (*Trichogramma* spp.) @ 5,000 /ha/week
Nomurea rileyi @ $1x10^9$ spores/ml
Insecticidal check
Control

Since there was no incidence of the pest conclusive results could not drawn. The experiment needs to be repeated.

MPKV

The experiment was laid out on the Research farm of Agril. Entomology Section, College of Agriculture, Pune. Tomato (cultivar: Abhinav) planting was completed on 28/12/2015, and spacing of 90 x 60 cm with a plot size of 3 x 2 m. The trial was laid out with eight treatments and three replications.

The Experimental trial was conducted but there was no incidence of American pinworm, *Tuta absoluta* on Tomato.

PJSTAU-Hyderabad (The experiment is in progress)

Treatments:

T1: *Trichogramma achaeae* @ 50000 per release (6 releases)
T2: *Trichogramma pretiosum* @ 50000 per release (6 releases)
T3: *Metarhizium anisopliae* @ 10^8 conidia/ ml
T4: *Lecanicillum lecanii* @ 10^8 conidia/ ml
T5: *Beauveria bassiana* @ 10^8 conidia/ ml
T6: Azadirachtin 1000 ppm @ 2 ml/lit.
T7: Indoxacarb @ 2 ml/ha
T8: Control

The trial was laid out in RBD with 3 replications. Plot size: 3 x 2 m^2; Treatment applications will be started at initial occurrence of American pin worm. In all, three sprays will be given during evening hours at fortnightly interval.

UAS-Raichur

1.	Crop	: Tomato
2.	Hybrid	: Mahyco 401
3.	Date of Transplanting	: 06-09-2015
4.	Area	: 100 sqm
4.	Design	: RBD
5.	Date of spray	: Two sprays on 12-10-2015 and 28-10-2015

One day before spray the pin worm ranged from 14.06 to 15.12 per top five leaves and it was statistically non significant. A minimum of 2.86 larvae per top five leaves was noticed in *Metarhizium anisopliae* @ 1.5 ml/l and it was followed by *Lecanicillium lecanii* @ 1.5 ml/l and *Beauveria bassiana* @ 1.5 ml/l which recorded 3.18 and 3.64 larvae per top five leaves, respectively. Per cent fruit damage was also indicated that *Metarhizium anisopliae* @ 1.5 ml/l recorded lowest damage of 5.32% and it was followed by *Lecanicillium lecanii* @ 1.5 ml/l and *Beauveria bassiana* @ 1.5 ml/l which recorded 6.68 and 7.14% fruit damage, respectively. *Metarhizium anisopliae* @ 1.5 ml/l recorded 25.84 t/ha fruit yield and it was followed by *Lecanicillium lecanii* @ 1.5 ml/l and *Beauveria bassiana* @ 1.5 ml/l which recorded 23.36 and 20.18 t/ha **(Table 113)**.

Table 113. Biological suppression of American pinworm, *Tuta absoluta* on tomato

Sl. No.	Particulars	Dosage (ml/l)	Number of larvae (Top 5 leaves)		Fruit damage (%)*	Fruit yield (t/ha)
			1 DBS	7 DAS		
1	*Metarhizium anisopliae* (1 x 10^8 conidia/g)	1.50	14.18	2.86 (1.83)	5.32 (13.34)	25.84
2	*Lecanicillium lecanii* (1 x 10^8 conidia/g)	1.50	14.86	3.18 (1.92)	6.68 (14.98)	23.36
3	*Beauveria bassiana* (Bb14) @ 1 x 10^8 conidia/g	1.50	15.02	3.64 (2.03)	7.14 (15.50)	20.18
4	Azadirachtin 1000 ppm @ 2 ml/l	2.0	14.64	2.16 (1.63)	3.84 (11.30)	27.98
5	Indoxcarb 15 EC	0.30	14.06	1.02 (1.23)	1.94 (8.01)	29.06
7	Untreated control	--	15.12	12.86 (3.66)	20.18 (26.69)	17.36
S Em +			**0.31**	**0.03**	**0.35**	**0.28**
CD (P=0.05)			**NS**	**0.10**	**1.05**	**0.84**
CV %			**11.98**	**10.46**	**11.34**	**12.16**

DBS: Day before spray DAS: Day after spray; Figures in parentheses are square root transformed values
*Figures in parentheses are arcsine transformed values

YSPUHF-Solan (The experiment is in progress)

Treatment details

T1: *Trichogramma achaeae* @ 50000 per release (6 releases)
T2: *Trichogramma pretiosum* @ 50000 per release (6 releases)
T3: *Metarhizium anisopliae* @ 10^8 conidia/ ml
T4: *Lecanicillum lecanii* @ 10^8 conidia/ ml
T5: *Beauveria bassiana* @ 10^8 conidia/ ml
T6: Azadirachtin 1000 ppm @ 2 ml/l
T7: Indoxacarb @ 2 ml/l
T8: Control

The trial will be laid out in RBD with 3 replications. Plot size: 3 x 2 m^2; Treatment applications will be started at initial occurrence of American pin worm. In all, three sprays will be given during evening hours at fortnightly interval.

1. Randomly selected 10 plants per 100 m^2 crop area and observed all the leaves for presence of leaf mine caused by larva.
2. Observations will be recorded at weekly interval from seedling to last harvest.
3. Work out the leaf damage percentage.
4. Randomly selected 10 plants per 100 m^2 crop area and observed all the fruits for the presence of pin head sized holes/damage caused by larva.
5. Observations will be recorded at weekly interval from fruit formation to last harvest. Work out the fruit damage percentage

4. Biological control of brinjal mealy bug, *Coccidohystrix insolitus* (TNAU)

Name of the farmer : Mr.Natarajan,
Location : Kunnathur, Annur block
Variety : Purple local
Date of planting : 18.7.2015
Replication : Three
Plot size : 4 X 5 m
No. of releases of predator/ insecticide treatment: Two (18.9.2015 and 4.10.2015)

Treatment details

T_1 :Release of *Cryptolaemus montrouzieri* @ 1500/ha
T_2 :Release of *Scymnus* @ 1500/ha
T_3 :Release of *Brumus suturoides* @ 1500/ha
T_4 :*Verticillium lecanii* @ 10^8 cfu /ml
T_5 :*Chrysoperla* @ 50,000 first instar grubs/ha
T_6 :Profenphos 50 EC @ 2ml /L
T_7 :Control

Observations on mealybug were made on top 3 leaves/ plant. Number of predators /plant was noted. Yield data at harvest recorded.

The observations on the population of mealybug, C*occidohystrix insolitus* was recorded prior to treatment and it ranged from 30 -57 numbers per plant. Different treatments were imposed as per schedule at 15 days interval. The predators, *viz*., *Cryptolaemus*, *Scymnus* and *Brumus* were found superior in controlling the mealybug population lesser than other treatments including white halo fungus (*L. lecanii*) and *Chrysoperla*. However, the population of mealybugs in insecticide treated plot was low and significantly superior to the population in plots released with predators. Among the coccinellid predators studied, population of *Cryptolaemus* in field was higher as compared to other coccinellids. The fruit yield in plots released with different coccinellids ranged 62.4 - 65.8 t/ha and found on par with each other. The highest yield of 68.5 t/ha recorded in insecticide treated plot. Lowest yield of 56.6 t/ha was recorded in untreated control **(Table 114)**.

Table 114. Biological control of brinjal mealybug, *Coccidohystrix insolitus*

Treatments	Pre Treatment	15 days after 1st release /spray		15 days after 2nd release /spray		Yield t/ha
	Mealybug/ Plant	Mealybug / Plant	Predator/ 10 Plants	Mealybug / Plant	Predator/ 10 Plants	
Release of *Cryptolaemus* @ 1500/ha	56.9[a] (48.97)	28.46[b] (32.24)	3.6	3.24[b] (10.37)	6.8	65.8[b]
Release of *Scymnus* @ 1500/ha	45.27[a] (42.29)	31.14[bc] (33.92)	4.5	16.6[c] (24.04)	5.3	65.1[b]
Release of *Brumus suturoides* @ 1500/ha	48.57[a] (44.18)	32.40[c] (34.70)	3.0	17.53[c] (24.75)	5.1	62.4[b]

Verticillium lecanii @ 10^8 cfu /ml	36.73[a] (37.29)	36.96 [e] (37.42)	1.2	29.30 [e] (32.77)	3.7	59.2 [c]
Chrysoperla 50,000 first instar grubs/ha	46.8[a] (43.17)	34.60 [d] (36.10)	2.1	24.63 [d] (29.74)	4.3	62.4[c]
Profenophos @ 2 ml/l	30.0[a] (33.21)	9.8 [a] (18.24)	0.0	1.93 [a] (7.99)	0.0	68.50 [a]
Control	35.53 [a] (36.57)	62.82 [f] (52.43)	1.3	114.73 [f] (74.82)	3.0	56.6[d]
CD (P= 0.05)		4.32	-	3.78	-	-

5. Biological suppression of shoot and fruit borer, *Leucinodes orbonalis* in brinjal (MPKV)

The experiment was laid out on the Research farm of Agril. Entomology Section, College of Agriculture, Pune. Transplanting of brinjal seedlings var. Panchaganga was done on 15.2.2016 at 75 x 60 cm spacing in 3 x 2 m^2 plot size. The trial was laid out with eight treatments and three replications.

The experiment trial is in progress.

6. Validation of different BIPM modules against shoot and fruit borer, *Leucinodes orbonalis* in brinjal (PAU)

The field experiment to validate different BIPM modules against shoot and fruit borer, *Leucinodes orbonalis* in brinjal was conducted at Entomological Research Farm PAU, Ludhiana. The nursery of the brinjal (Var. Punjab Nagina) was sown in the second week of March 2015 and the plants were transplanted on May 13, 2015 with plant to plant spacing of 60 cm and row to row spacing of 45 cm. Each block was further divided into sub-plots as replicates. The crop was grown as per PAU recommendations. The following different BIPM modules along with farmers practice and untreated control were evaluated. Different BIPM sub-treatments were given at weekly interval.

Treatment details

T1:*Trichogramma chilonis* (*Tc*) @ 50,000/ha, six releases (weekly interval)
T2:*Trichogramma chilonis* + Neem oil 1% (*Tc* + *Tc* + Nm + *Tc* + *Tc* + Nm)
T3:*Trichogramma chilonis* + *Bacillus thuringiensis* @ 1 Kg/ha (*Tc* + *Tc* + *Bt* + *Tc* + *Tc* + *Bt*)
T4:*Trichogramma chilonis* + Neem oil 1% + *Bacillus thuringiensis* @ 1 Kg/ha (*Tc* + Nm + *Bt* + *Tc* + Nm + *Bt*)
T5:Neem oil 1% + *Bacillus thuringiensis* @ 1 Kg/ha (Nm + Nm + *Bt* + Nm + Nm + *Bt*)
T6: Farmers practice (Three sprays at fortnightly interval: Quinalphos 25 EC @ 2000 ml/ha + Triazophos 40 EC @ 1250 ml/ha + Quinalphos 25 EC @ 2000 ml/ha)
T7: Untreated control

The observations were recorded on incidence of brinjal fruit and shoot borer in terms of shoot and fruit damage at weekly intervals. Total shoots, damaged shoot, total fruits and damaged fruits were counted from five randomly selected plants in each sub-plot at each observation and per cent incidence was worked out. The yield of marketable fruits per plot at each picking was pooled and has been expressed as quintals per ha.

The data in **Table 115** indicated that all the treatments were significantly better than control in reducing the incidence of brinjal fruit and shoot borer. The lowest incidence in terms of shoot (5.21%) and fruit damage (7.13%) was recorded in chemical control treatment. It was followed by BIPM module (T4) consisting two releases of *T. chilonis* as well as application of Neem oil (2 sprays) and *B. thuringiensis* (2 sprays) and it was at par with T5 (BIPM with Neem + *Bt*). The yield was also significantly higher in chemical control (313.9 q/ha) followed by T4 (278.4 q/ha), T5 (272.0 q/ha) and T3 (266.1 q/ha). However, significantly lower yield was recorded in untreated control (205.7 q/ha).

Table 115. Effect of different BIPM modules on infestation of brinjal fruit and shoot borer, *L. orbonalis* and yield of brinjal

Tr. no.	Treatments	Shoot damage (%)	% reduction over control	Fruit damage (%)	% reduction over control	Yield (q/ha)	% increase over control
T1	BIPM with *T. chilonis*	11.22^{e}	11.65	22.54^{e}	9.59	219.1^{d}	6.51
T2	BIPM with *T. chilonis* + Neem	9.44^{d}	25.67	18.35^{d}	26.39	250.9^{c}	21.97
T3	BIPM with *T. chilonis* + *Bt*	8.66^{c}	31.81	14.40^{c}	42.24	266.1^{b}	29.36
T4	BIPM with *T. chilonis* + Neem + *Bt*	7.49^{b}	41.02	13.63^{b}	45.33	278.4^{b}	35.34
T5	BIPM with Neem + *Bt*	8.20^{c}	35.43	14.01^{bc}	43.80	272.0^{bc}	32.23
T6	Chemical control	5.21^{a}	58.98	7.13^{a}	71.40	313.9^{a}	52.60
T7	Untreated control	12.70^{f}	-	24.93^{f}	-	205.7^{e}	-

*Average of seven observations at weekly interval; Mean followed by common letters in a column did not differ significantly at p=0.05 (LSD test)

7. Development of Biocontrol based IPM module against, *Leucinodes orbanalis* of Brinjal (AAU-J)

Location : Farmers field, Dangdhora, Titabar, Jorhat
Plot size : 500 sq.m
Crop : Brinjal
N:P:K : 50:50:50
Variety : JC-1
Date of Planting : 13.10.2015
Replication : 10
Treatments : 3

T1=

- Application of MOC @ 250 kg /ha 5 days before transplantation of crop
- Use of sex pheromone traps @ 10 /ha for *L. orbanalis*
- Mechanical collection and destruction of infested shoots and fruits
- Six releases of *Trichogramma chilonis* @ 10,00,000 /ha /week at 10 days interval
- Spray of NSKE 5% (three round of spray from vegetative statge at 15 days interval)
- Two spray of *Bt* @ 1kg /ha (before flowering and 10 days after flowering)

T2 = Farmers practice (chemical module) Alternate spray with profenofos @ 750 g *a.i*/ha and cypermethrin @ 50 g a.i /ha

The field experiment on the management of shoot and fruit borer, *Leucinodes orbanalis* was conducted on variety "JC1" at farmer's field, Dangdhora, Titabar, Jorhat.

The BIPM package was tested to compare with farmers practice (chemical control). The experimental plots were subdivided into 10 subplots and considered each subplot as individual replication. Post treatment count for per cent infestation of shoot and fruit was recorded from 10 randomly selected plants from each subplot at weekly interval after 30 DAP. Egg parasitism by *Trichogramma chilonis* was also recorded by placing sentinel egg cards of *Corcyra* at five spots in each treatments block. Data on per cent fruit damage of marketable fruits per plot at each picking was summed up and converted to q/ha.

The per cent shoot (9.5) and fruit (17.7) damage was minimum in BIPM package as compared to farmers practice (chemical control) where the per cent shoot and fruit damage were 13.0 and 20.0, respectively. The highest shoot and fruit damage was 20.6 and 29.5% recorded in untreated control plot. It was observed that all the treatments differed significantly from each other in respect of shoot and fruit damage except in yield parameter. However, four alternate sprayings of cypermethrin @ 50 g a.i /ha and profenofos @ 750 gm a.i/ha at fortnightly interval found superior in reducing the fruit infestation (20.0%) and gave maximum yield (208.7 q/ha) of marketable brinjal followed by BIPM package with 203.50 q/ha and both the treatments were on par with each other **(Table 116)**. Minimum yield of 125.72 q/ha recorded in untreated check.

Table 116. Effect of BIPM packageagainst *Leucinodes orbanalis* of Brinjal

Treatment	%shoot damage*	% fruit damage	% Parasitism	Yield (q/ha)
BIPM	9.5^{c} (17.86)	17.7^{c} (24.83)	12.4	203.50^{a}
Farmers practice	13.0^{b} (20.97)	20.0^{b} (26.97)	-	208.7^{a}
Untreated check	20.6^{a} (26.90)	29.5^{a} (32.88)	-	125.72^{b}
CD	2.55	1.38	-	7.55
CV (%)	12.40	5.24	-	4.48

*Mean of three observations, Figures in parenthesis are transformed angular values
Means followed by the same letter in a column are not significantly different

8. Bioefficacy evaluation of EPN formulations of NBAIR against ash weevil in brinjal (TNAU)

Name of the Farmer : Th.Manikandan, Madathur
Variety : Purple local
No of replication : 3
Plot size : 5 × 8 m

Treatment details

T1: Soil application of EPN WP formulation of NBAIR @ 20 kg/ha
T2: Soil application of *Metarhizium anisopliae* NBAIR formulation @ 2.5 kg + 250 kg FYM/ha
T3: Soil application of *Metarhizium anisopliae* TNAU formulation @ 2.5 kg + 250 kg FYM/ha
T4: Soil application of EPN (20 kg/ha) + *Metarhizium anisopliae* NBAIR @ 2.5 kg + 250 kg FYM/ha
T5: Soil application of EPN @ 20 kg/ha + *Metarhizium anisopliae* TNAU @ 2.5 kg + 250 kg FYM/ha
T6: Neem cake @ 100 kg/ acre as amendment in basal and one month after planting.
T7: Soil drenching with Chlorpyriphos @ 5 ml /l of water
T8: Control

A field trial to evaluate the EPN formulations of NBAIR against ash weevil in brinjal was conducted with eight treatments and three replications in farmers holding at Madathur. The field experiment was laid out in RBD with plot size of 40 m^2 per treatment. The treatments were imposed 45 days after transplanting. Observations on leaf damage by ash weevil and adult weevil harboured per plant were recorded at the time of treatment and after 30 and 45 days of treatment application. The data gathered on leaf damage and population of adult weevil were statistically analysed. The results showed that application of EPN 20 kg/ha along with *Metarhizium anisopliae* (NBAIR formulation) @ 2.5 kg in 250 kg FYM/ha was superior next to soil drenching of chlorpyriphos at 5ml/litre of water.

The reduction of adult weevil population over control was maximum (84.06%) in chlorpyriphos drenching followed by soil application of EPN along with *Metarhizium anisopliae* IPL (International Panacea Limited) formulation (76.36%) followed *Metarhizium anisopliae* NBAIR formulation (74.32%). Mean leaf damage of 10.2% on 45 DAT was observed in Chlorpyriphos soil drenching followed by 11.4% in soil application of EPN along with *Metarhizium anisopliae* NBAIR formulation **(Table 117)**.

Table 117. Efficacy of EPN formulations of NBAIR against ash weevil in brinjal

Treatments	Leaf damage (%)			Population of ash weevil / plant			
	Pre treatment	30 DAT	45 DAT	Pre treatment	30 DAT	45 DAT	Per cent reduction over control
T1: Soil application of EPN (NBAIR) @ 20 kg/ha	18.44^{a}	20.40^{cd}	15.55^{c}	8.62^{a}	10.30^{d}	7.46^{c}	47.50
T2: Soil application of *Metarhizium* (NBAIR) @ 2.5 kg + FYM 250 kg/ha	22.05^{a}	18.60^{c}	15.24^{c}	6.84^{a}	6.52^{c}	4.14^{b}	63.30
T3 : Soil application of *Metarhizium* (IPL) @ 2.5 kg + FYM 250 kg/ha	28.62^{a}	23.82^{e}	19.7^{d}	7.65^{a}	5.48^{bc}	4.52^{b}	64.16
T4 : T1 + T2	15.77^{a}	13.64^{b}	11.4^{ab}	5.48^{a}	4.62^{b}	2.32^{ab}	74.32

T5 : T1+T3	24.64[a]	21.56[d]	13.5[b]	6.62[a]	4.80 [b]	2.58 [ab]	76.36
T6 : Neem cake @ 250 kg/ha	19.53[a]	17.43[c]	14.8[c]	6.26[a]	5.34 [bc]	4.84 [b]	53.10
T7 : Soil drenching chlorpyriphos @ 5 ml/l	28.38[a]	8.68[a]	10.2[a]	8.83[a]	1.82[a]	2.12 [a]	84.06
T8 : control	26.24[a]	31.6[f]	38.5[e]	7.54[a]	10.64 [d]	12.4 [d]	-

Means followed by a common letter in a column are not significantly different by DMRT
*Mean of three replications

9. Bio-efficacy of microbial insecticides against *Spodoptera litura* in cabbage (AAU-A)

Location : Agronomy farm, BACA, Anand Agricultural University, Anand.
Variety : S-92
Season : *Rabi* 2015

Experimental details:

1. Treatments : 10
2. Replications : 3
3. Design : RBD
4. Spacing : 45 x 45 cm

Details of treatments

T_1 : *Bacillus thuringiensis* (2×10^8 cfu g^{-1}) 1.0 kg/ha
T_2 : *Bacillus thuringiensis* (2×10^8 cfu g^{-1}) 2.0 kg/ha
T_3 : *Beauveria bassiana* (2×10^8 cfu g^{-1}) @ 30 g /10 litres water
T_4 : *Metarhizium anisopliae* (2×10^8 cfu g^{-1}) @ 30 g /10 litres water
T_5 : *Metarhizium anisopliae* (2×10^8 cfu g^{-1}) @ 40 g /10 litres water
T_6 : *Nomurea rileyi* (2×10^8 cfu g^{-1}) @ 30 g /10 litres water
T_7 : *Nomurea rileyi* (2×10^8 cfu g^{-1}) @ 40 g /10 litres water
T_8 : *SI* NPV (1×10^{10} POB/ha)
T_9 : Recommended insecticide (Indoxacarb 15.8 EC @ 20 ml/ 10 litres water)
T_{10} : Control (water spray)

Sufficient infestation was not found in experimental area; hence conclusion could not be drawn. Next year the same experiment will be conducted in laboratory and conclusion will be drawn.

10. Role of habitat manipulation on natural enemies of cabbage pests (AAU-J)

Location: Horticultural Orchard, AAU, Jorhat
Plot size: 137.5 sq.m. (27.5X 5.5)
Treatments: 5
Design: Exported Block Design

T1 = Cabbage intercropped with mustard and cowpea
T2 = Cabbage intercropped with mustard and sorghum as border crop
T3 = cabbage intercropped with cowpea and sorghum as border crop
T4 = cabbage with sorghum as border crop
T5 = cabbage as sole crop (untreated check)

Larval counts of lepidopteran pests, sucking pests and natural enemies were randomly collected from 5 plants from each treatment at 10 days interval starting from 30 DAP. Moreover, to collect the parasitoids from eggs and immature stages of lepidopteran pests, the eggs and larvae were kept in the laboratory for emergence of parasitoids. Yield data of cabbage was recorded individually.

The incidence of DBM in various treatments is given in **Table 118 & 119**. Significantly, minimum larval population of *P. xylostella* (1.90/plant) was recorded in T1 (cabbage intercropped with mustard and cowpea), followed by T3 (cabbage intercropped with cowpea and sorghum as border crop) with 2.72 larva/plant and T2 (cabbage intercropped with mustard and sorghum as border crop) with 2.79 larva/plant after 70 DAP, respectively, however, later two treatments (T3 and T2) were on par with each other. Highest larval population of 4.02/plant was recorded in treatment T5, where only cabbage was grown. Relatively, more number of *B. brassicae* with 5.04/ plant was observed in treatment T5 (cabbage as sole crop) and 4.84/ plant in T4 (cabbage with sorghum as border crop). The minimum number of 2.10 aphid /plant was observed in T1 (cabbage intercropped with mustard and cowpea) which was on par with T3 (cabbage intercropped with cowpea and sorghum as border crop).

Significantly, higher number of coccinellids of 1.77/plant was recorded in T1 (cabbage intercropped with mustard and cowpea). The next best treatment was T3 (cabbage intercropped with cowpea and sorghum as border crop) and T4 (cabbage with sorghum as border crop) with 1.25 and 1.14 coccinelids/plant, respectively. Lowest number of 0.86/plant was observed in treatment T5 (cabbage as sole crop). The yield data however indicated that maximum yield of 174.92 q/ha was obtained in T1 (cabbage intercropped with mustard and cowpea) followed by 174.4 q/ha and 166.12 q/ha in treatment T2 (cabbage intercropped with mustard and sorghum as border crop) and T4 (cabbage with sorghum as border crop) respectively. All the treatments in case of yield parameters were on par with each other **(Table 119)**.

Table 118. Effect of habitat manipulation in cabbage on *Plutella xylostella*

Treatment	Larvae/plant*					Average larval population/plant
	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP	
T1	1.39[c]	1.64[c]	2.42[c]	2.86[c]	1.22[b]	1.90[d]
T2	2.84[b]	2.95[b]	3.04[bc]	3.40[bc]	1.72[b]	2.79[c]
T3	1.63[c]	2.00[c]	2.82[c]	2.96[c]	1.20[b]	2.72[c]
T4	3.34[ab]	3.57[ab]	3.68[ab]	3.69[b]	3.20[a]	3.49[b]
T5	3.50[a]	3.86[a]	4.13[a]	4.88[a]	3.75[a]	4.02[a]
CD	0.50	0.62	0.69	0.58	0.61	0.41
CV (%)	14.74	16.47	16.05	12.07	20.29	10.79

*Mean of two observation in between two sampling occasion

Table 119. Effect of habitat manipulation in cabbage on *Brevicoryne brassicae,* coccinelids and yield

Treatment	Aphid/plant*	Coccinelids / plant*	Yield(q/ha)
T1	2.10[c]	1.77[a]	174.92
T2	3.92[b]	0.70[c]	174.4
T3	2.35[c]	1.25[b]	163.4
T4	4.84[a]	1.14[b]	166.12
T5	5.04[a]	0.86[c]	160.84
CD	0.76	0.20	NS
CV (%)	15.47	13.33	

*Mean of two observation in between two sampling occasion

11. Efficacy of *Bt* strains against Diamond back moth in Cauliflower (TNAU)

Name of the Farmer : Th.Jeyaprakash, Nanjundapuram
Variety : NS131
Date of Transplanting :12.08.2015
I spray :27.09.2015
II spray :11.10.2015
III spray : 26.10.2015
Date of harvest :8.11.2015

Treatment deatils

T_1 PDBC-BT1 @ 1% spray
T_2 PDBC-BT1 @ 2% spray
T_3 NBAII-BTG4 @ 1% spray
T_4 NBAII-BTG4 @ 2% spray
T_5 *Beauveria bassiana* @ 2.0 kg/ha
T_6 NSKE 5%

T_7 Chlorpyriphos @ 0.04 % spray
T_8 control

Spray schedule **:** 3 sprays at 15 days interval
Design : RBD
Replications : 3
Plot size : 5 x 8 m.

Observation

1. Pest population at 15 days interval
2. Yield data at harvest

As per the protocol three rounds of *Bt* strains of PDBC BT1 and NBAII BTG 4 were applied as 1 and 2% concentrations at 15 days interval. The larval population of DBM ranged from 12-19/plant at 45 days after transplanting. The observation on larval population revealed that both the *Bt* strains were effective in reducing the larval population upto 79.23% over control after I round of spray **(Table 120)**. But, these *Bt* strains were found less effective as compared to insecticides which had 82.7% reduction of larval population over control. After three rounds of spraying, the *Bt* strains were able to reduce the larval population of DBM upto 78.65% (NBAII BTG 4 @ 2%) as compared to 86.45% reduction of larval population in insecticide in treated plot **(Table 120)**. Both the *Bt* strains were on par in their efficacy in checking the larval population of DBM. The other treatments like *Beaveria bassiana* @ 2 kg/ha and NSKE @ 5% showed a reduction of 42-49% after three rounds of spray indicating their moderate efficacy. The curd yield was maximum in insecticide treated plot 11.8 t/ha as compared to *Bt* strains treated plots which ranged 10.6 to 11.4 t/ha. Minimum yield was recorded in untreated check, 8.80 t/ha. The order of efficacy among the *Bt* strains in reductiom of DBM larval population was NBAII BTG4 @ 2% > NBAII BTG4 @ 1% > PDBC BT1 @ 2% > PDBC BT1 @ 1%.

Table 120. Efficacy of B.t strains against Diamondback moth in Cauliflower

Treatments	Pre Treatment	Three days after I spray		Three days after II spray		Three days after III spray		Yield t/ha
	No. of larva / Plant	No. of larva / Plant	% Reduction over control	No. of larva / Plant	% Reduction over control	No. of larva / Plant	% Reduction over control	
PDBC-BT1 @ 1% spray	15.0^{a}	9.7^{c}	54.02	9.0^{d}	40.00	6.0^{d}	54.71	10.60^{cd}
PDBC-BT1 @ 2% spray	15.30^{a}	7.0^{bc}	67.47	6.33^{c}	58.63	4.2^{c}	54.93	10.90^{c}
NBAII-BTG4 @ 1% spray	17.3^{a}	5.7^{b}	76.57	6.7^{c}	61.27	4.3^{c}	56.40	11.20^{bc}
NBAII-BTG4 @ 2% spray	12.67^{a}	3.7^{ab}	79.23	4.0^{b}	68.43	2.7^{b}	78.65	11.40^{b}

Beauveria bassiana @ 2 kg/ha	18.67 [a]	12.0[d]	54.30	12.3[e]	34.12	10.7 [e]	42.70	10.20[d]
NSKE @ 5%	15.67 [a]	13.6[e]	38.29	12.7[e]	18.95	8.0 [de]	48.95	9.90[c]
Chlorpyriphos @ 0.04 % spray	12.33 [a]	3.0[a]	82.70	2.33[a]	81.10	1.7 [a]	86.45	11.80 [a]
Control	12.30 [a]	17.3[f]	-	23.3[f]	-	34.3 [f]	-	8.80[e]

Means followed by a common letter in a column are not significantly different by DMRT.

12. Field evaluation of biocontrol based IPM module against pests of cabbage (*Plutella xylostella, Spodoptera litura, Pieris brassicae*) (PAU)

Treatment details

A. Biocontrol based IPM module:

i. Three releases of *Chrysoperla zastrowi sillemi* @ 5 larvae/ plant against aphids at weekly interval
ii. Planting of mustard crop to collect and destroy eggs of *P. xylostella*
iii. Two sprays of Azadirachtin (5%) against aphids at 15 days interval
iv. Three releases of *Trichogramma pieridis* @ 1,00,000/ ha against *P. brassicae* at seven days interval
v. Mechanical collection and destruction of *P. brassicae* eggs at weekly interval
vi. Three sprays of Delfin WG @ 300 gm/ acre against *Pieris* larvae at weekly interval

B. Chemical control: Spinosad 2.5 SC @ 250 ml/ acre at weekly interval – Three sprays
C. Control (no treatment)

The experiment on field evaluation of biocontrol based IPM module against pests of cabbage (*Plutella xylostella*, *Spodoptera litura*, *Pieris brassicae*) was conducted at Entomological Research Farm PAU, Ludhiana. The cabbage (commercial hybrid) was transplanted during December, 2015. The crop is being monitored for the incidence of lepidopteran pests (*Plutella xylostella*, *Spodoptera litura*, *Pieris brassicae*). *Plutella xylostella*, *Pieris brassicae* and aphid *Lipaphis erysimi* have started appearing during mid March 2016. The pre-treatment data for these pests is being taken and following treatments on need basis will be applied for these pests. The experiment is in progress.

13. Evaluation of fungal pathogens against sucking pest of hot chilli (*Capsicum sinensis*) (AAU-J and IIVR)

AAU-Jorhat

Location : Experimental Farm, Department of Horticulture, AAU, Jorhat
Target pests : *Aphis gossypii, Scirtothrips dorsalis*
Plot Size : 3 m x 3.5 m
Variety : Local
Replication : 4
Date of planting: 27.10.2015
Fertilizer dose : 120:60:60 kg N:P:K/ ha
Spacing : 100 X 100 cm

Tratment details

1. *Metarhizium anisopliae* (AAU strain) : ($1x10^8$ spores /g) @ 5 g/ litre
2. *Beauveria bassiana (*AAU strain*)* : ($1x10^8$ spores /g) @ 5 g/ litre
3. *Metarhizium anisopliae* (Ma-4) NBAIR strain: ($1x10^8$ spores /g) @ 5 g/ litre
4. *Metarhizium anisopliae* (Ma-35) NBAIR strain: ($1x10^8$ spores /g) @ 5 g/ litre
5. *Beauveria bassiana* (Bb-5a) NBAIR strain: ($1x10^8$ spores /g) @ 5 g/ litre
6. *Beauveria bassiana* (Bb-23) NBAIR strain : ($1x10^8$ spores /g) @ 5 g/ litre
7. Imidacloprid @ 15 g a.i./ha
8. Untreated control

Observations were recorded on number of sucking pests (*Aphis gossypii* and *Scirtothrips dorsalis*) before treatment as well as 10 days after each spray on 5 randomly selected plants from each plot at 10 leaves (top, middle and bottom). Three rounds of microbial agents ($1x10^8$ spores/g) @ 5 g/ litre and imidacloprid @ 15 g a.i/ha were sprayed at 15 days interval. Triton X @ 0.1% added as surfactant spray fluid along with microbial pesticides. Spraying was initiated at 35 DAP. The population of sucking pests per ten leaves at 3, 7 and 10 days interval was recorded after each spray. Yield data was recorded at each harvesting.

The results in **Table 121** showed that three spraying of imidacloprid @ 15 g a.i/ha at 15 days interval significantly reduced the mean population of *A. gossypii* and *S. dorsalis* in hot chilli in comparison to different biopesticide tested in the experiment. The mean population of *A. gossypii* and *S. dorsalis* was 4.67 and 2.72/10 leaves in imidacloprid treated plot and gave maximum yield of 50.75 q/ha after third spray. Among the different entomopathogenic fungi, Bb-5a (NBAIR strain) was the next best treatment which reduce the population of *A. gossypii* (8.00/10 leaves) and *S. dorsalis* (3.58/10 leaves) with next higher yield of 42.00 q/ha. However, the rest of the entomopathogenic fungi of NBAIR strains (Ma-4, Ma-35, Bb-23) and local strains (Bb-Biosona, Ma-Biometa) was equally effective after third spray and found to be significantly different from untreated check in reducing the bio suppression of sucking pest population. In untreated control plots, the sucking pests population were persistently high throughout the experimental period. Maximum no. of *A. gossypii* (24.00 /10 leaves) and *S. dorsalis* (12.50 /10 leaves) was recorded in untreated control plot. Minimum yield of 24.13 q /ha was obtained in untreated control plot.

Table 121. Evaluation of different bio-insecticides against sucking pests of hot chilli

Treatments	Pre treatment count (Adults/ 10 leaves)		Post treatment count *			Post treatment count *			Yield (q/ha)
			A. gossypii (Adults/10 leaves)			*S. dorsalis* (Adults/10 leaves)			
	A. gossypi	*S. dorsalis*	Ist spray	IInd spray	IIIrd spray	Ist spray	IInd spray	IIIrd spray	
M. anisopliae (AAU strain)- Biometa	21.56	11.92	14.83^{bc}	12.25^{cd}	10.75^{bc}	8.33^{b}	8.75^{b}	7.00^{b}	31.00^{de}
B. bassiana (AAU strain) - Biosona	19.75	10.58	13.67^{c}	12.25^{cd}	10.00^{c}	7.00^{c}	7.33^{c}	5.83^{c}	34.63^{cd}
M. anisopliae (Ma-4) NBAIR strain	19.72	13.0	14.17^{c}	13.67^{b}	9.91^{c}	8.83^{b}	6.33^{cde}	$5.33d^{c}$	29.50^{e}
M.anisopliae (Ma-35) NBAIR strain	22.59	12.92	16.17^{b}	15.42^{b}	11.08^{b}	9.83^{b}	6.42^{cd}	4.75^{de}	30.38^{e}
B. bassiana (Bb-5a) NBAIR strain	21.42	13.75	11.50^{d}	11.17^{d}	8.00^{d}	7.08^{c}	$5.58d^{e}$	3.58^{gf}	42.00^{b}
B. bassiana (Bb-23) NBAIR strain	20.17	11.08	11.33^{d}	9.84^{e}	8.75^{d}	5.42^{d}	4.75^{e}	4.50^{ef}	37.88^{c}
Imidacloprid	20.34	12.25	8.33^{e}	6.33^{f}	4.67^{e}	4.67^{d}	3.33^{f}	2.72^{g}	50.75^{a}
Untreated control	18.92	10.67	21.00^{a}	22.00^{a}	24.00^{a}	11.75^{a}	13.17^{a}	12.50^{a}	24.13^{f}
CD =0.05	NS	NS	1.99	1.21	1.11	1.11	1.03	1.07	3.78
CV %			9.75	6.41	6.92	9.61	10.06	12.54	7.34

Mean of three observations; Means followed by the same letter in a column are not significantly different

IIVR-Varnasi

Experimental details

Location – Experimental Farm of IIVR, Varanasi
Target pests – Yellow mites (*Polyphagotarsonemus latus*) and thrips (*Scirtothrips dorsalis*)
Plot size – 5 x 6 m^2
Variety – Kashi Anmol
Number of treatments – 6
Replication – 3
Round of application – 3 with 15 days intervals
Date of transplanting – 05/08/2015
Fertilizer dose – 120:60:60 (N:P:K)

T1 = *Metarhizium anisopliae* (Ma-59) IIVR strain 1 x 10^8 cfu/g @ 5 g /lit
T2 = *Beauveria bassiana* (Bb-83) IIVR strain 1 x 10^8 cfu/g @ 5 g /lit
T3 = *Metarhizium anisopliae* (Ma-35) NBAIR strain 1 x 10^8 cfu/g @ 5 g /lit
T4 = *Beauveria bassiana* (Bb-23) NBAIR strain 1 x 10^8 cfu/g @ 5 g /lit
T5 = Imidacloprid 17.8 SL @ 1 ml/3 lit
T6 = Untreated control

The data on number of sucking pests in chilli *viz*., yellow mite (*Polyphagotarsonemus latus* (Banks)) and thrips (*Scirtothrips dorsalis* Hood) were recorded from five tagged plants selected randomly. Three leaves were plucked from bottom, middle and top of each of the randomly selected five plants to count the number of mites and thrips per leaf. The leaves were brought to the laboratory and observations were taken under stereo zoom binocular microscope. Such observations were recorded on one day before and 1, 3 and 5 days after spray (DAS). Three rounds of microbial agents at their respective doses and Imidacloprid 17.8 SL @ 1 ml/3 lit of water was applied. Triton X-100 @ 1 ml/lit was added as surfactant with microbial pesticides. Spraying was initiated at 35 days after transplanting (DAT). The aphids and whiteflies population were negligible during the entire cropping season, hence not considered.

From **Table 122** it is evident that amongst all the entomopathogens, *Beauveria bassiana* (Bb-83) IIVR strain was found most promising against yellow mites in chilli with highest per cent reduction (44.34%) over the control followed by *Metarhizium anisopliae* (Ma-35) NBAIR strain (39.41 PROC). However, amongst all the treatments, Imidacloprid was the best with highest PROC (49.75) and lowest mites population (3.06 / leaf). Similar trend was followed in case of thrips. Native strain of *B. bassiana* (Bb-83) gave highest protection (64.29 PROC) with lowest of 0.9 thrips/leaf than any of the entomopathogens followed by *M. anisopliae* (Ma-35) NBAIR strain and *B. bassiana* (Bb-23) NBAIR strain.

A marked difference in green chilli yield was observed among the different treatments. *B. bassiana* (Bb-83) IIVR strain treated plots registered significantly highest yield (5940 kg/ha) as compared to other entomopathogens including untreated control. *M. anisopliae* (Ma-35) NBAIR strain (5390 kg/ha) and *M. anisopliae* (Ma-59) IIVR strain (5170 kg/ha) were the next in order in terms of yield and differed significantly with the untreated control (3510 kg/ha). However, Imidacloprid 17.8 SL, amongst the all treatments, registered significantly highest yield of 6057 kg/ha.

Table 122. Efficacy of different fungal pathogens against chilli yellow mites and thrips

Treatments	Pre-treatment count (per leaf)		Post-treatment* Number of Yellow mites/leaf					Post-treatment* Number of thrips /leaf					Yield (Kg/ ha)
	Mites	Thrips	1st spray	2nd spray	3rd spray	Pooled mean	ROC# (%) (Avg)	1st spray	2nd spray	3rd spray	Pooled mean	ROC# (%) (Avg)	
T1	8.23^{a}	3.11^{a}	5.04^{b}	4.67^{b}	2.17^{ab}	3.96^{a}	34.97	1.54^{b}	1.41^{b}	1.11^{b}	1.35^{b}	46.43	5170^{d}
T2	8.11^{a}	2.89^{a}	5.16^{b}	3.77^{a}	1.24^{a}	3.39^{a}	44.34	1.09^{a}	0.97^{a}	0.63^{a}	0.90^{a}	64.29	5940^{b}
T3	7.98^{a}	3.08^{a}	5.36^{b}	4.34^{b}	1.38^{a}	3.69^{a}	39.41	1.37^{ab}	1.25^{ab}	0.91^{b}	1.18^{ab}	53.18	5390^{c}
T4	8.56^{a}	2.79^{a}	6.08^{c}	4.88^{bc}	1.50^{a}	4.15^{ab}	31.86	1.71^{c}	1.53^{b}	1.30^{bc}	1.51^{b}	40.08	4840^{e}
T5	9.16^{b}	3.24^{a}	3.68^{a}	3.57^{a}	1.94^{a}	3.06^{a}	49.75	0.88^{a}	0.67^{a}	0.39^{a}	0.65^{a}	74.21	6057^{a}
T6	9.23^{b}	3.44^{ab}	7.63^{d}	6.58^{d}	4.05^{c}	6.09^{c}	--	2.89^{d}	2.55^{c}	2.13^{c}	2.52^{c}	--	3510^{f}

SEm (±)	0.27	0.25	0.27	0.21	0.31	0.32	--	0.13	0.16	0.17	0.21	--	12.91
LSD (0.05)	0.69	0.53	0.59	0.44	0.77	0.71	--	0.31	0.35	0.36	0.44	--	29.57

*Means of five observations; #ROC= Reduction over control
Means followed by the same letters in a column are not significantly different

14. Development of bio-intensive IPM package for the suppression of insect pests of capsicum under field conditions (YSPUHF)

An experiment was conducted at the experimental farm of the Department of Entomology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan to evaluate C*hrysoperla zastrowi sillemi* (1 larva/plant), *Lecanicillium lecanii* (5 g/L of 10^8 conidia/g), Azadirachtin (1500 ppm; 3 ml/L) and methyl demeton (0.025%) against the green peach aphid, *Myzus persicae* on capsicum (cv. Solan Bharpur). Each treatment was replicated 4 times in a randomized block design. Aphid population was counted before and 7 days after the application of each treatment. Data thus recorded were converted to per cent reduction in population over control which was further corrected through Abbott's formula to get per cent reduction over control. All the treatments were only moderately and statistically equally effective against the aphid resulting in 46.2 to 62.7% reduction in the aphid population over control **(Table 123)**.

Table 123. Evaluation of bio-control agents against *Myzus persicae* on capsicum under field conditions

Sl. No.	Treatment	Reduction (%) in aphid population over control
1	*Chrysoperla* (1 larva/plant)	46.2 (42.8)
2	*Lecanicillium lecanii* (5g/L of 10^8 conidia/g)	58.8 (52.2)
3	Azadirachtin (1500 ppm; 3ml/L)	55.8 (48.4)
4	Methyl demeton (0.025%)	62.7 (52.8)
	CD (p=0.05)	NS
	CV (%)	18.2

Figures in parentheses are angular transformed values

15. Biological suppression of fruit borer, *Earis vitella* in okra (MPKV)

The experiment was laid out at Research farm of Agril. Entomology Section, College of Agriculture, Pune. Transplanting of brinjal seedlings var. Panchaganga was done on 15.2.2016 at 75 x 60 cm spacing in 3 x 2 m plot size. The trial was laid out with eight treatments and three replications. The experiment trial is in progress.

16. BIPM in okra (OUAT)

T_1 : Application of *Beauveria bassiana* @ 1 x 10^8 cfu at 15 and 30 DAG (days after germitation) followed by spray of *Bt* @ 1.5 kg/ha at 40 and 55 DAG
T_2 : Application of *Metarrhizium anisopliae* @ 1 x 10^8 cfu and *Bt* @ 1.5 kg/ha as in T_1

T_3 : Application of *Verticillium lecanii* @ 1 x 10^8 cfu and *Bt* @ 1.5 kg/ha as in T_1.
T_4 : Application of Azadirachtin @ 4% at 15 and 30 DAG and *Bt* as in T_1.
T_5 : Application of *Beauveria bassiana* @ 2 x 10^8 cfu at 15 and 30 DAG followed by *Bt* @ 1.0 kg/ha at 40 and 55 DAG.
T_6 : Application of *Metarrhizium anisopliae* @ 2 x 10^8 cfu and Bt @ 1.0 kg/ha as inT_5.
T_7 : Application of *Verticillium lecanii* @ 2 x 10^8 cfu and *Bt* @ 1.0 kg/ha as in T_5.
T_8 : Application of Azadirachtin @ 5% at 15 and 30 DAG and *Bt* @ 1.0 kg/ha as in T_5.
T_9 : Application of Acetamiprid @ 0.025% and spinosad @ 0.4% as in T_1.
T_{10} : Untreated control.

Design	: RBD
No. of replications	: 3 (Three)
Date of sowing	: 10.08.2015
Okra variety	: Arka anamika
Spacing	: 50 cm x 30 cm
Plot size	: 3.5 m x 3.0 m
Fertilizer dose	: N:P:K (200:100:100 kg/ha)
Manuring	: 10 tonnes/ha
No. of sprayings	: 3 (Three) at 30, 40 and 55 DAG.
Harvesting Period	: 1.10.2015 to 31.10.2015.

The jassid population in different treatments one day before spraying and untreated control ranged from 5.0 – 7.67. There was significant reduction in jassid population due to the application of different biopesticides. All the tested fungal biopesticides at a dosage of 2 x 10^8 cfu and Azadirachtin 5% are comparable to chemical pesticides acetamiprid and spinosad **(Table 124)**. The aphid population ranged from 7.30-8.47 in different treatments one day before spraying and untreated control. The aphid population in almost all the treatments was nil during third spraying. The pesticidal effect was only noticed during the 1^{st} and 2^{nd} spraying. Like jassids, the reduction in aphid population due to fungal biopesticides @ 2 x 10^8 cfu and Azadirachtin 5% was comparable to the chemical pesticides acetamiprid and spinosad **(Table 125)**.

The average fruit borer infestation on weight and number basis in untreated control was 69.52 and 55.18%, respectively. Lowest fruit borer (2.56% by weight) damage was noticed in chemical insecticide treatment. The performance of all the biopesticides with respect to borer infestation except *Beauveria bassiana* remained at par with the chemical insecticide. Significantly higher borer infestation (27.88%) by weight was noticed in *B. bassiana* treatments. Lowest fruit yield (6.44 t/ha) was recorded in untreated control. The fruit yield of *B. bassiana* and *Verticillium lecanni* application each at 1 x 10^8 cfu followed by *Bt* spray (1.5 kg/ha) remained at par with control **(Table 126)**. All other treatments recorded significantly higher yield than untreated control. Highest yield (9.61 t/ha) was recorded in chemical insecticide treated plots followed by *Metarrhizium anisopliae* @ 2 x 10^8 cfu treatment.

Table 124. Effect of biopesticides on jassids of okra (*Arka anamica*) during Kharif, 2015

Treatments	Jassid population / leaf											
	1DBFS	3DAFS	5DAFS	7DAFS	1DBSS	3DASS	5DASS	7DASS	1DBTS	3DATS	5DATS	7DATS
T_1:*Beauveria Bassiana* @ 1x10^8 cfu followed by Bt 1.5 kg/ha	6.00 (2.54)*	0.49 (0.99)	0.29 (0.88)	0.45 (0.94)	9.00 (3.08)	0.57 (1.55)	1.78 (1.51)	2.03 (1.58)	5.23 (2.39)	1.70 (2.39)	1.59 (1.45)	1.81 (1.52)
T_2:*Metarrhizium anisopliae* @ 1x10^8 cfu followed by Bt as in T1	5.67 (2.48)	0.62 (1.22)	0.47 (0.98)	0.43 (0.97)	9.97 (3.24)	0.53 (1.50)	1.66 (1.45)	1.90 (1.53)	5.00 (2.35)	0.93 (1.20)	0.84 (1.16)	1.01 (1.23)
T_3: *Verticillium lecanii* @ 1x10^8 cfu followed by Bt as in T1	5.33 (2.41)	0.79 (1.09)	0.66 (1.04)	0.78 (1.07)	8.67 (3.03)	0.80 (1.76)	2.27 (1.66)	2.77 (1.79)	4.70 (2.28)	1.06 (1.24)	0.97 (1.20)	1.16 (1.28)
T_4 : Azadirachtin 4% followed by Bt as in T_1	6.33 (2.61)	0.55 (1.02)	0.46 (0.97)	0.60 (1.02)	9.20 (3.11)	0.77 (1.75)	2.43 (1.71)	2.75 (1.80)	5.07 (2.36)	1.19 (1.29)	1.04 (1.23)	1.27 (1.32)
T_5 : *B. bassiana* @ 2x10^8 cfu followed by Bt 1.0 kg/ha	5.00 (2.35)	0.18 (0.82)	0.11 (0.78)	0.31 (0.85)	9.13 (3.10)	0.30 (1.22)	0.89 (1.18)	1.03 (1.25)	5.13 (2.37)	0.73 (1.21)	0.88 (1.17)	1.06 (1.25)
T_6 : *M. anisopliae* @ 2x10^8 cfu followed by Bt 1.0 kg/ha	6.67 (2.67)	0.26 (0.86)	0.16 (0.81)	0.13 (0.80)	8.70 (3.03)	0.36 (1.30)	1.08 (1.25)	1.30 (1.34)	4.60 (2.26)	0.62 (1.05)	0.53 (1.01)	0.72 (1.09)
T_7 : *V. lecanii* @ 2x10^8 cfu followed by Bt 1.0 kg/ha	7.67 (2.86)	0.26 (0.87)	0.21 (0.84)	0.32 (0.88)	9.33 (3.13)	0.41 (1.34)	1.26 (1.30)	1.53 (1.40)	4.50 (2.24)	0.91 (1.17)	0.79 (1.13)	1.04 (1.23)
T_8 : Azadirachtin 5% followed by Bt as in T_5	7.00 (2.74)	0.29 (0.89)	0.22 (0.85)	0.31 (0.88)	8.33 (2.97)	0.32 (1.24)	0.97 (1.19)	1.22 (1.23)	4.37 (2.21)	0.84 (1.14)	0.77 (1.10)	0.95 (1.19)
T_9 : Acetamiprid 0.025% and Spinosad 0.4% as in T_1	7.33 (2.80)	0.33 (0.89)	0.27 (0.86)	0.35 (0.90)	10.23 (3.27)	0.75 (1.11)	0.64 (1.07)	0.95 (1.20)	4.83 (2.31)	0.71 (1.09)	0.65 (1.07)	0.89 (1.41)
T10 : Untreated control	7.67 (2.86)	7.33 (2.80)	6.27 (2.60)	7.27 (2.66)	9.57 (3.17)	9.63 (3.18)	9.50 (3.16)	9.53 (3.17)	4.77 (2.29)	4.67 (2.27)	4.50 (2.24)	4.07 (2.10)
S.E.(m) ±	- (0.08)	- (0.13)	- (0.10)	- (0.10)	- (0.08)	- (0.12)	- (0.25)	- (0.11)	- (0.02)	- (0.07)	- (0.07)	- (0.11)
C.D.0.05	- (0.22)	- (0.39)	- (0.29)	- (0.29)	- (0.22)	- (0.36)	- (0.75)	- (0.34)	- (0.06)	- (0.20)	- (0.20)	- (0.33)
C.V. (%)	- (4.98)	- (19.86)	- (15.68)	- (15.54)	- (4.18)	- (13.25)	- (29.68)	- (12.07)	- (1.63)	- (8.98)	- (9.24)	- (14.00)

*Figures in parentheses are √(x+0.5) transformed values.

DBFS-Day before 1st spraying, DAFS – Days after 1st spraying, DBSS – Day before 2nd Spraying, DASS – Days after second spraying, DBTS – Day before 3rd Spraying, DATS – Days after 3rd Spraying

Table 125. Effect of biopesticides on aphids of okra (*Arka anamica*) durng *kharif*, 2015

Treat-ments	Aphid population / leaf											
	1DBFS	**3DAFS**	**5DAFS**	**7DAFS**	**1DBSS**	**3DASS**	**5DASS**	**7DASS**	**1DBTS**	**3DATS**	**5DATS**	**7DATS**
T_1	8.23 (2.95)	1.63 (1.46)	1.53 (1.42)	1.76 (1.50)	5.26 (2.39)	1.31 (1.30)	0.89 (1.11)	1.38 (1.33)	0.33 (0.88)	0.67 (1.05)	0.45 (0.96)	0.33 (0.90)
T_2	7.50 (2.83)	2.06 (1.60)	1.94 (1.56)	2.15 (1.63)	5.53 (2.12)	0.64 (1.04)	0.55 (0.99)	0.68 (1.05)	0.67 (1.05)	0.22 (0.83)	0.10 (0.77)	0.10 (0.83)
T_3	7.43 (2.81)	2.25 (1.610	2.10 (1.56)	2.33 (1.64)	6.14 (2.57)	1.53 (1.35)	1.46 (1.33)	1.57 (1.36)	0.67 (1.05)	0.15 (0.80)	0.10 (0.77)	0.10 (0.83)
T_4	8.20 (2.95)	2.06 (1.96)	3.36 (1.93)	3.59 (1.99)	5.79 (2.50)	1.69 (1.39)	1.61 (1.37)	1.74 (1.41)	0.33 (0.88)	0.22 (0.83)	0.11 (0.78)	0.00 (0.71)
T_5	7.30 (2.79)	0.31 (0.89)	0.23 (0.85)	0.35 (0.91)	5.45 (2.10)	0.71 (1.04)	0.62 (1.17)	0.74 (1.05)	0.00 (0.71)	0.15 (0.80)	0.10 (0.78)	0.00 (0.71)
T_6	8.47 (2.99)	1.02 (1.23)	0.90 (1.18)	1.11 (1.27)	5.65 (2.48)	0.31 (0.89)	0.24 (0.85)	0.35 (0.91)	0.33 (0.88)	0.22 (0.83)	0.11 (0.78)	0.17 (0.81)
T_7	7.50 (2.83)	1.38 (1.32)	1.25 (1.27)	1.53 (1.38)	5.53 (2.45)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.67 (1.05)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_8	7.43 (2.81)	2.24 (1.64)	2.12 (1.60)	2.34 (1.67)	5.77 (2.50)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.00 (1.17)	0.11 (0.78)	0.00 (0.71)	0.00 (0.71)
T_9	7.77 (2.87)	0.02 (1.39)	0.02 (1.05)	0.05 (0.74)	5.91 (2.53)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_{10}	7.63 (2.85)	7.57 (2.84)	7.23 (2.78)	7.37 (2.80)	5.19 (2.38)	5.09 (2.36)	5.27 (2.39)	5.17 (2.35)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
S.E.(m)±	-- (0.07)	-- (0.27)	-- (0.17)	-- (0.23)	-- (0.14)	-- (0.16)	-- (0.18)	-- (0.17)	-- (0.24)	-- (0.09)	-- (0.06)	-- (0.05)
$C.D._{0.05}$	-- (0.21)	-- (0.81)	-- (0.51)	-- (0.68)	-- (0.41)	-- (0.49)	-- (0.53)	-- (0.51)	-- (0.71)	-- (10.28)	-- (0.18)	-- (0.15)
C.V.(%)	-- (4.24)	-- (29.72)	-- (19.54)	-- (27.42)	-- (10.01)	-- (24.89)	-- (27.16)	-- (25.57)	-- (42.92)	-- (20.62)	-- (13.86)	-- (11.52)

Table 126. Effect of biopesticides on fruit borer infestation and yield of okra (*Arka anamica*) during *kharif*, 2015.

Treatments	Fruit Borer Infestation (%)		Yield of healthy fruits (t/ha)	B : C ratio
	Wt. basis	No. basis		
T1	27.88 (5.33)	23.15 (4.86)	6.52	1.35
T2	7.04 (2.73)	9.53 (3.16)	8.24	1.96
T3	11.03 (3.39)	32.45 (5.74)	6.41	1.31
T4	9.57 (3.17)	11.39 (3.44)	7.36	1.59
T5	17.15 (4.22)	16.79 (4.16)	8.10	1.97
T6	6.29 (2.60)	8.95 (3.07)	8.33	2.05
T7	4.94 (2.33)	13.07 (3.68)	8.03	1.94
T8	4.58 (2.25)	5.94 (2.53)	7.96	1.88
T9	2.56 (1.75)	3.28 (1.94)	9.61	2.11
T10	69.52 (8.37)	55.18 (7.46)	6.44	1.58
SE(M) ±	-- (0.74)	-- (0.09)	0.18	-
C.D. $_{0.05}$	-- (2.19)	-- (0.26)	0.54	-
C.V.(%)	-- 37.74	-- (3.80)	4.12	-

17. Evaluation of Bio-intensive IPM module against, *Aleurodicus dispersus* on cassava (TNAU)

Name of the Farmer : Th.Rajagopal, Kunnathur pudur
Variety : Salem local
Area : 2.0 acres

Evaluation of BIPM against *A. disperses* on cassava was carried out using the Salem local. The trial was conducted in the field of Mr.Rajagopal at Kunnathur pudur, Annur block.

The BIPM treatments includes

- Yellow sticky traps @ 12 per ha for monitoring

- Release of *Chrysoperla zastrowi* @ 1.0 lakh first instar grub per ha
- Application of entomopathogen, *L. lecanii* @ 2 x 10^9 conidia per ml
- Application of NSKE @ 5%
- Application of triazophos 40% EC @ 2.5 ml/litre, acephate 75 SP @ 1.5 g/litre

Farmers practice

Insecticide sprays of Imidacloprid 17.8% SL @ 0.4 ml/l on three months old crop and triazophos 40% EC @ 2.5 ml per litre on 5 months old crop.

Observations

1. *A. disperses* population per 3 leaves in 5 plants at 15 days interval.
2. Population of natural enemies in 10 randomly selected plants at 15 days interval.

BIPM module effectively checked the spiralling whitefly population which showed 86.30 whiteflies/plant as compared to insecticide sprays 380.5 whiteflies/plant. The untreated check harboured 520.41 whiteflies per plant. The population reduction of spiralling whitefly achieved by BIPM was 83.40% as compared to 26.88% in farmer's practice with two rounds of insecticide sprays. The plots imposed with BIPM was free from sooty mold whereas the plots with insecticide sprays and untreated had severe incidence sooty mold indicating the presence of spiralling whitefly population. The BIPM plot recorded a tuber yield of 34.17t/ha which was superior to tuber yield of 28.85 t/ha recorded in farmer's practice. The untreated plot showed a tuber yield of 24.76 t/ha. The BC ratio was 1:3.3 in BIPM plot as against 1:2.26 noted in farmers practice **(Table 127)**.

Table 127. Effect of BIPM module on *A. dispersus* population and yield on cassava

Treatments	Pre treatment count	*A. dispersus*/ plant*	Per cent reduction over control	Yield (t / ha)	BCR
BIPM module	426.10[a]	86.30[c] (9.12)	83.40	34.17	1 : 3.30
Farmer's practice	420.30[a]	380.5[b] (19.84)	26.88	28.85	1 : 2.26
Control	425.30[a]	520.41[a] (25.26)	0.00	24.76	-
CD (P = 0.05)	NS	28.52			

*Mean of eight replications; significant at 1%; figures in parentheses are square root transformed values;
In a column, means followed by a common letter(s) are not significantly different by DMRT (P = 0.05)

18. Evaluation of predatory bug, *Blaptostethus pallescens* against saffron thrips, *Haplothrips* sp. on saffron (SKUAST)

Field releases of 8 days old nymphs as well as adults of *Blaptostethus pallescens* were made @ 5 and 3 nymphs and adults/ plant respectively, during flowering season (1st Nov. to 20th Nov.) of saffron to study the effects of predators against saffron thrip, *Haplothrips* sp. The bugs, however, failed to survive in released area, probably because of low temperature condition (Max. 8.2 °C, Min. 1.5 °C) during this period. The experiment was therefore discontinued.

19. Biological Suppression of Bud Worm (*Hendecasis sp*) and Blossom Midge (*Contarinia sp*) in Jasmine (TNAU)

Name of the Farmer : Th.Rengasamy, Bhavanisagar
Variety : Ramnad local
No. of plants per replication : 10
No. of Replications : 3

Treatment details

T1 : NSKE 5 % three times starting from bud initiation stage at 10 days interval
T2 : Release of *T. chilonis* @ 40,000/ acre at 10 days interval for two months from bud initiation based on light trap monitoring
T3 : T2+ three rounds of spraying with *Beauveria bassiana* NBAIR formulation (1 x 10^8 spores/g) @ 5g / litre at 10 days interval
T4 : T2+ three rounds of spraying with *Metarhizium anisopliae* NBAIR formulation (1 x 10^8 spores/g) @ 5g / litre at 10 days interval
T5 : Soil drenching with *Metarhizium anisopliae* @ 10^{13} spores/ha- two times at fifteen days interval
T6 : Soil application of Neem cake @ 100 kg/acre two times per year
T7 : Soil application of Carbofuran 3G @ 20 g/plant
T8 : Control

Observations

- 3 branches / plant / replication
- No. of infested buds/ flowers will be counted on 7 days after each application
- Per cent damage will be worked out

The field experiment was conducted in farmer's field at Bhavanisagar, Erode district to evaluate the bio control agents against bud borer and blossom midge damage in jasmine. The field experiment was conducted with eight treatments and three replications. The treatments were imposed at flower initiation stage during first week of March 2016 and the treatments were repeated at 7 days interval for three times. The occurrence of bud borer and blossom midge were recorded prior to treatment application and at 7 days after the application of treatments. The data collected revealed that use of *Trichogramma chilonis* and application of *Beauveria bassiana* (NBAIR) @ 5 g/l significantly superior than carbofuran @ 20 g/plant in checking bud borer

damage whereas the same treatment was on par with carbofuran @ 20 g/plant treatment in checking blossom midge after third spray **(Table 128)**.

Table 128. Efficacy of biocontrol agents in suppression of bud borer and blossom midge in jasmine

Treatments	Pre Treatment		Per dent damage 7 days after I spray		Per cent damage 7 days after II spray		Per cent damage 7 days after III spray		Per cent reduction over control	
	Bud borer	B.M	Bud borer	B.M	Bud borer	*B.M*	Bud borer	*B.M*	Bud borer	*B.M*
T1: NSKE @ 5%	12.3[a]	16.4[a]	11.6[bc]	15.2[c]	9.8[ab]	13.8[bc]	8.4[c]	11.2[c]	54.90	55.04
T2 : *T. chilonis* @ 40,000/acre	14.6[a]	20.5[a]	12.3[c]	21.6[d]	9.4[ab]	23.4[d]	7.2[b]	22.8[e]	67.43	26.79
T3 : T2+ *B. bassiana* (NBAIR) @ 5g/l	10.5[a]	15.8[a]	8.4[a]	13.6[b]	7.2[a]	11.3[b]	3.4[a]	8.7[a]	78.61	63.75
T4 : T2+ *M. anisopliae* (NBAIR) @ 5g/l	16.8[a]	18.4[a]	12.6[c]	15.8[c]	9.6[ab]	12.4[b]	7.1[b]	10.6[b]	72.10	62.10
T5 : Soil drenching of *M. anisopliae* (NBAIR)	13.5[a]	23.6[a]	12.5[c]	20.8[d]	10.3[b]	18.6[c]	9.2[d]	15.3[d]	55.00	57.32
T6 : Soil application of Neem cake @ 100 kg/acre	12.4[a]	17.5[a]	10.6[b]	14.8[bc]	8.6[ab]	11.8[b]	6.7[b]	10.5[b]	64.31	60.50
T7: Soil application of carbofuran @ 20 g/plant	15.6[a]	12.8[a]	12.3[c]	10.5[a]	9.5[ab]	8.7[a]	8.2[c]	7.8[a]	65.28	59.89
Control	14.2[a]	18.3[a]	17.3[d]	21.6[d]	18.8[c]	24.5[d]	21.5[e]	27.8[f]	--	--

Means followed by a common letter in a column are not significantly different by DMRT
*Mean of three replications

20. Effect of host plants on natural parasitism of *Diaphania indica* by the larval parasitoid, *Dolichogenidea stantoni* (IIHR)

The melon borer, *Diaphania indica* (Saunders) (Lepidoptera: Pyralidae) is an important pest of cucurbitaceous vegetables. This pest infests cucumber (*Cucumis sativus L.*), melon (*C. melo* L.), gherkin (*C. sativus* L.), bottle gourd (*L. agenaria siceraria* Molina), bitter gourd (*Momordica charantia L.*) and snake gourd (*Trichosanthes anguina L.*) Diverse array of natural enemies were recorded on *D. indica f*rom different countries. Among the natural enemies recorded, the larval parasitoid, *Dolicohgenidea stantoni* was reported as a potential natural enemy of *D. indica.* The objective of the present study was to assess the percentage parasitism of *D. indica* by *A. stantoni* in the field condition, in relation to on different host plants.

The experiment was conducted in the cucurbit field of Indian institute of Horticultural Research (ICAR-IIHR), Bangalore (13°58 N, 77°35 E). Bitter gourd, bottle gourd, cucumber and ridge gourd plants were raised persistently during the year .The plots were maintained by

following normal agronomic practices and there were no chemical pesticides were sprayed during the study period. Thirty plants from each cucurbit variety (from a total of 100 plants) were randomly selected to collect *D. indica* larva at weekly intervals from the field.

Field collected *D. indica* larvae from different cucurbits were reared on the respective cucurbit leaves in separate rearing jars. Food was changed once in two days to prevent microbial contamination.

The field collected larvae were observed for parasitisation. Observations were made on number of larvae collected and parasitized in relation to host plant. This was later converted to percentage parasitoid pupation to determine the effect of host plant on per cent parasitism.

Among the different host plants maximum percentage parasitism of *D. indica* by *D. stantoni* was recorded on bitter gourd and ridge gourd (65.45% and 63.99% respectively). The least preference (20% parasitism) was recorded on bottle gourd **(Table 129)**.

Table 129. Effect of host plants on parasitisation by *Dolichogenidea stantoni* on *Diaphania indica*.

Host plants	**% Parasitisation by *D. stantoni***
Bitter gourd	65.45%*
Ridge gourd	63.99%*
Cucumber	48.79%
Bottle gourd	20.00%

*Significantly different at 5%

2.15. Mealybugs

1. Monitoring the diversity and outbreaks for invasive mealy bug and other sap sucking pests on Cotton (TNAU, KAU and IIVR)

TNAU-Coimbatore

Survey conducted in Coimbatore, Erode and Tiruppur districts of Tamil Nadu on cotton and other host plants indicated the incidence of five species of mealy bugs *viz.*, *Paracoccus marginatus, Maconellicoccus hirsutus, Phenacoccus solenapsis, Nipaecoccus viridis* and *Ferrisia virgata* **(Table 130)**. *Phenacoccus solenapsis* and *Nipaecoccus viridis* were the predominant species recorded on cotton. *Paracoccus marginatus* was observed on papaya, cotton, tapioca, mulberry, jatropa and other host plants. The natural enemies *viz.*, *Acerophagus papayae, Cryptolaemus montrouzieri, Scymnus coccivora, Spalgis epius, Coccinella septumpunctata, Mallada* sp, *Chrysoperla zastrowi sillemi* and *Menochilus sexmaculatus* were recorded on different species of mealybugs in the surveyed cotton fields.

Table 130. Sucking pests and their natural enemies recorded in cotton

Sl. No.	Species of sucking pests	Host Plants	Natural enemies recorded
1	*Phenacoccus solenapsis*	Cotton, sunflower, bhendi, parthenium, Black night shade and *Hibiscus*	*Cryptolaemus montrouzieri* (Mulsant) (Coleoptera: Coccinellidae) *Coccinella septumpunctata* (Coleoptera: Coccinellidae), *Chrysoperla zastrowi sillemi* Esben- Peterson (Neuroptera: Chrysopidae) *Spalgis epius* (Lycaenidae: Lepidoptera) *Scymnus coccivora* Ayyar (Coleoptera: Coccinellidae)
2	*Ferrisia virgata*	Cotton, tapioca, custard apple, guava, Papaya and tuberose	*Scymnus coccivora* Ayyar (Coleoptera: Coccinellidae), *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae) *Menochilus sexmaculatus* (Fabricius) (Coleoptera: Coccinellidae) *Mallada* sp (Neuroptera: Chrysopidae)
3	*Paracoccus marginatus*	Cotton, Papaya, tapioca, *Jatropha curcas*, mulberry, bhendi, sunflower, hibiscus, marigold, parthenium,	*Acerophagus papayae* Noyes & Schauff (Hymenoptera: Encyrtidae), *Chrysoperla zastrowi sillemi* Esben- Peterson (Neuroptera: Chrysopidae) , *Spalgis epius* Westwood (Lepidoptera: Lycaenidae), *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae), *Scymnus coccivora* Ayyar (Coleoptera: Coccinellidae), *Menochilus sexmaculatus* (Fabricius) (Coleoptera: Coccinellidae)

4	*Nipaecoccus viridis*	Cotton, mango, gooseberry, tamarind, jack,	*Scymnus coccivora* Ayyar (Coleoptera: Coccinellidae), *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae) *Menochilus sexmaculatus* (Fabricius) (Coleoptera: Coccinellidae)
5	*Maconellicoccus hirsutus*	Cotton, bhendi, grapevine, guava, hibiscus, mulberry	*Scymnus coccivora* (Coleoptera: Coccinellidae) *Cryptolaemus montrouzieri* (Coleoptera: Coccinellidae) *Mallada* sp (Neuroptera: Chrysopidae)
6.	*Amrasca devastans, Oxycarenus laetus*	Cotton, bhendi	Anthocorid bugs,
7	*Thrips tabaci*	Cotton, bhendi,	*Chrysoperla zastrowi*
8	*Aphis gossypii*	Cotton, bhendi,	Syrphids, *Chrysoperla zastrowi*
9	*Aleurodicus disperses*	Cotton, bhendi, guava, papaya, ornamentals	*Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae), *Mallada* sp, Syrphids
10	Mirid bug	Cotton, bhendi	--

KAU-Thrissur

Monitoring visits to different crop fields yielded no invasive species of mealybugs.

IIVR

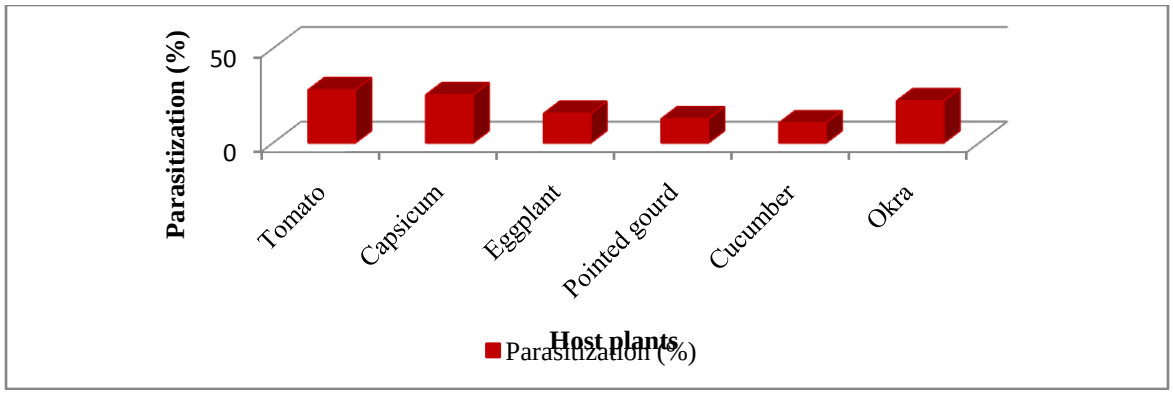
Extensive surveys were conducted in and around Varanasi revealed the occurrence of two mealy bug species *viz*., *Phenacoccus solenopsis* (Tinsley) and *Centrococcus insolitus* (Green) (Pseudococcidae: Homoptera) infesting major vegetables from April, 2015 to March, 2016. The dominant species was identified as *P. solenopsis* infesting several vegetables namely tomato, brinjal, *Capsicum*, okra, cucumber and pointed gourd. Incidence of this mealy bug was observed almost thorough out the year on one or other vegetable crops available in the region except peak summer during May – June. In case of tomato, this mealy bug existed from February to April where as in brinjal the infestation was recorded during March – April **(Fig 4)**. Similarly, in pointed gourd, cucumber and okra its infestations were noted during July- August, August – September and August to October, respectively. From October to December its incidence was documented on *Capsicum* grown mainly under poly-house condition. During peak summer (May-June) the incidence of *P. solenopsis* was restricted to weeds particularly, *Parthenium hysterophorus*. In case of brinjal, *C. insolitus* was recorded particularly during September - October.

Fig 4. Occurrence of *P. solenopsis* on different vegetables

Month	Peak period of activity					
	Tomato	*Capsicum*	Brinjal	Cucumber	Pointed Gourd	Okra
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						

During the study, one prominent nymphal, endoparasitoid *viz., Aenasius arizonensis* (Girault) (Encyrtidae: Hymenoptera) of *Phenacoccus solenopsis* was recorded. Tritrophic interaction (Host plant – *P. solenopsis* – parasitoids) was observed during the recovery of the parasitoids from different hosts. Highest cumulative recovery was obtained from tomato (33.67%) followed by okra (28.07%) whereas lowest recovery (10.56%) was in case of cucumber **(Fig. 5)**.

Fig 5. Host preference of *Aenasius arizonensis* parasitoid of *Phenacoccus solenopsis* of different vegetables



OUAT-Bhubaneswar: Survey for the host range, damage intensity and bio control agents of the solenpsis mealy bug in Odisha.

Survey was made in the agroecosystem in and around Bhubaneswar during *kharif* and *rabi* of 2015-16 for the host range and biocontrol agents of *Phenacoccus solenopsis*. The results are presented in **Table 131**.

Table 131. Host plants and natural enemies of *Phenacoccus solenopsis* recorded from Odisha during 2015-16.

Sl. No.	Host Plant	Infestatio (%)	Natural enemies	Season	Place of Collection
1	*Hibiscus rosachinensis*	53.85	*Aenasius bambawalei*	Kharif and Rabi	OUAT research farm, Forest park, Bhubaneswar
2	*Solanum melongena*	73.07	---	Rabi	OUAT farm colony, Bhubaneswar
3	*S. lycopersicum*	39.18	---	Rabi	OUAT research farm, Bhubaneswar
4	*S. tuberosum*	71.12	---	Rabi	OUAT research farm, Bhubaneswar
5	*Abelmoschus esculentus*	58.67	---	Kharif	OUAT research farm, Bhubaneswar
6	*Gossypium hirsutum*	83.33	*A. bambawalei, Chelomenes sexmaculatus, Cryptolaemus montrouzieri*	Rabi	OUAT research farm, Bhubaneswar
7	*Achyranthes* sp.	60.13	Spider (unidentified)	Kharif	OUAT research farm, Bhubaneswar
8	*Tagetes* sp.	74.61	*A. bambawalei*	Rabi	OUAT research farm, Bhubaneswar
9	*Zea mays*	61.90	*C. sexmaculatus*	Rabi	Baramunda, Bhubaneswar
10	*Helianthus Annuus*	8.73	*C. sexmaculatus*	Rabi	Baramunda, Bhubaneswar

2.16. Biological suppression of polyhouse crop pests

1. Monitoring the diversity of pests and natural enemies in chrysanthemum under polyhouse conditions (TNAU)

Polyhouses at Kothagiri, Hosur and Kodaikanal were surveyed for occurance of chrysanthemum pests and their natural enemies. In all the places, occurrence of whitefly (*Bemisia tabaci*), serpentine leaf miner (*Liriomyza trifolii*) and tetranychid mite (*Tetranychus urticae*) were noted. The population of whitefly ranged 0-9 no./plant, whereas, tetranychid mite population was 0-4 /2 sq.cm. The population of serpentine leaf miner as indicated by mined leaf damage 3-7 nos. /plant. Presence of coccinellid *Stethorus sp*. and predatory thrips *Scolothrips sp*. were also noted in chrysanthemum **(Table 132)**.

Table 132. Pest incidence in chrysanthemum under poly house condition

Locations	Period	Whitefly (No/plant)	Leaf miner damage (No /plant)	Mite incidence no. per 2 sq.cm
Kothagiri	September 2015	0.0-2.6	2.3 - 7.2	0.0 – 4.3
Hosur	December 2015	0.0 – 8.6	3.8 – 9.6	0.0 – 3.6
Kodaikanal	January 2016	0.0 – 1.6	1.8 – 3.4	0.0 – 3.2

2. Evaluation of anthocorid predators against spider mites, *Tetranychus urticae* under insect net cage condition (PAU)

Okra

The experiment on evaluation of anthocorid predator, *Blaptostethus pallescens* against mite, *Tetranychus urticae* on okra (PAU variety Punjab-8) was conducted at Entomological Research Farm, PAU, Ludhiana. The crop was sown in the field in the month of March, 2015 at the farm. The small net cages (4 x 4 x 4 feet) were installed in the field and the mite was released to establish on the plants in these cages.

There were following five treatments:

a) *Blaptostesthus pallescens* @ 10 nymphs per plant
b) *Blaptostesthus pallescens* @ 20 nymphs per plant
c) *Blaptostesthus pallescens* @ 30 nymphs per plant
d) Chemical control: Omite @ 300 ml/ acre
e) Untreated control

There were three replications per treatment and five plants per replication. The population of mite was established in the month of June 2015 and thereafter data was recorded before and after the treatments.

When the 6-7 days old nymphs of *B. pallescens* were released at weekly interval on the okra plants under net condition, it was observed that the population of mites decreased significantly on the plants. All the treatments *i.e.*, releases of 6-7 days old nymphs of *B. pallescens* and spray of chemical on the okra were significantly better than control, where the mean population of mite was comparatively very high (31.9 mites/ plant) and yield of okra was lowest (36.0 kg/ acre). Among predator treatments, the release of *B. pallescens* @ 30 nymphs/ plant was found best in suppressing the mite population (7.7 mites/ plant) and it was at par with chemical control (4.2 mites/ plant). The release of *B. pallescens* @ 20 nymphs/ m row was at par with *B. pallescens* @ 10 nymphs/ plant, which reduced the population to 11.0 mites/ plant and 12.7 mites/ plant, respectively. The data on yield from the plots of *B. pallescens* @ 30 nymphs/ plant and chemical control was also at par with each other (225.25 and 263.50 kg/acre, respectively) and it was better than other two treatments of *B. pallescens*. The yield in the plots treated with @ 10 nymphs/ plant and 20 nymphs/ plant was on par with each other (137.0 and 161.75 kg/ acre, respectively). It was concluded that *B. pallescens* @ 30 nymphs/ plant along with chemical control (Omite 300 ml/ acre) can be included in the IPM of two-spotted spider mite, *T. urticae* on okra in net house condition **(Table 133)**.

Table 133. Evaluation of anthocorid predator, *Blaptostethus pallescens* against spider mite *Tetranychus urticae* on okra in insect net house condition during 2015

Treatments	Number of mite population/ plant						Yield (kg/acre)
	Before treatment	After release/spray*					
		1st	2nd	3rd	4rth	Mean	
Blaptostethus pallescens @ 10 nymphs/ plant	24.3 (5.01)	12.5^{c} (3.7)	23.1^{b} (4.9)	8.1^{a} (3.0)	6.9^{b} (2.8)	12.7^{ba} (3.6)	137.00^{b}
B. pallescens @ 20 nymphs/ plant	20.6 (4.6)	12.3^{c} (3.6)	17.2^{b} (4.2)	7.6^{a} (2.9)	7.0^{b} (2.8)	11.0^{ba} (3.4)	161.75^{b}
B. pallescens @ 30 nymphs/ plant	23.8 (4.9)	8.6^{b} (3.1)	13.2^{b} (3.8)	5.5^{a} (2.5)	7.8^{b} (2.9)	7.7^{a} (2.9)	225.25^{a}
Chemical control, Propargite (omite @ 300 ml/ acre)	25.7 (5.2)	0.6^{a} (1.2)	2.8^{a} (1.9)	5.1^{a} (2.5)	3.6^{a} (2.1)	4.2^{a} (2.1)	263.50^{a}
Control (untreated)	27.3 (5.3)	31.9^{d} (5.7)	38.1^{c} (6.2)	33.0^{b} (5.8)	24.8^{c} (5.1)	31.9^{c} (5.7)	36.00^{c}
CD (5%)	(NS)	(0.4)	(1.1)	(0.6)	(0.7)	(0.9)	64.90
CV	5.43	7.32	14.6	11.0	12.2	17.3	25.7

3. Evaluation of efficacy of predators against cabbage aphids in polyhouse (SKUAST)

Cabbage saplings were planted in six beds (2.5 x 1.0 m^2) of a block, in the last week of March 2015 in the polyhouse of Biocontrol unit. The plants were allowed to grow for a month followed by sufficient inoculation of cabbage aphids, during April. The block was equally divided into three parts, each with two beds of the plants. Two being totally covered with mosquito net for evaluation of efficacy of released grubs of *Coccinella septempunctata* and *Chrysoperla zastrowi sillemi*. The third block was left open as untreated check. Five weekly

releases of second instars of *C. septempunctata* (T1) and *C. zastrowi* (T2) were made separately in the netted blocks. Number of aphids/5 plants was recorded before and after every release for each treatment. Each plant was thoroughly examined for the presence of aphids. The data was compared both with pre count as well as untreated check (T3). The data was statistically analyzed using Minitab.

The aphid density in the three blocks varied from 204.8 to 244.0/ plant prior to release of predators, and was found statistically identical (F= 0.94 NS; d.f.= 2(8); P= 0.430). The number of aphids in untreated block continued to rise from 204.8 to 621.4 during the experiment. Treatments T1 and T2 which were treated weekly with *C. septempunctata* and *Chrysoperla* respectively, showed a significant decline in aphid density/ plant. Average number of aphids/ plant in T1 and T2 was recorded as 101.73 and 158.43/ plant, at the end of experiment as compared to 440.36/ plant in untreated control (T3).

Analysis of data through one way ANOVA indicated difference in feeding potential of the two predators was statistically significant from first to fifth week, as also indicated by per cent reduction in aphids, week wise **(Table 135)**. Overall reduction in aphid density/ plant over control was worked out as 76.52 and 63.09% in T1 and T2 respectively **(Table 134)**. Average reduction in aphid density by *C. septempunctata* and *Chrysoperla zastrowi* was however worked out as 53.76 and 34.62% **(Table 135)**.

Table 134. Impact of weekly releases of predators on cabbage aphids in poly house during 2015

Predators	Mean no. of aphids/ 5 plants							
	Pre count	**After 1st release**	**After 2nd release**	**After 3rd release**	**After 4th release**	**After 5th release**	**Mean no. of aphids**	**% reduction in aphid density over control**
Coccinella septempuctata (T1)	219.8 (14.77)[a]	160.00 (12.58)[a]	104.2 (10.17)[a]	68.6 (8.22)[a]	36.6 (5.99)[a]	21.2 (4.57)[a]	101.73 (10.04)[a]	76.52
Chrysoperla zastrowi sillemi (T2)	244.00 (15.57)[a]	213.4 (14.57)[b]	175.6 (13.23)[b]	139.00 (11.75)[b]	109.6 (10.44)[b]	69.00 (8.27)[b]	158.43 (12.56)[b]	63.09
Untreated Check (T3)	204.8 (14.26)[a]	308.2 (17.54)[c]	432.4 (20.69)[c]	498.8 (22.22)[c]	576.6 (23.94)[c]	621.4 (24.89)[c]	440.36 (20.94)[c]	-
CD (0.05)	1.79	1.47	1.90	2.16	1.67	1.22	1.58	-
CV (%)	18.34	30.50	65.34	86.09	105.25	119.86	67.63	-

Figures in each column represent mean of 5 replications
Values in parentheses are √n
Different alphabets in a column indicate values statistically significant

Table 135. Week wise per cent reduction in cabbage aphids in response to predators

Predators	% reduction					
	After 1st release	After 2nd release	After 3rd release	After 4th release	After 5th release	Average
Coccinella septempuctata	27.55 (31.56)[b]	52.53 (46.44)[b]	69.00 (56.21)[b]	83.41 (66.05)[a]	90.05 (71.8)[b]	53.76 (47.15)[b]
Chrysoperla zastrowi sillemi	12.15 (20.2)[a]	26.98 (30.97)[a]	42.34 (40.54)[a]	54.74 (74.72)[b]	71.48 (57.79)[a]	34.62 (35.99)[a]
CD (0.05)	3.56	7.30	6.96	2.86	4.48	3.35
CV (%)	26.45	24.12	19.07	17.5	12.33	15.15

Figures in each column represent mean of 5 replications
Values in parentheses are arc sin transformation
Different superscripts in a column indicate values statistically significant

4. Evaluation of entomopathogenic fungi against spider mite, *Tetranychus urticae* on capsicum /bell pepper under protected cultivation (PAU)

The capsicum seedlings were transplanted under protected conditions according to agronomic practice norms. The crop was transplanted with plant to plant spacing of 30 cm and row to row spacing of 90 cm. The formulations of entomopathogenic fungi *viz*., *Beauveria bassiana*, *Metarhizium anisopliae*, *Lecanicillium lecanii* (Supplied by NBAIR, Bangalore) along with commercially available *Beauveria bassiana (*Mycozaal), chemical control (Malathion 50 EC) and untreated control were evaluated against sucking pest of capsicum. There were three sprays of biopesticides at 10 days interval and two sprays of insecticide at 15 days interval. The biopesicides were sprayed @ 5 g/ml. The incidence of capsicum aphid was recorded at 5 and 10 days after spray (DAS). It was found that incidence of capsicum aphid in all the treatments were non-significant up to third spray till 5 DAS. After 10 DAS of third spray chemical control recorded minimum aphid population (23.66/3 leaves) on capsicum and was at par with population recorded from *M. anisopliae* treated plot. This was followed by other treatments. However, all treatments were better than untreated plot **(Table 136)**.

Table 136. Incidence of capsicum aphid on capsicum cultivated under protected conditions

Sl. No.	Treatments	Pre-treatment	Incidence of capsicum aphid/ 3 leaves/ plant					
			First spray		Second spray		Third spray	
			5 DAS	10 DAS	5 DAS	10 DAS	5 DAS	10 DAS
1	*Beauveria bassiana* NBAIR	5.66	8.33	22.33	22.00	15.00	28.33	33.66[b]
2	*Metarhizium anisolpae* NBAIR	5.33	9.33	13.00	30.66	24.00	21.00	28.33[ab]
3	*Lecanicillium lecanii* NBAIR	7.66	8.33	16.00	26.66	30.33	24.66	38.00[b]
4	*Beauveria bassiana* (l)	6.33	12.00	15.00	28.33	24.33	21.33	34.33[b]
5	Mycozaal	7.00	11.00	20.66	15.66	30.66	27.00	38.33[b]
6	Chemical control	8.00	10.33	14.66	26.00	30.00	17.66	23.66[a]
7	Untreated control	5.66	11.66	19.33	33.00	42.00	46.00	49.66[c]
	CV	2.71	3.23	3.89	5.05	5.20	5.14	5.92

No statistical analysis

5. Biological management of red spider mite, *Tetranychus urticae* infesting rose in polyhouse conditions (MPKV)

The experimental trial was laid out to evaluate entomopathogenic fungi against mites on rose under polyhouse conditions. The experiment was conducted at Hi-tech Floriculture Project, College of Agriculture, Pune by using Cultivar: Passion with spacing of 90 x 60 cm and plot size of 5 x 2 m, RBD, drip irrigation, light soil. Entomopathogenic fungi formulations and predatory mites were obtained from the ICAR-National Bureau of Agricultural Insect Resources (NBAIR), Bangalore.

Observations were recorded on initial mite population per plant on 3 leaves from 10 plants and post count was recorded 7 days after each spray and yield was calculated. The first release of predatory mite and spray of entomopathogenic fungi formulation was done on 24/03/2015, further applications were given at an interval of 15 days. It is seen from table 7 that the three sprays of abamectin 0.5 ml/lit at 15 days interval found effective in reducing the mite population on rose (8.22 mites/ 10 compound leaves/plant). However, four releases of preadatory mites @ 10 per plant at weekly interval and three sprays of *H. thomsonii* (1 x 10^8 conidia/g) @ 5 g/litre were the next best treatments showing average 18.22 and 20.89 mites/ 10 compound leaves/plant, respectively **(Table 137)**.

Table 137. Bioefficacy of bioagents against red spider mite *Tetranychus urticae* infesting rose in polyhouse conditions

Treatments	Mean mite population/10 compound leaves/plant				
	Pre-count	I spray	II spray	III spray	Average
		7 DAS			
T1: *Lecanicillium lecanii*	75.67 (8.73)	48.00 [c] (6.96)	17.33 [b] (4.19)	7.67 [c] (2.78)	24.33 [c] (4.97)
T2: *Hirsutella thomsonii*	76.33 (8.75)	44.67 [b] (6.72)	14.67 [b] (3.89)	3.33 [b] (1.94)	20.89 [b] (4.62)
T3: *Beauveria bassiana*	78.33 (8.88)	58.33 [c] (7.66)	33.67 [d] (5.84)	15.00 [d] (3.92)	35.67 [d] (6.01)
T4: *Metarhizium anisopliae*	77.00 (8.80)	51.33 [c] (7.20)	21.33 [c] (4.67)	6.33 [c] (2.60)	26.33 [c] (5.18)
T5: Predatory mites	78.67 (8.88)	34.67 [b] (5.89)	15.33 [b] (3.97)	4.67 [b] (2.26)	18.22 [b] (4.31)
T6: Abamectin	71.33 (8.47)	15.33 [a] (3.97)	8.33 [a] (2.97)	1.00 [a] (1.17)	8.22 [a] (2.95)
T7: Untreated control	73.33 (8.58)	87.33 [d] (9.37)	96.67 [e] (9.85)	115.67 [e] (10.77)	99.89 [e] (10.02)
CD @ 5%	(0.72)	(0.85)	(0.68)	(0.59)	(0.44)

Figures in parentheses are $\sqrt{n + 0.5}$ transformed values

6. Evaluation of biocontrol agents against sap sucking insect pests of ornamentals/ vegetables in polyhouses (YSPUHF)

Biocontrol agents like *Beauveria bassiana, Metarhizium anisopliae, Lecanicillium lecanii* (5 g/L each of 10^8 conidia/g), *coccinella septempunctata* (10 beetles/plant) and Neem Baan (1500 ppm; 3 ml/L) were evaluated against the rose aphid, *Microsiphum rosaeiformis* on rose under polyhouse conditions at Nauni, Solan during October-2015. Methyl demeton (0.025%) and water spray were included in the experiment as standard recommended insecticide and control, respectively. Aphid population was counted on 10 randomly selected plants before and 7 days after the application of treatment. Data on aphid count were converted to percent reduction in aphid population over pre-treatment count which was further corrected through Abbott's correction to get percent reduction over control. Data **(Table 138)** revealed that among bio-pesticides and botanical, Azadirachtin (1500 ppm; 3 ml/L) resulted in the highest reduction (79.9%) reduction in aphid population over control and equally good performance (68.8% reduction) was given by *Coccinella septempunctata* when released at the rate of 10 beetles/plant. Entomopathogenic fungi viz. *Lecanicillium lecanii, Metarhizium anisopliae* and *Beauveria bassiana* (each at 5 g/L of 10^8 conidia/g), however, were only moderately effective resulting in 51.2, 36.3 and 31.3% reduction in aphid population over control, respectively. In contrast, methyl demeton (0.025%) was the most effective causing 92.5% reduction in aphid population.

Table 138. Evaluation of bio-control agents against *Microsiphum rosaeiformis* on rose under polyhouse conditions

Sl. No.	Treatment	Reduction (%) in aphid population over control
1	*Beauveria bassiana* (5 g/L of 10^8 conidia/g)	31.3 (33.8)^{d}
2	*Metarrhizium anisopliae* (5 g/L of 10^8 conidia/g)	36.3 (36.7)^{cd}
3	*Lecanicillium lecanii* (5 g/L of 10^8 conidia/g)	51.2 (45.7)^{c}
4	*Coccinella septempunctata*(10/plant)	68.8 (56.2)^{b}
5	Azadirachtin (1500 ppm; 3 ml/L)	79.9 (57.8)^{b}
6	Methyl demeton (0.025%)	92.5 (76.8)^{a}
	CD @ 5%	(9.2)
	CV (%)	11.8

Figures in parentheses are angular transformed values

7. Evaluation of predatory mite, *Neoseiulus longispinosus* against phytophagus mite in carnation under polyhouse conditions (YSPUHF)

Predatory mite, *Neoseiulus longispinosus* was evaluated against *Tetranychus urticae* on carnation under polyhouse conditions at Nauni, Solan during 2015 at predator: prey ratio of 1:10, 1:20 and 1:30. Neem Baan (1500 ppm; 3 ml/l), fenazaquin (0.0025%) and untreated control. Three releases of predatory mite were made at 7 days interval. Similarly, three sprays each of Azadirachtin (3 ml/l) and fenazaquin (0.0025%) at 7 days interval were made. Each treatment was replicated 4 times in a randomized block design. Mite count was recorded before spray/release and 7 days after final release/spray. The data on mite population was converted to per cent reduction in mite population over pre-treatment count, which was further converted to per cent reduction over control by applying Abbott's correction. Among bioagents/ biopesticides, *N. longispinosus* at 1:10 predator: prey ratio was the most effective resulting in 74.2% reduction in mite population over control which was on par with fenazaquin (0.0025%) resulting 85.2% reduction **(Table 139)**. *N. longispinosus* at predator: prey ratio of 1:20 and 1:30 resulted in 66.5 and 60.2% reduction in the mite population over control which was statistically on par with the reduction in the mite population obtained by releasing the predatory mite at predator: prey ratio of 1:10. Azadirachtin (1500 ppm; 3 ml/L), however, was the least effective among the tested biopesticides resulting in 48.3% reduction in mite population over control.

Table 139. Evaluation of *Neoseiulus longispinosus*and neem against phytophagus mite in carnation under polyhouse condition.

Sl. No.	Treatment	Reduction(%) in mite population over control
1	*N. longispinosus* (1:10)	74.2 (60.1)[ab]
2	*N. longispinosus* (1:20)	66.5 (55.3) [bc]
3	*N. longispinosus* (1:30)	60.2 (51.7) [bc]
4	Azadirachtin (1500 ppm; 3 ml/L)	48.3 (43.9)[c]
5	Fenazaquin (0.0025%)	85.2 (71.8)[a]
	CD @ 5%	(14.7)
	CV (%)	21.1

Figures in parentheses are angular transformed values

8. Evaluation of Anthocorid predator, *Blapposthetes pallescens* against spider mites in polyhouse (NCIPM)

Crop: Cucumber

Treatment details

a) *Blaptostethus pallescens* @ 10 nymphs/m row
b) *Blaptostethus pallescens* @ 30 nymphs/m row
c) Chemical control (Recommended dose of acaricide)
d) Untreated control

- Two releases were made at weekly intervals.
- Spray of insecticides per recommendation (Azadirachtin @ 100 ppm, 2 sprays at 15 days interval)
- Plot size: 1 X 3 m; NCIPM Polyhouse
- Replications: 5
- Observations were taken: (1 sq. cm of randomly selected five leaf average)
- Mite population from 10 randomly selected plants before release or spray were recorded after 7 days of treatment and about 15 days after second release of bug
- Number of leaves with yellow specks or webbing and percent leaf damage/was calculated
- First Release: 12th Nov. 2015
- Second Release: 19th Nov. 2015

Trial on the management of two-spotted spidermites, *Tetranychus urticae* in greenhouse cucumber was taken up in the greenhouses of NCIPM field campus at Rajpurkhurd, Mehrauli, New Delhi. One month old cucumber plants were severely infested with spider mites with an average of 8 mites per sq. cm (five-leaf average on the day of first release *i.e.*, 12th Nov. 2015) were taken up for the study. For the biological control of mites, predatory anthocorid bug, *Blaptostethus pallescens*, which obtained from NBAIR, Bangalore, was used. These bugs were released at two levels *i.e.*, 10 bugs/m rows of plants and 30 bugs/m rows of plants. Plot size was

1 x 3 m comprising an average of 6 plants. There were 5 replications for each treatment. Similar crop was maintained in adjacent greenhouse for a treatment of chemical control (two sprays of azadirachtin @ 100 ppm were given weekly coinciding with release of *B. pallescens*). Predatory bugs were released again after one week of the first release.

Observations were recorded for the number of mites per sq. cm (five-leaf average) and number of bugs surviving. Two releases of the bugs were done in T_1 and T_2 @ 10 bugs/m and 30 bugs/m row of plants **(Table 140)**. Poor survival of the predatory bugs during second fortnight, despite the second release, was apparently due to lower availability of their prey *i.e*., *T. urticae*. However, the predatory bugs were seen preying upon the spider mites in laboratory observations under microscope.

Table 140. Effect of predatory bug, *Blaptostethus pallescens* on management two-spotted spidermite *Tetranychus urticae* in greenhouse cucumber

Treatments	Mite Population		Anthocorid Population	
	1st Week	15 DAR	1st Week	15 DAR
T1 (*Blaptostethus pallescens* @ 10 nymphs/ m row)	8	1.8	1.4	0.4
T2 (*Blaptostethus pallescens* @ 30 nymphs/ m row)	5.6	1	2.8	1.2
T3 (Chemical Control)	5.4	0	0	0
T4 (Control)	6.2	0.6	0	0

Mite population per sq. cm (mean of 5-leaf sample and 5 replicates)
Anthocorid population per plant (mean of 5 plants and 5 replicates)

Among predator treatments, the release of *B. pallescens* at 30 nymphs/m row was found in suppression of mite population (1/sq. cm) after 15 DAR which was similar to chemical control.

2.17. Biological suppression of storage pests

1. Evaluation of *Uscana* sp. (Trichogrammatidae) against *Callosobruchus* sp. on storability of pigeonpea seed (Dir.Seed.Res)

1. To evaluate *Uscana* sp. against *Callosobruchus* sp damaging pigeonpea seed
2. To assess parasitisation effect of *Uscana* sp. on the eggs of *Callosobruchus* sp. under ambient condition
3. To find out longevity of *Uscana* sp. on the eggs of *Callosobruchus* sp. in pigeon pea seed under storage
4. To monitor the effect of *Uscana* sp. release on seed quality attributes particularly seed viability during storage

Treatment details:

T1: Release of 20 *Uscana* sp. + 50 eggs of *Callosobruchus* sp.
T2: Release of 40 *Uscana* sp. + 50 eggs of *Callosobruchus* sp.
T3: Release of 60 *Uscana* sp. + 50 eggs of *Callosobruchus* sp.
T4: Release of 80 *Uscana* sp. + 50 eggs of *Callosobruchus* sp.
T5: Control: 50 eggs of *Callosobruchus* sp.

Certified seeds of pigeonpea with very high percentage of germination and low moisture content (about 10%) should be taken for the experiment. Prepare cards by pasting pigeonpea seeds (12-15 no.) with gum and keep it in test tubes. Allow freshly emerged bruchids into test tubes for egg laying on the seeds pasted on cards. Remove the bruchids after egg laying from test tubes. Transfer cards with eggs into new test tube and maintain equal no. of eggs on each card (50 no.). Release required no. of freshly emerged *Uscana* sp. into test tubes containing eggs. Test tubes will be closed with cotton plug and kept it in room under ambient condition. The temperature and relative humidity of the room will be recorded on standard weekly basis.

Observations to be recorded

1. No. of eggs parasitized
2. No. of adult parasitoids emerged
3. Insect infestation (% seed damage)
4. No. of adult insects emerged
5. Seed germination and seed moisture

At every 12-15 days for a total period of 6 months or loss of germination below Indian minimum seed certification standard (IMSCS) whichever is early.

The observations and results of the experiments showed that increase in parasitoid (*Uscana* sp) number is directly proportional to increased level of parasitization (Table 1). The highest percent parasitization (100%) was observed in treatment (T4) where 80 *Uscana* sp were released. Lowest egg parasitization was noticed in the treatment (T1) with 41.33%. Treatment

T2 and T3 recorded parasitization percentage of 68.00 and 91.33 respectively. Nil parasitization was observed in Control (T5) with no *Uscana* sp released.

Exit hole of bruchid was observed in all the treatments. The 100 percent seed infestation was observed in T5 (control). Lowest infestation of seed was noticed in T4 (1.33 per cent) followed by T3 (15.00%). Highest seed infestation with 65.33 and 58.33% was observed in T1 and T2 respectively **(Table 141)**.

Increase in moisture content was observed when the infestation starts. The highest of 17.28% moisture content was observed in control (T5) where as 14.00, 12.33, 12.38 and 10.38% was recorded in T1, T2, T3 and T4 respectively **(Table 141)**. Ten per cent moisture content was observed on the day of experiment.

The germination of pigeon pea seeds was highest in T4 which was 93.00%. There was drastic reduction in moisture content after infestation and it was 72.67 % in T5 (control). Treatment T1, T2 and T3 recorded 80.67, 85.67 and 89.00% respectively **(Table 141)**. The insect infestation reduced the germination to 15% (initial germination 95%).

The highest root length with 16.07 cm was recorded in the seedlings of T4 followed by 14.07 cm in the seedlings of T3. The lowest root length of 7.07 cm was recorded in T5 (control), Treatment T1 and T2 showed moderate root length **(Table 141)**. It was observed that the similar trend in shoot length as in the root length. The lowest length of 6.17 cm was recorded in T5 (control) and highest with 10.00 cm in T4 seedlings. The seedling vigour index has reduced significantly from T5, T1, T2, T3 and T4 **(Table 141)**.

The results also revealed that all the infestation leads to deterioration of pigeon pea seed, affecting germination and loss of vigour except T4. The pigeon pea seeds germinate even after insect infestation when the infestation is other than germ portion but with lesser vigour in that germinated seedling.

Table 141. Parasitization effect of *Uscana* sp. on eggs of *Callosobruchus maculatus* in pigeon pea

Treatment	Parasitazation (%)	Seed infestation (%)	Moisture content (%)	Germination (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Vigour Index
T1 (20 *Uscana* sp)	41.33 (6.43)	65.33 (8.08)	14.00 (3.74)	80.67 (8.98)	8.17	7.30	15.47	1247.81
T2 (40*Uscana* sp)	68.00 (8.25)	58.33 (7.64)	12.33 (3.51)	85.67 (9.26)	10.67	8.50	19.17	1642.1
T3 (60*Uscana* sp)	91.33 (9.56)	15.00 (3.87)	12.38 (3.52)	89.00 (9.43)	14.02	8.73	22.75	2024.75
T4 (80 *Uscana* sp)	100.00 (10.00)	1.33 (1.15)	10.83 (3.29)	93.00 (9.64)	16.07	10.00	26.07	2424.51
T5 (control)	0.00 (0.00)	100.00 (10.00)	17.28 (4.16)	72.67 (8.52)	7.07	6.17	13.24	962.01
Sem±	0.41	1.14	0.55	0.99	0.46	0.22	-	-
CD @ 5%	2.04	5.65	4.70	4.88	2.27	1.10	-	-

*Observations based on mean values of three replications.
*Figures in within () are square root transformed values.

2.18. Enabling Large scale adoption of proven biocontrol technologies

1. Rice (AAU-J. KAU, PAU, GBPUT and OUAT)

AAU-J

Large scale demonstration of bio control based IPM package in rice was carried out in the farmer's field at Borhola area of Jorhat district on variety '**Ranjit'** covering an area of 20 ha. The crop was transplanted in 3rd week of July. The BIPM package as per technical programme was evaluated in comparison with farmer's practice (chemical control) where chlorpyrifos 20 EC @ 2.5 ml/lit of water was applied. Three rounds of chemical sprays were made at 40, 50 and 60 DAT in farmers practice plots.

The practices followed in BIPM package

- Seedling root dip treatment with *Pseudomonus fluorescens* @ 2 % solution,
- Two sprays of *Beauveria bassiana* @ 10^{13} spores/ha against sucking pests,
- Erection of bird perches @ 15 nos /ha,
- Six releases of *T. japonicum* @ 1,00,000 /ha at ten days interval starting from 30 DAT against *Scirpophaga* spp. and *Cnaphalocrocis* spp,
- Spray of Botanicals (Pestoneem @ 5 ml/lit) against foliar as well as sucking pests
- Spray of *P. fluorescens* 2 % against foliar diseases

Observations on the population of the pest and natural enemies were recorded before and after the release of bioagent and biopesticides. Population of skippers, case worm, hairy caterpillar was negligible (<1%). Statistical analysis was carried out using student '*t*' test and the results are given below in **(Table 142-146**).

No significant difference was observed in population of *Nephotettx sp* /hill in BIPM and farmers practice plots **(Table 142)**. The mean per cent incidence of damaged leaves due to *Cnaphalocrosis* sp. (1.90%) at 65 DAT and white ear head (1.90%) caused by *Scirpophaga sp* at 125 DAT was significantly low in BIPM plot as compared to 2.56 and 2.77% in farmers practice, respectively. The dead heart incidence in BIPM plots was 5.14 and 2.47 at 45 and 65 DAT, respectively. The corresponding figures in farmers' practice was 4.86 and 2.63% and both the treatments were on par in their efficacies **(Table 143)**. Maximum grain yield of 4366.0 Kg/ ha was recorded in BIPM package, was significantly superior as compared to 3940.0 Kg/ha in farmers practice plots.

The population of natural enemies like spiders and coccinellids were significantly high in BIPM when compared to farmers practice **(Table 144 & 145)**. Higher number of spider and coccinellids population of 0.8 /m^2 and 1.10/m^2 was recorded in BIPM plots as against 0.46/m^2 and 0.38/m^2 in farmers practice plots after 45 and 65 DAT respectively. The important predatory spiders recorded were *Oxyopes javanus, Tetragnattha sp.* and *Lycosa pseudoannulata.* In case of coccinellids beetles, *Micraspis* sp was more predominant. The investigation revealed that BIPM package was superior in respect of low occurrence of pests and thus increasing the crop yield.

It can be concluded that BIPM package proved as effective as farmers practice on large scale for the management of important key pests of rice. The cost benefit analysis showed the net return of Rs. 52,774.00 /ha in BIPM package as compared to Rs. 47,315.00/ha in farmers practice **(Table 1146).**

Table 142. Observation on incidence of *Nephotettix* sp./ hill

Treatments	Pre-count (*Nephotettix* sp/ hill)	Post count (*Nephotettix* sp/ hill)	
		1st Spray	2nd Spray
BIPM Package	4.31	2.95	1.73
Farmers practice	4.24	2.82	1.61
"*t*" value	0.256	0.871	0.890
Remarks	NS	NS	NS

Table 143. Observation on incidence of Dead heart, WEH, LFDL and grain yield of rice

Treatments	Dead heart (%)		WEH (%)	LFDL (%)		Grain yield (kg/ha)
	45DAT	65DAT	125DAT	45DAT	65DAT	
BIPM Package	**5.14**	**2.47**	**1.90**	**2.97**	**1.90**	**4366.0**
Farmers practice	**4.86**	**2.63**	**2.77**	**3.22**	**2.56**	**3940.0**
"*t*" value	**1.124**	**1.056**	**4.036**	**1.597**	**4.005**	**6.623**
Remarks	**NS**	**NS**	**S**	**NS**	**S**	**S**

Table 144. Observation on spider population/m^2

Treatments	Pre count (spider/m^2)	Post count (spider/ m^2)	
		45 DAT	65 DAT
IPM package	0.64	0.66	0.80
Farmers practice	0.46	0.38	0.36
'*t*' value	1.274	1.655	4.296
Remarks	NS	NS	S

Table 145. Observation on coccinellids population/m^2

Treatments	Pre count coccinellids /m^2	Post count coccinellids /m^2	
		45 DAT	65 DAT
BIPM package	1.30	0.82	1.10
Farmers practice	1.10	0.46	0.38
'*t*' value	0.801	3.515	5.51i
Remarks	NS	S	S

Table 146. Cost benefit analysis

Treatment	Yield (Kg /ha)	Additional yield over chemical control	Value of yield/ ha (Rs/ha)	Cost of bio control/ chemical treatment (Rs /ha)	Net return (Rs/ ha)
BIPM plot	4366.0	426.0	61,124.00	8350.00	52,774.00
Farmers' practice	3940.0		55160.00	7845.00	47,315.00

Rs. 14/kg of rice grain

KAU-Thrissur

Location :Vadakkenchery panchayath in Palghat District
Season : October 2016 to February 2016
Area : 5 ha
Variety : Uma

The practices followed in IPM were

- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds
- *Trichogramma japonicum* and *T. chilonis* @ 1 lakh/ha were released from 20 days after transplanting. Five releases were made at 10 days interval.
- Sprayed *Pseudomomas* @ 2% against foliar diseases.

The practices followed in conventional farming included

- Seed treatment with *Pseudomonas* @ 10 g/kg of seeds
- Flubendiamide @ 50 ml/ha against rice stem borer and leaf folder
- Malathion 0.05% against rice bug

The results of the large scale validation of rice IPM in terms of pest infestation, natural enemies population and yield are presented in **Table 147**.

Table 147. Comparison between IPM and non IPM plots at Anakkappara, Vadekkenchery

Sl. No.	Particulars	IPM plot	Non IPM plot
1	Dead heart (No's)	1.8	10.6
2	White ear head (No's)	1	12
3	Stem borer (No's)	1.2	3.2
4	Green leaf hopper (No's)	3.25	2.8
5	Rice bug (No's)	3	3.3
6	Spiders (No's)	44.4	30.14
7	Coccinellids (No's)	13.86	15
8	*Ophionea* sp (No's)	10	10.67
9	Others	47	39.4
10	Parasitoids (No's)	28.14	26

11	Yield (kg/ha)	7800 kg	5700 kg
12	Returns per ha (@21.5/kg)	Rs1, 67,700/-	1,22,550/-
13.	Cost of cultivation (Rs/ha)	42250	50060
14	Net return per ha	1,25,450/-	72490/-
15	Cost benefit ratio	2.97	1.45

Adoption of IPM practices led to substantial reduction in infestation by major pest. The mean stem borer population in IPM plots was 37% lower as compared to non IPM plots. Similarly, the dead heart as well as white ear head symptoms recorded 83 and 92% reduction respectively. The population of natural enemies too was higher in IPM plots.

The yield obtained from IPM plots was 37% more than that obtained from non IPM plots. The cost of cultivation also was 16 per cent lower in the former. The increased yield as well as reduced cost resulted in an increase in profit by Rs 52,960/ha. The cost benefit ratio, at 2.97 was almost double for IPM fields as compared to 1.45 for non IPM fields.

PAU: Large scale demonstration of proven biocontrol technologies against pests of organic *Basmati* rice

A) Releases of *Trichogramma chilonis* and *T. japonicum* in organic *basmati* rice

Large scale demonstration of biocontrol of yellow stem borer, *Scirpophaga incertulas* and leaf folder, *Cnaphalocrocis medinalis* were conducted at 10 locations in Nabha block (Patiala) in organic *basmati* rice (cv. Pusa 1121) over an area of 150 acres was conducted. The demonstrations included six releases of *T. chilonis* and *T. japonicum* each @ 1,00,000 parasitoids/ha starting from 30 days after transplanting (DAT) and was compared with untreated control. Tricho-cards each having approximately 1000 parasitized eggs were cut into 100 strips and were stapled uniformly to the underside of the leaves in biocontrol treatment. The data were recorded on dead hearts due to stem borer and leaf damage due to leaf folder at vegetative stage (45 and 60 DAT). White ear incidence was recorded a week prior to harvest. Grain yield was recorded on plot basis and economics was worked out.

Based on the mean of all locations **(Table 148)**, mean dead heart incidence in biocontrol fields were 1.54 and 2.00% at 45 and 60 DAT, respectively. The corresponding figures in untreated control were 3.63 and 4.96%. The mean reduction of dead heart incidence in release fields was 58.63% over control. The mean incidence of white ears was significantly lower in biocontrol field (2.06%) as against untreated control (4.20%) resulting in a reduction of 50.95%. Similarly, leaf folder damage in release field was significantly lower in biocontrol fields as compared to untreated control. The damage was 2.04 and 2.47% at 45 and 60 DAT, respectively as compared to 4.61 and 6.01% in untreated control with a mean reduction of 57.33%. Grain yield in biocontrol field (28.93 q/ha) was significantly better as compared to 24.39 q/ha in untreated control, respectively. The yield increase in release fields was 18.61% more than untreated control. It can be concluded that 6 releases of *T. chilonis* and *T. japonicum* each @ 1,00,000/ha resulted in lower incidence of rice insect pests and higher grain yield in organic *basmati* rice.

The BIPM practices involving regular pest surveillance and monitoring, cultural control, biological control and bio-rational approaches were compared with farmers practices (chemical control) and untreated control in *basmati* rice at village Sahauli (Patiala). The area was divided into three blocks representing three treatments, *i.e.*, T1 – BIPM (1 ha), T2 - farmers practice (1 ha) and T3 - untreated control (500 m^2). The treatments are given in **Table 149**. T1 and T2 fields were divided into four blocks. All the observations were recorded from randomly selected 20 hills from each block. The observations on stem borers infestation (dead hearts), leaf folder damage leaves (at least $1/3^{rd}$ leaf area damaged) and plant hopper population were recorded at weekly intervals starting from 30 DAT. White ear incidence by stem borers was recorded one week before the harvest of the crop. The population of predators was recorded on whole plant basis as well as through sweep nets. Grain yield was recorded on whole plot basis.

Table 148. Large scale demonstration of biocontrol of stem borer in organic basmati rice during 2015

Treatments	Dead hearts (%)				White ears (%)		LFDL (%)				Paddy yield (q/ha)	% increase over control
	45 DAT	60 DAT	Mean	% reduction over control	At harvest	% reduction over control	45 DAT	60 DAT	Mean	% reduction over control		
Biocontrol (*T. chilonis* and *T. japonicum*)*	1.54[a]	2.00[a]	1.77[a]	58.63	2.06[a]	50.95	2.04[a]	2.47[a]	2.26[a]	57.33	28.93[a]	18.61
Untreated control	3.63[b]	4.96[b]	4.30[b]	-	4.20[b]	-	4.61[b]	6.01[b]	5.31[b]	-	24.39[b]	-

DAT – days after transplanting; * 6 releases of *T. chilonis* and *T. japonicum* each @ 1,00,000/ha at weekly interval starting from 30 DAT

Table 149. Treatments followed in different modules

Particular	BIPM	Farmers practices (Non-IPM)	Untreated control
Host plant resistance	Recommended variety (Pusa 1121)	Recommended variety (Pusa 1121)	Recommended variety (Pusa 1121)
Cultural control			
Fertilizers	Green manuring with *dhaincha*	Excessive use of chemical fertilizers	Green manuring with *dhaincha*
Plant Population	Optimum plant spacing (33 hills / m^2)	20-22 hills /m^2	33 hills / m^2
Water Management	Alternate wetting and drying for hoppers	-	-
Alleyways	Alleyways of 30 cm after every 2 m	-	-
Bio-rational approach			
Pheromone traps	Installation of pheromone traps for yellow stem borer @ 20 / ha	-	-
Biological control			
Augmentative releases	Six releases of *Trichogramma chilonis and T. japonicum* each @ 1,00,000/ha at weekly intervals starting from 30 DAT	-	-
Predation	Bird perches @ 10/ha		-
Conservation of natural enemies	Delaying sprays on basis of ETL	Indiscriminate use of insecticides for insect pests	-
Monitoring and Surveillance	For insect pests at regular intervals to determine ETL	-	-
Chemical control			
Seed treatment	Seed treatment with fungicide (*Trichoderma harzianum* @ 15 g/kg seed)	No seed treatment	-
Insecticidal Sprays	Spray on basis of ETL (Botanical/ Microbials) Neem oil 1% @ 1250 ml/ha	Blanket application without caring ETL (Padan @ 15 kg/ha, Acephate 75 SP @ 1.25 kg/ha, Bifenthrin 500 ml/ha, Imidacloprid 17.8 SL @ 250 ml/ha	-

The overall incidence of rice stem borer and leaf folder was less in IPM as well as farmers practiced (non-IPM) fields as compared to untreated control **(Table 150)**. The mean dead heart incidence over a period of months was 2.49, 1.16 and 4.30% in IPM, non-IPM and untreated control, respectively. The mean incidence of white ears was 3.31, 1.78 and 5.06% in IPM, non-IPM and untreated control, respectively. Similarly, leaf folder damage in IPM fields was 3.12 as compared to 1.90% in farmer's fields. The incidence of leaf folder in non-IPM fields was 5.41%. The population of plant hoppers was nil in IPM as well as non-IPM fields. The hoppers' population in untreated control was 1.08 per hill. The data on pheromone trap catches for rice yellow stem borer revealed moth population ranging from 3.13 to 14.75 moths per trap per week during the entire season **(Table 151)**. The maximum population (14.75 moths/trap/week) was recorded during 38th SMW (3rd week of September). Highest grain yield was recorded in farmers' practiced fields (30.63 q/ha) followed by yield in IPM fields (28.07 q/ha). These yields were significantly better as compared to untreated control (25.18 q/ha).

The population of natural enemies was high in IPM fields than in non-IPM and untreated control fields. The population of spiders on whole plant basis was 4.25, 3.63 and 4.35 spiders per hill cent in IPM, non-IPM and untreated control, respectively. Similarly, in sweep net collection, the mean population of spiders (4.25/plot), dragonflies (0.75/plot) and damselflies (4.50/plot) was higher than in non-IPM fields and comparable with untreated control **(Table 152)**.

Table 150. Mean incidence of insect pests, natural enemy count and grain yield in BIPM, farmers practice and untreated control during 2015

Particulars	BIPM	Farmers' practices (Non-IPM)	Untreated control
Dead hearts (%)	2.49	1.16	4.30
White ears (%)	3.31	1.78	5.06
Leaf folder damaged leaves (%)	3.12	1.90	5.41
Plant hoppers (no./hill)	0.00	0.00	1.08
Spiders (no./hill)	1.32	0.46	0.93
Grain yield (q/ha)	28.07	30.63	25.18

* Average of weekly observations; White ears one week before the harvest of the crop; grain yield at harvest

Table 151. Moth catch of rice yellow stem borer from sex pheromone traps in IPM plots at village Sahauli during 2015

Standard Meteorological Week	No. of moths/trap/week
34	3.88
35	9.38
36	6.38
37	1.00
38	14.75
39	10.63
40	3.13

Table 152. Diversity of natural enemies in sweep net in BIPM and conventional plots at village Sahauli during 2015

Natural enemies	Mean* no. of natural enemies/plot		
	BIPM	Farmers practices (Non-IPM)	Untreated control
Spiders	4.25	3.63	4.35
Dragonflies	0.75	0.38	0.73
Damselflies	4.50	3.88	4.60

*Mean of 8 weeks observations

OUAT

Area covered : 100 ac of paddy (MTU-1010, Kaveri, Naveen, Lalat)
Location : Pakhimunda village of Puri district

BIPM adopted :

- Seed treatment with *Pseudomonas* @ 8 g/kg of seeds/seedling.
- Spray of *Beauveria bassiana* 10^{13} spores/ha against sucking pests.
- Bird perches erected @ 10/ha.
- Release of *Trichogramma japonicum* @ 1 lakh/ha when either the leaf folder or stem borer occurrence is noticed. Release initiated as soon as moth activity was noticied.
- Spray of *Bt* @ 2 kg/ha, 2 sprays given at 15 days interval.
- Spray of *Pseudomonas fluorescens* @ 1.5 kg/ha against foliar diseases.
- Spray of Azadirachtin @ 2.5 l/ha twice at 45 and 60 DAT.

Farmers Practice

Six to eight rounds of spray with insecticides like Monocrotophos, Chlorpyriphos, Rynaxypyr, Imidacloprid, Acetamiprid etc.

The dead heart, white ear head leaf folder and case worm incidence in BIPM demonstrated plots were recorded as 4.7, 6.5, 5.1 and 3.3%, respectively whereas their incidence in non-IPM farmers plots were 13.2, 17.1, 10.1 and 4.9%, respectively. Population of other pests like hairy caterpillar, GLH and BPH were less in IPM plots (0.8, 1.9 and 1.8/hill) as compared to non-IPM plots (1.6, 8.1 and 6.1/hill). The predatory spider and mirid bug population per hill were 0.8 and 0.7 in IPM plots as compared to 0.2 and 0.3 in non-IPM plots **(Table 153)**.

Table 153. Large scale demonstration of BIPM in paddy (100 acre) during *rabi,* 2015-16 at village Pakhimunda (Block-Satyabadi) of Puri District

Treatments	Dead heart (%)	While ear head (%)	Leaf folder (%)	Case worm (%)	Hairy Caterpillar (No./hill)	GLH (No./hill)	BPH (No./hill)	Spiders (No./hill)	Mirids (No./hill)
BIPM (Bio intensive Pest management	4.7	6.5	5.1	3.3	0.8	1.9	1.8	0.8	0.7
FP (Farmers practice)	13.2	17.1	10.1	4.9	1.6	8.1	6.1	0.2	0.3

GBPUAT-Pantnagar

Large scale field demonstrations of bio-control technologies on rice crop were conducted at the field of 49 different farmers in Nainital district (Halduchur and Golapar area) covering an area of approximately 70 acre with per farmers acreage ranging from 0.25-5.0 acre. Ten kg of PBAT-3 (Th-14 + Psf-173) was distributed to each adopted farmer.

Bio- control technologies adopted by farmers were as under:

i. Soil treatment: PBAT-3 was applied as soil application with pre-colonized FYM/ vermi-compost @ 10 q/ha mixed with FYM to be applied by the farmers.
ii. Seed bio-priming (10 g/kg seed).
iii. Seedlings dip treatment (10g/lit water) for 24 hr. prior to transplanting.
iv. Two foliar sprays with bio-agent, 1st at 45 DAS and 2nd at 70 DAS
v. Pheromone traps

The incidence and disease severity of sheath blight (*Rhizoctonia solani*) and brown spot (*Drechslera oryzae*) disease were low (5-10%) in treated plots as compared to untreated plots (20-30%).The disease incidence of false smut (*Ustilaginoides virens*) of rice in hybrid rice was high (30%) in both treated and untreated plots. The plots without pheromone traps showed 20 per cent stem borer incidence however, incidence was very low (3%) in plots with pheromone traps. Twenty pheromone traps were distributed to five farmers for capturing yellow stem borer. An average yield of 45q/ha was recorded from the farmers who had applied bio-control technologies under IPM programme, however an average yield of 37q/ha was recorded from the farmers who applied conventional farmers practices.

2. Sugarcane (PAU and OUAT)

1. Enabling large scale adoptation of proven biocontrol technologies against early shoot borer, top borer of sugarcane in collaboration with sugar mills (PAU)

a. Use of *T. chilonis* against early shoot borer, *Chilo infuscatellus*

i) In collaboration with sugar mills

Large scale demonstration of effectiveness of *T. chilonis* against early shoot borer, *Chilo infuscatellus* over an area of 1500 acres was carried out in collaboration with three sugar mills of the state i.e. Doaba Co-operative Sugar Mills Ltd. Nawanshehar (SBS nagar), Morinda Co-operative Sugar Mills Ltd. Morinda (Roop Nagar) and Nahar Sugar Mills Pvt. Ltd. Amloh (Fatehgarh Sahib). The egg parasitoid, *T. chilonis* was released during mid-April to end-June, at 10 days interval @ 50,000/ha. The incidence of *C. infuscatellus* at Nawanshehar, Morinda and Amloh in release fields was 2.6, 1.1 and 1.8%, respectively **(Table 154)**. The corresponding figures in control (non-adopted) fields were 5.2, 2.4 and 4.0%. The reduction in damage over control in these two mills was 50.0, 54.2 and 55.0%, respectively. It can be concluded that in large-scale demonstration, eight releases of *T. chilonis* @ 50,000 per ha at 10 days interval during mid-April to end-June reduced the incidence of early shoot borer by 53.1%.

Table 154. Demonstration of *T. chilonis* against *Chilo infuscatellus* in collaboration with three sugar mills of Punjab during 2015

Mill area	Area covered (acres)	Incidence of *Chilo infuscatelus*		
		IPM*	Non- Adopted	Per cent reduction over control
Doaba Co-op Sugar Mills Ltd, Nawanshehar	500	2.6	5.2	50.0
Morinda Co-op sugar Mills Ltd, Morinda	500	1.1	2.4	54.2
Nahar Sugar Mills Pvt. Ltd, Amloh	500	1.8	4.0	55.0
Total/ Mean	**1500**	**-**	**-**	**53.1**

Note: Eight releases of *T. chilonis* were made @ 50,000/ha at 10 days interval during mid-April to end June.

Data not statistically analysed

ii) Large-scale demonstrations

Large-scale demonstrations on the effectiveness of *T. chilonis* against early shoot borer, *C. infuscatellus* were carried out on an area of 221 acres at villages Paddi Khalsa (Jalandhar), Rawalpindi (Hoshiarpur), Karni Khera (Fazilka), Khuban (Ferozepur) and Barerwal (Sangrur). The parasitoid, *T. chilonis* was released 8 times at 10 days interval from mid-April to mid-June @ 50,000 per ha and was compared with chemical control, *i.e.* Fipronil 0.3 G (@ 25 kg/ ha applied 45 days after planting and untreated control. The incidence of early shoot borer in release fields (4.7%) and chemical control (2.0%) and was significantly better than untreated control (11.5%). The reduction in incidence over control was 59.1 and 82.6% in release fields and chemical control, respectively. The mean parasitism of eggs of *C. infuscatellus* in release fields was 48.8 per cent as compared to 4.0% in chemical control and 6.1 per cent in control **(Table 155)**. The yield in control (652.2 q/ha) was significantly lower than release fields (716.6 q/ha) and chemical control (791.0 q/ha). It can be concluded that eight releases of *T. chilonis* at 10 days interval during mid-April to mid-June @ 50,000/ha were better than untreated control, however, these were inferior to chemical control against early shoot borer. However, the cost: benefit ratio (1: 24.41) was high in biocontrol as compared to chemical control (1: 16.31) **(Table 156)**.

Table 155. Demonstration of *T. chilonis* against *C. infuscatellus* by PAU, Ludhiana during 2015

Treatments	Incidence (%)	Per cent reduction over control	Per cent parasitism	Yield (q/ha)
T. chilonis @ 50,000 per ha*	4.7[b]	59.1	48.8[a]	716.6[b]
Fipronil 0.3 G @ 25 kg/ ha	2.0[a]	82.6	4.0[b]	791.0[a]
Control	11.5[c]		6.1[b]	652.2[c]

* 8 releases at 10 days interval

Table 156. Cost Benefit analysis (2015)

Treatments	Yield (q/ha)	Additional yield over control (kg/ha)	Gross returns over control (Rs)	Cost of treatment* (Rs/ha)	Net return over control (Rs/ha)	Cost benefit ratio
T. chilonis @ 50,000 per ha	716.60	64.40	18676.00	630.00	18046.00	1: 24.41
Fipronil 0.3 G @ 25 kg/ ha	791.00	138.80	40252.00	2325.00	37927.00	1:16.31
Control	652.20	-	-	-	-	-

Price of sugarcane: Rs. 290/- per quintal during 2015; * includes trichocard/insecticide + labour cost; Price of Fipronil 0.3 G Rs. 85/ kg

b. Use of *Trichogramma chilonis* for the suppression of the stalk borer, *Chilo auricilius*

i) In collaboration with sugarmills

Large scale demonstration of effectiveness of *T. chilonis* against stalk borer, *Chilo auricilius* over an area of 7150 acres was carried out in collaboration with five sugar mills of the state i.e. Doaba Co-operative Sugar Mills Ltd. Nawanshehar (SBS Nagar), Morinda Co-operative Sugar Mills Ltd. Morinda (Roop Nagar) and Nahar Sugar Mills Pvt. Ltd. Amloh (Fatehgarh Sahib), Rana Sugar Mills Ltd. Buttar Seviyan (Amritsar), Gurdaspur Cooperative Sugar Mills, Paniar (Gurdaspur) **(Table 157)**. The egg parasitoid, *T. chilonis* was released from July to October in the mill areas at 10 days interval @ 50,000/ha. The incidence of *C. auricilius* at Nawanshehar, Morinda, Amloh, Buttar Seviyan and Paniar in IPM fields was 3.2, 1.6, 3.5, 2.4 and 3.2% respectively. The corresponding figures in control (non-adopted) fields were 7.7, 4.0, 9.8, 6.2 and 7.2%. The reduction in damage over control in these mills was 58.4, 60.0, 64.3, 61.3 and 55.6%, respectively. It can be concluded that in large-scale demonstration, 12 releases of *T. chilonis* @ 50,000/ha at 10 days internal during July to October reduced the incidence of stalk borer by 59.9%.

Table 157. Large-scale demonstration of biocontrol based IPM on sugarcane in five sugarcane mills of Punjab during 2015

Mill area	Area covered (acres)	Incidence of *Chilo auricilius*		
		IPM*	Non- Adopted	Per cent reduction over control
Doaba Co-op Sugar Mills Ltd, Nawanshehar (SBS nagar)	2100	3.2	7.7	58.4
Morinda Co-op sugar Mills Ltd, Morinda (Roop Nagar)	2300	1.6	4.0	60.0
Nahar Sugar Mills Pvt. Ltd, Amloh (Fatehgarh Sahib)	2000	3.5	9.8	64.3
Rana Sugar Mills Ltd, Buttar Seviyan (Amritsar)	500	2.4	6.2	61.3
Gurdaspur Cooperative Sugar Mills, Paniar (Gurdaspur)	250	3.2	7.2	55.6
Total/ Mean	**7150**	**-**	**-**	**59.9**

Note: Twelve releases of *T. chilonis* @ 50,000 per ha at 10 days interval during July to October.

Data is statistically not analysed

ii) Large-scale demonstrations

Large-scale demonstrations of effectiveness of *T. chilonis* against stalk borer, *C. auricilius* were carried out on an area of 305 acres at villages Paddi Khalsa (Jalandhar), Rawalpindi (Hoshiarpur), Karni Khera (Fazilka), Khuban (Ferozepur) and Bararwal (Sangrur). The parasitoid, *T. chilonis* was released 12 times at 10 days interval from July to October @ 50,000/ha and was compared with untreated control. The incidence of stalk borer in released fields (2.5%) was significantly lower than untreated control (6.3%). The reduction in incidence over control was 60.3%. The mean parasitism of eggs of *C. auricilius* in release fields was 52.2% as compared to 6.0% in control **(Table 158)**. It can be concluded that twelve releases of *T. chilonis* at 10 days interval during July to October @ 50,000/ha were better than untreated control against stalk borer.

Table 158. Demonstration of *T. chilonis* against *C. auricilius* by PAU, Ludhiana during 2015

Treatments	Incidence (%)	Per cent reduction over control	Per cent parasitism
T. chilonis @ 50,000/ha*	2.5[a]	60.3	52.2[a]
Control	6.3[b]	-	6.0[b]

* 12 releases at 10 days interval

c. Use of *Trichogramma japonicum* for the suppression of Top borer, *Scirpophaga excerptalis*

i) In collaboration with sugarmills

Large scale demonstration of effectiveness of *T. japonicum* against top borer, *Scirpophaga excerptalis* over an area of 400 acres was carried out in collaboration with two sugar mills of the state *i.e.*, Doaba Co-operative Sugar Mills Ltd. Nawanshahar and Morinda Co-operative Sugar Mills Ltd. Morinda **(Table 159)**. The egg parasitoid, *T. japonicum* was released from mid April to end June, at 10 days interval @ 50,000/ha. The incidence of *S. excerptalis* at Nawanshahar and Morinda in release fields was 4.4 and 3.2%, respectively. The corresponding figures in control fields were 10.1 and 6.7%. The reduction in damage over control in these two mills was 56.4 and 52.2%, respectively.

It can be concluded that in large-scale demonstration, eight releases of *T. japonicum* @ 50,000/ha at 10 days internal during mid April to end June reduced the incidence of top borer by 54.3%.

Table 159. Large scale demonstration of *T. japonicum* against *Scirpophaga excerptalis* in collaboration with sugar mills of Punjab during 2015

Mill area	Area covered (acres)	Incidence of *S. excerptalis*		
		IPM*	Non-Adopted	Per cent reduction over control
Doaba Co-op Sugar Mills Ltd, Nawanshahar	200	4.4	10.1	56.4
Morinda Co-op sugar Mills Ltd, Morinda	200	3.2	6.7	52.2
Total/ Mean	**400**			**54.3**

Note: Eight releases of *T. japonicum* were made @ 50,000/ha at 10 days interval during mid-April to end-June.

ii) Large-scale demonstrations

Large-scale demonstrations of effectiveness of *T. japonicum* against top borer, *S. excerptalis* were carried over an area of 190 acres at villages Paddi Khalsa (Jalandhar), Rawalpindi (Hoshiarpur), Karni Khera (Fazilka), Khuban (Ferozepur) and Bararwal (Sangrur). The parasitoid, *T. japonicum* was released 8 times at 10 days interval from mid-April to mid-June @ 50,000/ha and was compared with chemical control (Chlorantraniliprole 0.4 GR @ 25 kg/ha applied during last week of June). The egg masses of *S. excerptalis* were collected to record per cent parasitization. The incidence of top borer in released and chemical control fields was 5.1 and 2.2%, respectively. However, both the treatments were significantly better that untreated control (11.0%). The reduction in incidence over control was 53.6 and 80.0% in release fields and chemical control, respectively. The mean parasitism of eggs of *S. excerptalis* in release field was 34.2% as compared to 2.1% in chemical control and 4.0% in control **(Table 160)**. The yield in control (641.0 q/ha) was significantly lower than release fields (712.5 q/ha) and chemical control (825.4 q/ha). It can be concluded that eight releases of *T. japonicum* at 10 days interval during mid-April to mid-June @ 50,000/ha proved as effective as chemical control for the control of top borer. The cost benefit ratio **(Table 161)** was high in biocontrol (1: 27.21) as against chemical control (1: 10.69).

Table 160. Large scale demonstration of *T. japonicum* against *Scirpophaga excerptalis* during 2015

Treatments	Incidence (%)	Per cent reduction over control	Per cent parasitism	Yield (q/ha)
T. japonicum @ 50,000/ha	5.1[b]	53.6	34.2[a]	712.5[a]
Chlorantraniliprole 0.4 GR @ 25 kg/ha	2.2[a]	80.0	2.1[b]	825.4[b]
Control	11.0[c]	-	4.0[b]	641.0[c]

*8 releases at 10 days interval

Table 161. Cost Benefit analysis (2015)

Treatments	Yield (q/ha)	Additional yield over control (kg/ha)	Gross returns over control (Rs)	Cost of treatment * (Rs/ha)	Net return over control (Rs/ha)	Cost benefit ratio
T. japonicum @ 50,000/ha	712.50	71.50	20735.00	735.00	20000.00	1: 27.21
Chlorantraniliprole 0.4 GR @ 25 kg/ha	825.40	184.40	53476.00	4575.00	48901.00	1:10.69
Control	641.00	-	-	-	-	-

Price of sugarcane: Rs. 290/- per quintal during 2015; * include trichocard/insecticide + labour cost; Price of Chlorantraniliprole 0.4 GR Rs 175/ kg

OUAT-Bhubaneswar

Area covered : 105 acres of sugarcane (87A-298 and CO-86032)
Location : Barada village of Dhenkanal district.

BIPM adopted

Release of *Trichogramma chilonis* @ 1 lakh parasitoids/ha against early shoot borer (ESB) and internode borer (IB) and *T. japonicum* against top shoot borer at 10 days interval.

Farmers Practice

Application of granular insecticides and sprayable insecticides as per availability.

The crop was planted in the month of November-December 2015. First release of *T. chilonis* was done in the month of January (20.1.2016) after taking pre-release ESB infestation which ranged from 11.8 to 15.3%. Release of *T. chilonis* is continuing and observation on incidence of ESB is being taken at weekly intervals. The mean incidence of ESB was 6.8% in *T. chilonis* released plots. On the contrary, the average incidence of ESB was 22.3% in the fields where no parasitoids have been released and the farmers took their own control measures of pesticide application. Parasitoid release resulted in significant reduction of ESB population as compared to pesticide application. The IB incidence was also least (10.2%) in parasitoid released plots as compared to 26.8% in farmers practice **(Table**

162). The top shoot borer incidence has not yet noticed in the field. The experiment is continuing and will be concluded in 2016-17.

Table 162. Incidence of borer pests of sugarcane in BIPM and non-BIPM fields during Rabi 2015-16 at village Barada (Block Barada) of Dhenkanal District

Treatments	Early shoot borer (%)		Internode borer (%)
	Pre-release	Post-release	
1.Release of *Trichgramma chilonis* @ 1 lakh/ha at 10 days interval	11.8	6.8	10.2
2.Farmers practice of pesticide application	15.3	22.3	26.8

Data not analysed statistically

3. Maize (PAU)

1. Demonstration of biological control of maize stem borer, C*hilo partellus* using *Trichogramma chilonis*

The demonstrations on the biological control of maize stem borer, C*hilo partellus* were conducted at farmers fields on an area of 325 acres in Hoshiarpur, Nawanshehar, Roop Nagar, Pathankot, Jalandhar, Fazilka and Sangrur districts of Punjab in collaboration with Maize Section, Department of Plant Breeding & Genetics, KVK Pathankot, FASS Hoshiarpur and KVK Hoshiarpur. The demonstration area was divided into three blocks representing three treatments, *viz.*, one release of *T. chilonis* @ 1,00,000 parasitoids/ha, chemical control (farmers practice) and untreated control. Tricho-cards each having approximately 1000 parasitized eggs were cut into 100 strips and were stapled uniformly to the underside of the central whorl leaves on 10-15 days old crop in biocontrol treatment. In chemical control (farmers practice), Deltamethrin 2.8 EC @ 200 ml/ha was sprayed 1-2 times using 150 litres of water per ha. The observations were recorded on dead heart incidence and the yield was recorded at harvest on whole plot basis.

Based on the mean of all locations **(Table 163)**, mean dead heart incidence in fields with the release of *T. chilonis* (4.83%) was significantly lower than chemical control (3.60%). However, both the treatments were significantly better than untreated control (10.90%). Similarly, yield in release (49.38 q/ha) and chemical control (52.21 q/ha) fields were significantly more than in untreated control (41.17 q/ha). The net returns over control in biocontrol package was Rs. 9858.00/- as compared to Rs.13607.75/- in farmers practice with cost benefit ratio of 1: 47.09 and 1: 36.80, respectively **(Table 164)**. It can be concluded that biological control using *T. chilonis* @ 1,00,000/- per ha rendered effective control of maize stem borer, *C. partellus* as against untreated control and was comparable to chemical control (farmers practice). Moreover, the cost benefit ratio was higher in biocontrol treatment as against the farmers practice.

Table 163. Effect of *T. chilonis* releases on incidence of *C. partellus* and yield in *Kharif* maize during 2015

Treatments	Dose / ha	Dead hearts (%)	Yield (q/ha)
T. chilonis *	1,00,000	4.83[a]	49.38[a]
Farmers' practice (Deltamethrin 2.8 EC @ 200 ml/ha)	200 ml	3.60[b]	52.21[b]
Untreated control		10.90[c]	41.94[c]

*Single release

Table 164. Cost Benefit analysis (2015)

Treatments	Yield (q/ha)	Additional yield over control (kg/ha)	Gross returns (Rs)	Cost of treatment * (Rs/ha)	Net return over control (Rs/ha)	Cost: benefit ratio
Biocontrol (release of *T. chilonis*)	49.38	7.44	9858.00	180.00	9653.00	1:47.09
Farmer's Practice (Chemical control)	52.21	10.27	13607.75	360.00	13247.75	1:36.80
Untreated control	41.94	-	-	--	-	

Price of maize Rs. 1325 / Q; * includes trichocard/insecticide + labour cost; Price of Deltamethrin 2.8 EC Rs 550/ litre

4. Brinjal (OUAT)

Area covered : 101 acre of brinjal (Patana local, Tarini)

Location : Khandeita (61.5 acres) and Gatiroutpatana (39.5 acres)

BIPM adopted:

- Pheromone traps erected @ 25/ha after 15 DAP (days after planting).
- Weekly release of egg parasitoid *Trichogramma chilonis* @ 50,000/ha/week after 20 DAP (total of 15 releases) (released till the final harvest)
- Two sprays of *Bt* (Dipel) @ 2 ml/l at 10 days interval at peak flowering.

Farmers Practice: Rynaxypyr @ 0.3 ml/l at fortnightly intervals or other insecticide application as per availability.

Data in **Table 165** indicated that, the infestation in shoots (10.8 – 12.9%) and fruits (20.3-21.6%) recorded in BIPM plots was significantly lower as compared to farmers own practice in both the locations, where it ranged from 26.3-27.9 and 41.2-46.7%, respectively. The consequent yield (19.6-19.8 ton/ha) and C:B ratio (1:4.7-1:5.6) was also higher in BIPM plots as compared to farmers own practice, where it ranged from 12.3-13.4 t/ha and 1:1.26 to 1:1.28, respectively. Further, the BIPM package produced higher net return per hectare ranging from Rs.1,13,502/- to Rs.1,22,735/- over farmers conventional practice. The number of moths catched per trap per week ranged from 5-50 during December 2015 to February 2016.

Table 165. Incidence of shoot and fruit borer and yield of brinjal in IPM and non-IPM fields during Rabi, 2015-16

Treatments	Shoot borer Incidence (%)	Fruit borer incidence (%)	Marketable fruit Yield (kg/ha)	C : B ratio	Net return over Farmers practice (Rs/ha)
Location 1 : Vaillage – Khandeita, Block-Khaneita, Dist-Cuttack, Area-61.5 acres					
BIPM package	10.8	21.6	19,623	1:4.7	1,22,735.00
Farmers practice	27.9	46.7	12,281	1:2.8	
Location 2 : Village-Gatiroutpatana, Block-Sadar, Dist-Cuttack, Area-39.5 acres					
BIPM package	12.9	20.3	19,812	1: 5.6	1,13,502.00
Farmers practice	26.3	41.2	13,427	1: 2.6	-

2.19. Tribal sub plan programme (TSP)

1. AAU-Anand: Biocontrol technologies for the management of *Fusarium* wilt and pod bore (*H. armigera*) in pigeon pea

Large scale demonstration was carried out at various fields of Panchmahal district during *rabi*- 2015 in collaboration with Tribal Research and Training Centre, Devgadh bariya to manage *H. armigera* as well as wilt disease in pigeon pea.

Under the TSP project, 50 tribal farmers were selected from Panchmahal and Mahisagar districts (the then Panchmahal district of Gujarat). Primarily the selected farmers were suggested to grow pigeon pea with improved seeds and biocontrol based IPM techniques to get better yield. We have provided *Trichoderma asperellum*, pheromone traps and neem based azadirachtin formulation as inputs to manage the pests and diseases. With the use of biocontrol based IPM techniques in pigeon pea production, an increase of 15-20% yield and 60-70% pest and disease management was recorded.

2 .ANGRAU-Anakapalle: Organic Paddy cultivation

Interventions **:** Front line demonstrations and Training Programmes.
Locations **:** Two villages - Kothavalasa and Gunjariguda (Dumbriguda mandal), Arakuvalley, Visakhapatnam District, Andhra Pradesh .
Area Covered **:** Total 40 acres (20 acres/ village)
Number of farmers benefited : Total 40 farmers (28 farmers in Kothavalasa and 22 in Gunjariguda villages) **Total of 40 farmers**
Inputs supplied : Paddy seeds of MTU 1010
Pseudomonas flourescens for seed treatment and also for foliar spray.
Liquid Biofertilizers – Azospirillum and Phosphobacteria
Trichocards (*Trichogramma chilonis*) for pest management.

Arakuvalley Tribal Farmers with small land holdings of half an acre to one acre are benefited from ICAR- Tribal sub Plan Programme implemented by AICRP on Biological Control Scheme, ANGRAU by conducting Front line demonstrations on Paddy Organic farming techniques in 40 acres area at two villages *i.e*., Kothavalasa and Gunjariguda, Dumbriguda mandal, Araku valley, Visakhapatnam district, Andhra pradesh during kharif and rabi, 2015-16. The main objective of the programme is to increase net incomes of small and marginal farmers and women farmers. About 50 farmers are successfully cultivated paddy and obtained good yields due to adoption of organic farming practices in paddy. Organic farming in paddy was spread in 40 acres in Arakuvalley benefiting 50 farmers , 20 acres in Kothavalasa benefiting 28 farmers, 20 acres in Gunjariguda benefiting 22 farmers with each of them cultivating in half an acre to one acre each in agency areas in Visakhapatnam district.

Training Programmes

Training programmes on organic farming was conducted in paddy during July, 2015, on importance of organic farming, biofertilizers and biopesticides in paddy cultivation. Scientists of District Agricultural Advisory & Transfer of Technology (DAATT) centre, Visakhapatnam participated in training programme. Supplied paddy variety 2 kg per each

farmer; supplied *Pseudomonas flourescens* @ 250 g/ 30 kg seeds/acre. Conducted demonstration on seed treatment method with *Pseudomonas flourescens* for seed treatment @ 5 g/kg seed during first and second week of July, 2015. Provided liquid Biofertilizers – *Azospirillum* and Phosphobacteria @ 500 ml/ acre.

Method demonstrations

Conducted method demonstration on mixing of liquid biofertilizers with well decomposed farm yard manure and its application at 10-15 days after transplanting. Conducted method demonstration and issued Trichocards (*Trichogramma chilonis*) for 4 releases @ 40,000 egg parasitoids per acre from 30 Days after transplanting, 4 releases at weekly interval for the management of stem borer and leaf folder. Issued *Pseudomonas flourescens* and conducted foliar spray with *Pseudomonas flourescens* @ 5 -10 g/L at PI stage against blight disease. Scientist of RARS, Anakapalle and DAATT Centre participated in the method demonstration. Four knapsack sprayers were issued to TSP farmers of Kothavalasa and Gunjariguda villages (One sprayer for a group of 10 farmers) for biopesticide spraying.

Field Day

Conducted field day on 3.11.15 at maturity stage of the crop at Kothavalasa village and 60 farmers of Kothavalasa and Gunjariguda villages participated. Dr. N. Venugoapala rao, ADR, RARS, Anakapalle and Dr. Padmodaya, ADR, RARS, Chinthapalli, Coordinatoor, Scientist DAATTCentre, Visakhapatnam participated in ruthusadassu. Interacted with farmers regarding usefulness of the technology. Farmers realized the use of biofertilizers application with good tillering and more productive tillers in organic farming block compared to check plot and also recognized nil incidence of stem borer and leaf folder in organic farming block compared to check plot with severe incidence of stemborer as deadhearts and white ears.

Farmer- Scientists interaction

Condutcted interaction meeting during the visit of Dr. B. Ramanujam, AICRP incharge from ICAR- NBAIR, Bangalore on 01.03.2016. Tribal farmers realized the use of biofertilizers application with good tillering and more productive tillers (8-10 tillers/hill) without zinc deficiency symptoms in organic farming block compared to check plot with poor tillering severe zinc deficiency in organic farming compared to traditional practice without using any fertilizers (4 tillers/hill) and observed nil incidence of stem borer as deadhearts and white ears and also leaf folder damage and severe incidence of stemborer as deadhearts and white ears and leaf folder damage . Organic farming FLD farmers recorded higher yields (4025 kg/ha) compared to 2100 kg/ha in farmers practice of without using fertilizer application and plant protection.

Tribal farmers realized the use of biofertilizers application with good tillering and more productive tillers (8-10 tillers/hill) without zinc deficiency symptoms in organic farming block compared to check plot with poor tillering severe zinc deficiency in organic farming compared to traditional practice without using any fertilizers (4 tillers/hill) and observed nil incidence of stem borer as deadhearts and white ears and also leaf folder damage and severe incidence of stemborer as deadhearts and white ears and leaf folder damage .

Organic farming FLD farmers recorded higher yields (4025 kg/ ha) compared to 2100 kg/ha in farmers practice of without using fertilizer application and plant protection.

TSP farmers expressed that application of biofertilizers in paddy gave good tillering without zinc deficiency symptoms and healthy vigorous crop helps in obtaining higher paddy yields over traditional paddy cultivation. TSP farmers recognized that Trichocards prevented deadhearts and white ears by stem borer and leaf damage by leaf folder in paddy compared with severe incidence of deadhearts and white ears and leaf folder damage in traditional rice cultivation. TSP FLD farmers of both the villages said that paddy cultivation became profitable with the assistance of AICRP on Biological control, ANGRAU technology and benefited with organic farming technology in obtaining good paddy yields and expressed willingness to organic farming for achieving higher yields.

3. MPKV, Pune: Management of insect pests in fruit crops in tribal area

Details of locations of tribal areas/STS where TSP is going to be extended

Tribal (ST) dominating areas of Daltpatpur in Trimbak Tahsil of Nasik district in Maharashtra in collaboration with Bharatiya Agro Industries Foundation (BAIF), Maharashtra Institute of Technology Transfer for Rural Areas (MITTRA), Nasik.

No. of villages/ No. of farmers/area to be covered in TSP project

Sl. No.	Year	No. of Villages	No. of farmers	Area in Horticultural crops covered under TSP
1	2014-15	10	50	50 Acres.
2	2015-16	10	50	50 Acres.
3	2016-17	10	50	50 Acres.
Total	**3 years**	**30**	**150**	**150 Acres**

Selection of village: In Tribal (ST) dominating area of the villages **Daltpatpur, Toragan,** Taluka Trimbak Dist Nashik in Maharashtra were selected for implementation of TSP.

Fifty Wadis (fruit orchards) of tribal farmers established by BAIF MITTRA at **Harsul** and **Daltpatpur** were selected to carry out operation under TSP. The wadi of 0.40 ha consisting 9-10 year old plantation of fruit crops such as 40 plants of Mango, 30 plants of Cashew nut, 10 plants of Amla, 5 plants of Drumstick and forest species *i.e.*, Teak and Bamboo planted on border.

Survey: Survey was carried out to find out the insect pest problems of fruit orchard. The infestation of mango stem borer, fruit fly, mango hopper and leaf webber, tea mosquito bug on Cashew and leaf webber infestation on mango and cashew and bark eating caterpillar problem on the plantation crops was observed. In vegetable crops, the infestation of aphids and pod borer were serious on French bean, fruit borer and leaf miner on rain fed tomato.

Water supply for irrigation to fruit trees in wadi is the major constraint for increase in yield. Tribal farmers strongly demanded for irrigation facilities so that their income will be increased. Guidelines have been given to create irrigation facilities from the river. Some

farmers created irrigation facilities and therefore able to increase yield and they have also taken intercrops *viz.*, wheat, onion and groundnut.

Training programme: One day training programme of tribal youths and tribal farmers was organized on 2.12.2015 and 19.2.2016 at Dalpatpur respectively. Taught tribal youths and farmers about different pests of fruit crops, marks of identification, nature of damage, symptom and their management etc. Talk was also delivered on identification of natural enemies. The information on 3P mission programme was given to protect the parasitoids, predators and pollinators in nature. They were guided to remove leaves affected by webbers in mango and cashew nut.

Crops to be dealt

Sl. No	Horticultural crops	Major Insect pests
1	Mango	Mango hoppers, Stem borer, Leaf webber, fruit fly and gall fly
2	Cashew nut	Tea mosquito bug, Stem borer, Leaf webber, Jassids and bark eating caterpillar
3	Amla	Stem borer and bark eating caterpillar
4	Forest trees	Stem borer and bark eating caterpillar
5	French bean	Aphids and pod borer
6	Tomato	Fruit borer and leaf miner

The application of 40 kg Neem cake enriched with *Trichoderma* + *Paecilomyces* + *Metarhizium anisopliae* + Phosphorus solublizing bactria + Potash solublizing bacteria + *Pseudomonas fluorescence*. 1 kg each will be mixed properly and water will be added to moist and covered with plastic or gunny bags for 15 days for enrichment and then will be applied @ 1 kg/tree near the root zone mixed in soil during monsoon. The population of beneficial microbes will be built-up in monsoon due to high humidity.

For the management of pests and diseases, two sprays of NSKE + Biopesticides will be given during flowering stage at 10 days interval as preventive measure and details are given below:

- Spraying of NSKE 5% + *Lecanicillium lecanii* 5 gram + *Metarhizium anisopliae* @ 5 g +*Pseudomonas fluorescence* @ 5 g + *Beauveria bassiana* 5 g/L of water
- For management of stem borers, after cleaning the hole made by stem borer, apply *Metarhizium anisopliae* 10 ml injection and plug the hole with wet soil/mud.
- Curative spraying on demand if infestation of pests or diseases noticed.

Supply of input (2015-16)

The sanction grants of TSP are 0.90 Lakhs only. The following biofertilizers, bio pesticides, fruit fly and yellow sticky traps were supplied to fifty selected tribal farmers.

- PSB : 1 litre
- KSB : 1 litre

- Phule Trichoderma + *Paecilomyces lilacinus* : 1 kg
- Phule *Pseudomonas* : 2 kg
- *Phule Metarhizium anisopliae* : 2 kg
- *Phule Lecaniicillium lecanii* : 2 kg
- *Beauveria bassiana* : 2 kg

Total quantity: 11 kgs supplied to each wadi owner

Participatory Approach demonstration

Enrichment of FYM with biofertizer and biopesticdes (2014-15 and 2015-16)

For the application to soil by enriched FYM. The demonstration on enrichment of FYM with biofertizers and biopesticdes was organized to increase the beneficial flora and fauna near the rhizosphere of fruit trees. About 250 kgs FYM was mixed with 1 litre each of PSB,KSB and 1 kg each of Phule *Trichoderma + Paecilomyces*, Phule *Pseudomonas, Phule Metarhizium anisopliae,* moistened and covered with plastic paper for 15 days for enrichment and then applied to the fruit trees.

Important Visitors to TSP project

Dr. B Ramanujum, Project Co-ordinator visited AICRP on Biological Control, Pune centre and also visited Dalpatpur Tal. Trimbakeshwar, Dist.: Nashik where Tibal sub plan was implemented by our centre since 2014 onwards. During his visit, he had interacted with farmers about benefits received due to training and he had also supplied inputs to the farmers. Farmers realized the importance of yellow sticky trap. They purchased traps from the market. It shows technology has been adopted by the farmers. Similarly they also enriched their FYM. Application of biopesicides saved their crop from the pests *viz*., Mango hopper and cashew tea mosquito bug. Thus yield of Mango and cashew nut has increased **(Table 166).**

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Table 166. Materials supplied to the TSP farmers with clear financial details:

Sl. No	Components	Price of component (Rs.)	Quantity Litre/Kg	No. of farmers	Area covered/ (Acres) Persons covered	Total expenditure (Rs.)
I st Year (2014-15)						
1	Biofertilizers	400	50	50	50	20,000
2	Biopesticides + Growth promoter	120X6 = 720	6 kg.	50	50	34,000
3	Yellow sticky traps and Fruit fly trap with lure (100 Nos.)	161x 1=161	100 No.	50	50	16,100
4	Sealer cum Healer	107x 3 Kg= 322	150 Kg	50	50	16, 100
5	Training	-	-	100	-	3838
I st Year				**Total (Rs.)**		**90,038**
II year (2015-16)						
1	Biofertilizers	400	50	50	50	20,000
1	Biofertilizers	550	150	50	50	27,500

2	Biopesticides + Growth promoter	960	400	50	50	48,000
3	Mango Harvester	200	50	50	50	10,000
4	Krushi darshani	130	50	50	50	6500
4	Fruit fly Trap lure	115	20	20	20	2300
	lure	26	120	60	60	3120
5	Training	-	-	100	-	2570
II[nd] Year Total (Rs.)						**99,990**
III [rd] Year						
6	Same as above		-do-	50	150	**90000**
Total for 3 Years				**150 acres**		**2,80,038**

Achievements of First two years of TSP

- Tribal farmers understood the insect pest problems of Wadi (Fruit orchard) and IPM practices.
- Tribal farmers can identify the nature of damage of pests and remedies to be adopted.
- They learned how to control the mango stem borer and bark eating caterpillar by doing self demonstration with PRA techniques.
- Extension principle, "Learning by Doing and seeing is Believing" was adopted by them.
- The use of biopesticides increased instead of chemical pesticides.
- They are now able to identify the pest as well as natural enemies.
- Due to preventive sprays of biopesticides, mango and cashew nut fruit drop reduced and fruit setting increased. Hence, tribal farmers are convinced with effectiveness of biopesticides in spite of unfavorable weather conditions.
- Increased the beneficial fauna near the rhizosphere of fruit trees to reduce pests and diseases.
- The cost of plant protection in horticulture crops was reduced by ecofriendly pest management measures.
- Income has been increased due to increase in irrigation facilities and by taking intercrops viz., onion, groundnut and wheat in fruit orchards.
- They realized the importance of irrigation facilities

Anticipated impact of TSP Project on economic improvement of the tribal people and wealth creation in tribal areas

Fruit setting will be good. Hence the yield of mango and cashew will be increased as compared to previous year. Farmers will be satisfied with this project.

4. OUAT: Demonstration on biointensive pest management on brinjal at Kandhamal and Keonjhar districts.

Demonstration on biointensive pest management was carried out in 20 acres of farmers field on brinjal crop at Kandhamal and Keonjhar districts. Twenty beneficiaries were selected covering three blocks and six villages near KVK, G.Udayagiri. Similarly, twenty beneficiaries were selected covering one block and two villages of Keonjhar district near RRTTS, Keonjhar. Demonstration was given on 0.5 acre of existing brinjal crop of each beneficiary. The inputs, such as pheromone traps with lucin-lure @ 10 traps/ac, *Btk* @ 2 g/l and *Trichogramma chilonis* egg parasitoid @ 20,000/ac were provided to the beneficiaries

and compared with the existing practice of spraying insecticides like Coragen @ 0.3 ml/l at 15 days interval **(Table 167)**.

Table 167. Demonstration on BIPM in brinjal

Sl. No.	Tribal district	Block	Village	Beneficiaries	Area (ac)
1	Kandhamal	G. Udayagiri	Lamungia	3	1.5
			Alankupa	2	1.0
		Riakia	Sisapanga	4	2.0
			Pukimaha	1	0.5
			Kambarkia	2	1.0
		K. Nuagaon	Madikia	8	4.0
2	Keonjhar	Sadar	Tikarapada	18	9.0
			Mahadeijoda	2	1.0
Total	2	4	8	40	20

5. TNAU-Coimbtore

Under the TSP, three trainings to tribal farmers were organised during the period under report. First training was organised at Kolli hills of Namakkal district. In this training thirty tribal farmers were trained on the establishment of kitchen garden and its utility on nutritional security with free supply of vegetable seeds and other bioinoculants. They were explained about the bio intensive pest management of vegetable crops to obtain pesticide residue free vegetables. Demonstrations were carried out to explain the preparation of neem oil emulsion, neem seed kernel extract, seed treatment, use of sticky traps, pheromone traps and release of tricho cards, *Chrysoperla* and *Cryptolaemus* predators. The programme was conducted along with Department of Horticulture, Government of Tamil Nadu. The officials of the Horticultural Department *viz*., DDH and ADH attended the training program.

In the second training 30 tribal farmers of Bargur hills, Anthiyur taluk, Erode district were given training on skill development. The farmers were explained about the cultivation of minor millets and their usefulness in nutritional security. Biocontrol based insect pest and disease management for the major pests of ragi was discussed. In addition, the farmers were shown the demonstrations of botanical pesticide preparation, release of biocontrol agents and seed treatment with bioagents. The programme was conducted in collaboration with MYRADA KVK, Erode.

Third training was organised at Pokkapuram, Gudalur Taluk of Nilgiris district. Thirty tribal farmers were given training on skill development on the establishement of kitchen garden and production of chemical pesticide free vegetables using biological control agents. The farmers were explained about the cultivation of vegetable crops and their usefulness in nutritional security. Biocontrol based insect pest and disease management for the major pests of vegetables was discussed. In addition, the farmers were also shown the demonstrations of botanical pesticide preparation, release of biocontrol agents and seed treatment with bioagents. The programme was conducted in collaboration with UPASI, KVK, Coonoor.

Date	Location	District	No. of farmers trained	Inputs supplied
03.12.2015	Kolli hills	Namakkal	30 (28 males, 12 females)	*Pseudomonas flourescens, Trichoderma asperellum, Beauveria bassiana, Metarhizium anisopliae,* neem seed kernel, neem oil, Vegetable seeds of cluster bean, lab lab, bhendi, tomato and bitter gourd.
03.02.2016	Bargur hills Anthiyur Tk.	Erode	30 (20 males, 10 females)	*Pseudomonas flourescens, Trichoderma asperellum, Beauveria bassiana, Metarhizium anisopliae, Azospirillum, Phosphobacteria,* Pancha kavya, neem seed kernel, neem oil and ragi seeds.
06.2.2016	Pokkapuram Gudalur Tk.	Nilgiris	30	*Trichoderma asperellum, Beauveria bassiana, Metarhizium anisopliae, Azospirillum, Phosbacteria,* Pancha kavya, neem seed kernel, neem oil and vegetable seeds like bhendi, cluster bean, lab lab, bottle gourd and amaranthus.

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

Details of the location of tribal area where TSP was implemented: District Lahaul and Spiti, Himachal Pradesh

No of village covered: 3 and number of farmers benefitted: 152

Sl. No.	Village	Date of training/demonstration	No of farmers
1	Poh	2-11-2015	53
2	Tabo	3-11-2015	54
3	Lari	4-11-2015	45
	Total		152

Crops covered

Apple, apricot, peas, beans, cauliflower and cabbage

Area covered

Crop	Area (ha)
Apple	150
Apricot	25
Peas	50
Beans	25
Cauliflower & cabbage	25
Total	275

Management of the insect-pests and diseases of important cash crops of the area through eco-friendly methods to reduce the application of chemical pesticides on these crops.

IPM technologies demonstrated/ implemented

i. Use of *Metarhizium anisopliae* and Neem Baan for the management of apple root borer and apple stem borer.
ii. Use of *Trichoderma* and *Pseudomonas* for the management of diseases in apple vegetable nursery.
iii. Use of yellow and blue sticky traps for the management of thrips, whiteflies and leaf miner in apple, beans and peas.
iv. Use of *Bt*, neem products in cole crops for the management of caterpillar pests.
v. Use of Helilure, Spodolure and DBM lure for the management of *Helicoverpa armigera, Spodoptera litura* and DBM in peas and cole crops.
vi. Need based and safe use of insecticides for the conservation of parasitoids of apple woolly aphid and other natural enemies.
vii. Use/conservation of predatory mites on beans and apple against phytophagous mites.

Inputs supplied to the farmers

Sl. No.	Material	Number/ quantity
1	*Metarhizium anisopliae*	15 Kg
2	Yellow sticky traps	150
3	Blue sticky traps	150
4	Azadirachtin	150
5	*Helicoverpa* pheromone lure	150
6	*Spodoptera* pheromone lure	150
7	DBM pheromone lure	150
8	*Trichoderma asperellum*	150
9	*Pseudomonas*	150
10	Literature regarding the management of apple root borer	150

Training/ demonstration conducted

Trainings and demonstrations were organized at Poh, Tabo and Lari villages of Kaza block of District Lahaul and Spiti in which 152 farmers participated. Farmers were trained and demonstrated regarding the use of above said bio-pesticides for the management of insect and mite pests of apple, apricot, peas, beans, cauliflower and cabbage. The farmers of the area were exposed to the use of biopesticides for the management of crop pests for the first time.

Expenditure

Total amount allocated for the year	: Rs. 1,00,000/-
Amount received till date	: Rs. 1,00,000/-
Amount spent till date	: Rs. 1,00,000/-

Head wise breakup of the expenditure

Inputs, training material, light refreshment, literature, banner etc.	Rs 89,000/-
POL, miner repair/taxi	Rs 11000/-
Total	Rs 1,00,000/-

Outcome of the project

Total 152 farmers of villages Poh, Tabo and Lari of district Lahaul and Spiti were benefited from the trainings/demonstrations. These farmers were exposed to the use of biopesticides for pest management for the first time. On peas, beans and cole crops there was a reduction upto 2-3 sprays of chemical pesticides. In case of apple, however, due to severity of apple woolly aphid, *Eriosoma lanigerum* remained to be serious and farmers had to depend on insecticide application.

3. Functioning of the co-ordinated project

3.1. Staff position

Sl. No.	Name	Designation	Joining date	Date of leaving
National Bureau of Agricultural Insect Resources, Bangalore				
1	Dr. Abraham Verghese	Director	04.04.2013	Continuing
2	Dr. Prashanth Mohanraj	HOD Biosystematics	07.04.2001	Continuing
3	Dr. (Ms) Chandish R. Ballal	HOD Insect Ecology	06.02.1985	Continuing
4	Dr. S. K. Jalali	HOD Molecular Entom.	06.02.1985	Continuing
5	Dr. N. Bakthavatsalam	Principal Scientist, Ento.	01.10.1994	Continuing
6	Dr. B. Ramanujam	Principal Scientist, Path.	11.12.2000	Continuing
7	Dr. (Ms.) K. Veenakumari	Principal Scientist, Ento.	07.04.2001	Continuing
8	Dr. A. N. Shylesha	Principal Scientist, Ento	04.08.2007	Continuing
9	Dr. T. Venkatesan	Principal Scientist, Ento	29.10.1994	Continuing
10	Dr. P. Sreerama Kumar	Principal Scientist, Path.	31.07.1995	Continuing
11	Dr. K. S. Murthy	Principal Scientist, Ento	04.04.2001	Continuing
12	Dr. Sunil Joshi	Principal Scientist, Ento	04.11.1994	Continuing
13	Dr. R. Rangeshwaran	Principal Scientist, Micr.	05.03.1997	Continuing
14	Dr. T. M. Shivaling Swamy	Principal Scientist, Ento.	2009	Continuing
15	Dr. K. Subhaharan	Senior Scientist, Ento.	2014	Continuing
16	Dr. G. Siva Kumar	Senior Scientist, Micr.	2009	Continuing
17	Dr. Mohan	Senior Scientist, Ento.	01.06.2012	Continuing
18	Dr. Mahesh Yandigeri	Senior Scientist, Micr.	04.06.2012	Continuing
19	Dr. M. Pratheepa	Senior Scientist, CS	23.09.1999	Continuing
20	Dr. Deepa Bhagat	Senior Scientist, OC	30.03.2007	Continuing
21	Dr. Gandhi Gracy	Scientist, Ento.	2009	Continuing
22	Dr. Ankitha Gupta	Scientist, Ento.	2010	Continuing
23	Mr. K.J. David	Scientist, Ento.	28.12.2011	Continuing
24	Mrs. S. Salini	Scientist, Ento.	28.12.2011	Continuing
25	Dr. Jagdesh Patil	Scientist, Nemat.	2012	Continuing
26	Dr. Richa Varshney	Scientist, Ento.	2015	Continuing
27	Ms.Rachana R R	Scientist, Ento.	2015	Continuing
Central Tobacco Research Institute, Research Station, Guntur				
1.	Dr. P.Venkateswarulu	Principal Scientist (Nem.)	2015	Continuing
Central Plantation Crops Research Institute, Regional Station, Kayangulam				
1	Dr. (Ms.) Chandrika Mohan	Principal Scientist (Ent.)	01.04.1996	Continuing
Indian Agricultural Research Institute, New Delhi				
1	Dr. B. Paul	Senior Scientist (Ent.)	2012	Continuing
2	Dr. Shankar Ganesh	Scientist (Ent)	2015	Continuing
Indian Institute of Sugarcane Research, Lucknow				
1	Dr. Arun Baitha	Senior Scientist (Ent.)	01.10.2006	Continuing
Indian Institute of Horticultural Research, Bangalore				
1.	Dr. A. Krishnamoorthy	Princ. Scientist (Ent.)	1977	Up to Sep2015
2	Dr. P. N. Ganga Visalakshy	Princ.Scientist (Ent.)	1987	Continuing
3	Ms. Jayanthi Mala	Scientist (Ent)	2016	Continuing

4	Dr. N.R. Prasannakumar	Scientist (Ent)	2016	Continuing
Directorate of Weed Science Research, Jabalpur				
1	Dr. Sushil Kumar	Princ. Scientist (Ent.)	2006	Continuing
National Centre for Integrated Pest Management, New Delhi				
1	Dr. Naved Sabir	Princ. Scientist (Nemat.)	2014	Continuing
Indian Institute of Millet Research, Hyderabad				
1	Dr. V.R. Bhagwat	Princ. Scientist (Ent.)	2013	Continuing
Directorate of Seed Research, Mau				
1	Dr. Raghavendra	Scientist (Ent.)	2013	Continuing
Central Institute of Sub-Tropical Horticulture, Lucknow				
1	Mr. Balaji Rajkumar	Scientist (Ent)	2016	Continuing
2	Dr. Gundappa	Scientist (Ent.)	2013	Continuing
Indian Institute of Rice Research, Hyderabad				
1	Dr. Chitra Shanker	Princ. Scientist (Ent.)	2013	Continuing
Indian Institute of Vegetable Research, Varanasi				
1	Dr. Jaydeep Halder	Scientist (Ent.)	2013	Continuing
Anand Agricultural University, Anand				
1	Dr. D. M. Mehta	Principal Res. Scientist	July 2012	Continuing
2	Dr.P. H. Godhani	Asso. Res. Scientist	Sept. 2012	Continuing
3	Dr. B.L. Raghunandan	Asso. Res. Scientist	2015	Continuing
Acharya N. G. Ranga Agricultural University, RARS, Anakapalle				
1	Dr. M. Visalakshi	Sr. Scientist (Ent.)	April 2015	Continuing
Assam Agricultural University, Jorhat				
1	Dr. D. K.Saikia	Principal Scientist (Ent.)	23.03.2001	Continuing
2.	Dr.Rudranarayana Borkakati	Scientist (Ent.)	2015	Continuing
Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar				
1	Dr. J. Kumar	Dean	2008	Continuing
2	Dr. Anand Kumar Tewari	Professor, Pl. Pathology	2012	Continuing
Kerala Agricultural University, Thrissur				
1.	Dr.(Mrs.) K.R.Lyla	Professor (Ent.)	23-11-95	Continuing
2.	Dr. Madhu Subramanian	Asst. Professor (Ent.)	2015	Continuing
Mahatma Phule Krishi Vidyapeeth, Pune				
1	Dr. R.V Nakat	Associate Entomologist	Aug. 2007	upto Aug2016
2	Dr. S.M. Galande	Asst. Entomologist	2013	Continuing
Professor Jayashankar Telangana State Agricultural University, (PJTSAU) Hyderabad				
1	Dr. S.J Rehman	Professor & Head	Feb. 2007	Continuing
Punjab Agricultural University, Ludhiana				
1.	Dr.K.S. Sangha	Entomologist	2014	Continuing
2.	Dr Neelam Joshi	Microbiologist	8.5.1997	Continuing
3.	Dr Rabinder Kaur	Asstt. Entomologist	20.12.2004	Continuing
4.	Sh. Sudhendu Sharma	Asstt. Entomologist	1.1.2009	Continuing
5.	Dr Parminder Singh Shera	Asstt. Entomologist	7.3.2014	Continuing
Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar				
1.	Dr. Jamal Ahmed	Associate Professor	Nov. 2007	Continuing
2.	Mr. Sajad Mohi-ud-din	Assistant Professor	June 2013	Continuing

Tamil Nadu Agricultural University, Coimbatore				
1.	Dr. S. Sridharan	Professor Entomology	2014	Continuing
2.	Dr. P.A. Saravanan	Assistant Professor Ent.	2014	Continuing
Dr. Y.S. Parmar University of Horticulture and Forestry, Solan				
1	Dr. Usha Chauhan	Sr. Entomologist	June 2009	Continuing
2	Dr. P. L. Sharma	Principal Scientist (Ent.)	16.05.2008	Continuing
Central Agricultural University, Pasighat				
1	Dr. Raghubir Kumar Patidar	Asso. Prof. (Ent.)	2015	Continuing
Maharana Pratap University of Agriculture & Technology, Udaipur				
1	Dr. B. S. Rana	Asso. Prof. (Ent.)	2007	Continuing
Orissa University of Agriculture & Technology, Bhubaneshwar				
1	Dr. Bhagaban Patro	Prof. (Ent.)	2015	Continuing
University of Agriculture Sciences, Raichur (Voluntary Centre)				
1	Dr. Arunkumar Hosmani	Asso. Prof. (Ent.)	2007	Continuing

3.2. Budget for AICRP on Biocontrol 2015-16 (Rupees in Lakhs)

AICRP on Biocontrol, NBAIR, Bangalore

Head	Plan (Rs. in lakhs)	Non-Plan	Total (Rs. in lakhs)
Pay & Allowances	397.78	-	397.78
Recurring Contingencies	55.36	-	55.36
TA	16.86	-	16.86
Other charges including Equipment	0.00	-	0.00
TSP	5.00	-	5.00
Total	**475.00**	**-**	**475.00**

AAU-Anand

Item of Expenditure	ICAR Share (75 %)	State Share (25 %)	Total Amount (Rs)
Pay and allowances	36,62,131	12,20,710	48,82,841
Rec. Contingencies	4,11,012	1,37,004	54,801
T.A	2,30689	76,896	3,07,585
TOTAL	**43,03,832**	**14,34,610**	**57,38,442**

AAU-Jorhat

Head	Budget allotted (Lakhs)	Expenditure (Rs)	ICAR -75%	State 25%	Remarks
Pay and allowances	24.50	Officers (27,60,606.00) Estt (6,85,861.00)	20,70,454.50 5,14,395.00	6,90,151.50 1,71,465.25	Some bills are under process
TA	0.50	62,500.00	50,000.00	12,500.00	
Recurring Contingencies	1.0	1,25,000.00	1,00,000.00	25,000.00	

KAU-Thrissur

Sl. No.	Item	Budget (Rs. in lakhs)	Expenditure (Rs.)
1.	Pay & allowances	37.88	3796971
2.	TA	2.00	51152
3.	Contingencies	3.50	275217
	Total	**43.38**	**4123340**

MPKV-Pune

Sl. No.	Items	Sanctioned and allotted grants (Rs. in lakh)	Grants released during 2014-15 from ICAR (Rs. in lakh)	Total expenditure (Rs.)
1	Est. charges (Pay & allow.)	37.76	37.76	35,33,099
2	Recurring contingencies	3.70	3.50	2,99,047
3	T. A.	1.00	1.00	38,139
4	Non-recurring contingencies	-	-	-
Total		**42.46**	**42.26**	**38,70,285**
	ICAR share (75%)	31.85	31.70	29,02,714
	State share (25%)	10.61	10.56	9,67,571
	Tribal Sub-Plan	1.00	1.00	99,990

PAU-Ludhiana

Sub Head	Approved head wise allocation (Lakhs)	Expenditure up to 31st March, 2016
Pay and Allowances	73.36	53.09
Travelling Allowances	3.00	0.56
Recurring Contingency	7.00	7.00
Total	83.36	60.65

PJSTAU-Hyderabad

Item of Expenditure	ICAR Share (75%)	State Share (25%)	Total Amount (Rs.)
Pay & Allowances	20.69	6.87	27.56
Rec. Contingencies	2.00	0.67	2.67
T.A.	1.00	0.33	1.33
Total	23.69	7.87	31.56
Grand Total			31.56

SKUAST-Srinagar

Budget Head	ICAR share	State share	Total	Expenditure	Awaited expenditure	Total expenditure	Balance Available
Salary	37.5 2	9.38	46.9	35.26	4.0	39.26	**7.64**
T.A.	1.20	0.30	1.50	0.87	0.63	1.50	**Nil**
Contingency	3.5	0.875	4.375	1.65	2.725	4.375	**Nil**
Gross Total	42. 22	10.55	52.775	37.78	7.355	45. 135	7.64

3.3. Problems encountered during the year 2015-16

AAU-Jorhat

As there was no allocation under TA and RC head in the approved budget against AICRP on Biological control, Assam Agricultural University , Jorhat centre for last two years 2013-14 & 2014-15, difficulties had to be faced for conducting different demonstration trials and survey programme under AICRP on bio control. During 2015-16 grant has been released lately. Therefore, survey of different geographical areas could not be done in schedule time against major insect pest of economically important crops.

KAU-Thrissur

The posts of Technical Assistant and Farm Officer are vacant.

MPKV-Pune

Survey and collection of natural enemies from different agro-ecological zones, demonstrations and field trials on farmer's fields are required to carry out in time. The University vehicle may not be available in time because of College activities. Hence, separate provision may be made in budget for hiring the vehicle. Maintenance of polyhouse and purchase of planting material, pots, soil/medium for beds, engaging labour units, etc. become very expensive. Hence, an additional recurring contingent grants are required for conducting trials in polyhouse crops.

PAU-Ludhiana

Equipment needed (one vertical autoclave and, one Grinder) for production of *Bt* formulation, so that it can be popularized among farmers.

4. General

4.1. Meteorological data (2015-16)

AAU, Jorhat

Month	Temperature (^{0}C)		R/H		Total rainfall	Evaporation (mm)	Wind speed	BSSH	Rainy days
	Temp		Morn.	Even.					
January	25.1	10.8	95	57	4.3	1.6	1.3	6.4	2
February	26.0	12.4	93	59	23.4	2.0	1.3	4.9	6
March	29.8	16.1	90	55	42.7	3.0	2.0	5.0	6
April	27.4	19.0	93	73	293.3	2.8	2.7	3.9	21
May	30.1	22.5	92	77	298.0	2.8	2.1	3.1	24
June	31.6	24.4	94	80	335.8	2.7	1.7	2.6	28
July	34.0	25.3	90	72	344.8	3.7	2.3	5.2	19
August	32.0	24.9	94	79	307.3	2.7	1.8	3.2	25
September	32.3	24.6	92	77	257.2	2.8	1.0	4.0	18
October	31.1	21.0	91	70	46.8	2.8	0.9	6.4	5
November	27.5	15.1	96	68	10.2	2.1	0.7	6.2	4
December	22.9	10.9	99	70	35.7	1.4	0.9	4.2	3
January	22.3	9.9	99	71	35.2	1.2	1.1	3.7	4
February	24.2	13.3	97	66	6.6	1.8	2.0	2.3	2
March	27	16.2	91	64	72.6	2.7	2.7	3.8	8

KAU, Thrissur

Month	Temperature ^{O}C		Relative Humidity (%)	Rainfall (mm)
	Min.	Max.		
April 2015	24.6	34	89	132.8
May	24.8	32.9	92	277
June	24.1	30.9	94	629.8
July	23.9	30.3	95	510.1
August	23.9	31	95	322.7
September	23.8	31.9	93	247
October	24.4	32.7	90	203.8
November	23.7	31.6	83	151.2
December	23.2	32.3	78	88.3
January 2015	23	33.2	71	23.8
February	32	35.4	78	11.4
March	25.2	36.3	86	9.8

PAU-Ludhiana

Month	Week	Temperature (^{0}C)		RH (%)		Total Rainfall (mm)	Rainy Days (No.)	Sunshine (hrs.)
		Max	Min	M	E			
April, 2015	I	27.1	17.3	85	60	3.4	-	6.7
	II	32.6	18.1	79	49	17.6	1	9.5
	III	34.7	20.3	80	45	8.0	1	9.0
	IV	36.6	21.7	56	25	00	-	10.4
May, 2015	I	37.9	20.6	53	20	00	-	10.3
	II	39.3	24.8	51	25	10.8	2	6.9
	III	37.5	23.6	66	31	6.2	1	9.6
	IV	42.7	25.6	40	17	00	-	10.9
June, 2015	I	37.8	24.8	49	31	1.2	-	6.1
	II	38.7	24.7	57	30	4.8	-	11.0
	III	38.7	26.0	56	32	00	-	9.9
	IV	37.6	27.9	63	47	7.8	-	6.3
July, 2015	I	36.1	26.4	72	44	4.1	-	9.1
	II	31.3	27.6	77	55	11.8	3	5.4
	III	31.2	25.8	89	83	181.0	4	4.6
	IV	32.7	27.6	86	71	58.1	2	3.8
	V	34.2	27.8	75	62	00	-	8.9
August, 2015	I	32.5	27.0	84	65	7.0	2	7.1
	II	32.2	26.9	90	74	48.0	3	1.5
	III	33.8	26.0	85	68	87.0	2	5.2
	IV	33.3	25.7	86	67	26.8	1	8.2
September, 2015	I	35.0	27.2	84	57	00	-	9.6
	II	34.6	25.4	82	47	00	-	10.2
	III	35.0	25.2	86	52	1.4	-	7.0
	IV	31.0	23.7	91	68	65.6	3	4.7
	V	31.7	21.7	92	60	00	-	9.9
October, 2015	I	33.1	20.5	93	47	00	0	10.1
	II	32.7	22.0	87	52	7.0	1	6.5
	III	31.3	19.2	94	46	00	0	7.3
	IV	29.5	16.4	84	39	9.0	1	7.0
November, 2015	I	27.8	14.4	94	43	00	0	3.8
	II	26.8	14.8	88	42	00	0	3.1
	III	28.0	12.5	89	30	00	0	7.1
	IV	27.0	9.9	94	29	00	-	7.4
December, 2015	I	24.7	11.4	93	48	00	-	1.4
	II	23.8	10.0	96	47	00	-	3.7
	III	20.0	7.9	91	44	1.7	-	5.2
	IV	20.0	4.9	95	38	00	-	6.0
January, 2016	I	21.1	7.3	95	49	00	0	2.9
	II	19.1	7.9	94	59	16.0	1	3.4
	III	13.0	8.0	94	77	00	0	0.2
	IV	14.1	5.2	97	69	0.4	0	2.9
February, 2016	I	20.5	7.6	93	52	3.0	1	6.4

	II	21.4	8.2	89	48	0.8	0	6.5
	III	22.1	7.5	89	41	0.6	-	7.8
	IV	24.2	11.7	94	53	7.4	1	8.1
March, 2016	I	28.1	12.9	94	42	00	0	7.9
	II	26.7	14.5	90	47	23.0	2	7.8
	III	24.2	14.2	91	56	14.9		6.5
	IV							

PJSTAU-Hyderabad

Month	Temperature ^{0}C		Relative Humidity (%)		Rainfall (mm)
	Min	Max	M	E	
April, 2015	22.9	35.2	77	39	117.5
May, 2015	26.7	39.3	64	30	13.8
June, 2015	24.9	33.5	78	54	160.0
July, 2015	23.8	33.6	78	50	25.2
August, 2015	22.8	31.2	88	64	126.8
Sept., 2015	22.4	31.0	90	65	168.2
Oct., 2015	19.7	32.3	91	46	36.4
Nov.,2015	17.7	30.5	88	55	17.3
Dec., 2015	14.8	30.9	87	35	1.4
Jan.,2016	13.7	29.7	79	31	0.0
Feb.,2016	17.4	33.6	79	30	0.0
March, 2016	20.5	36.2	73	29	3.0

SKUAST-Srinagar

Date	Max. Temp. ° C	Min. Temp.	Average Temp.	Max. Humidity	Min. humidity	Average Humidity	Rainfall	SSH	WS
1-15 Jan	10.8	-2.8	3.9	89.3	58	73.7	0.2	3.9	1.7
16-31 Jan	10	-2.9	3.5	89.7	54.4	72	0.7	4.5	2.4
1-15 Feb	9.9	-1.6	4.1	88.2	59	73.6	4	4.07	1.9
16-29Feb	8.5	1.4	5	91.8	75.6	83.7	14.5	1.19	2.8
1-15 March	8.4	0	4.2	90.4	70.5	80.4	15.7	2.3	2.4
16-31March	14.6	3.4	9	88.6	61.3	75	12.7	4.3	2.8
1-15Apr	18.4	5.7	12	79.2	50.5	64.9	4.1	5.8	2.7
16-30Apr	20.4	7.5	13.9	81.2	54	67.6	8.3	6	3.1
1-15 May	23.9	8.8	16.3	74.7	55.2	64.9	1.3	7.5	3
16-31 May	23.7	9	16.4	79	62.8	70.9	2.7	8.9	3.1
1-15 June	23.7	11	17.3	80.2	62.8	71.5	3.2	6.2	2.6
16-30 June	26.7	13.1	19.9	74.6	52.4	63.5	5.1	7.9	2.4
1-15 July	28.4	17.1	22.7	82	62	72	5.1	6.2	1.5

16-31 July	29.5	17.8	23.7	85.5	64.3	74.9	12	6.7	2.1
1-15 Aug	29.9	18.2	24.1	86.4	59.8	73.1	6.1	5.9	1.1
16-30 Aug	29.6	16.2	22.9	82.5	57.2	69.9	8.6	7.5	1.8
1-15 Sep	27.7	10.5	19.1	85.2	50	67.6	0.9	8.2	1.5
16-31 Sep	24.9	9.4	17.1	79.4	55.3	67.3	4.1	7.2	1.7
1-15 Oct	25	6.9	15.9	89.2	52.1	70.6	0.5	7.2	1.2
16-31 Oct	17.1	4.4	10.8	87.5	65.9	76.7	5.2	4.6	1.6
1-15 Nov	13.6	4.8	9.2	88.6	71.1	79.9	2.5	0.9	1.2
16-30 Nov	13.5	-0.4	6.5	87.8	66.9	77.3	0	3	1.3
1-15 Dec	10.1	-0.8	4.6	89	72.9	80.9	1.4	1	1.3
16-31 Dec	8	-3.8	2	89.7	66.5	78.1	0	3.1	1.6

TNAU-Coimbatore

Month	Week	Temperature (^{0}C)		RH (%)		Total Rainfall (mm)	Rainy Days (No.)	Sunshine (hrs.)
		Max	Min	M	E			
April, 2015	I	27.1	17.3	85	60	3.4	-	6.7
	II	32.6	18.1	79	49	17.6	1	9.5
	III	34.7	20.3	80	45	8.0	1	9.0
	IV	36.6	21.7	56	25	00	-	10.4
May, 2015	I	37.9	20.6	53	20	00	-	10.3
	II	39.3	24.8	51	25	10.8	2	6.9
	III	37.5	23.6	66	31	6.2	1	9.6
	IV	42.7	25.6	40	17	00	-	10.9
June, 2015	I	37.8	24.8	49	31	1.2	-	6.1
	II	38.7	24.7	57	30	4.8	-	11.0
	III	38.7	26.0	56	32	00	-	9.9
	IV	37.6	27.9	63	47	7.8	-	6.3
July, 2015	I	36.1	26.4	72	44	4.1	-	9.1
	II	31.3	27.6	77	55	11.8	3	5.4
	III	31.2	25.8	89	83	181.0	4	4.6
	IV	32.7	27.6	86	71	58.1	2	3.8
	V	34.2	27.8	75	62	00	-	8.9
August, 2015	I	32.5	27.0	84	65	7.0	2	7.1
	II	32.2	26.9	90	74	48.0	3	1.5
	III	33.8	26.0	85	68	87.0	2	5.2
	IV	33.3	25.7	86	67	26.8	1	8.2
September, 2015	I	35.0	27.2	84	57	00	-	9.6
	II	34.6	25.4	82	47	00	-	10.2
	III	35.0	25.2	86	52	1.4	-	7.0
	IV	31.0	23.7	91	68	65.6	3	4.7
	V	31.7	21.7	92	60	00	-	9.9
October, 2015	I	33.1	20.5	93	47	00	0	10.1
	II	32.7	22.0	87	52	7.0	1	6.5

	III	31.3	19.2	94	46	00	0	7.3
	IV	29.5	16.4	84	39	9.0	1	7.0
November, 2015	I	27.8	14.4	94	43	00	0	3.8
	II	26.8	14.8	88	42	00	0	3.1
	III	28.0	12.5	89	30	00	0	7.1
	IV	27.0	9.9	94	29	00	-	7.4
December, 2015	I	24.7	11.4	93	48	00	-	1.4
	II	23.8	10.0	96	47	00	-	3.7
	III	20.0	7.9	91	44	1.7	-	5.2
	IV	20.0	4.9	95	38	00	-	6.0
January, 2016	I	21.1	7.3	95	49	00	0	2.9
	II	19.1	7.9	94	59	16.0	1	3.4
	III	13.0	8.0	94	77	00	0	0.2
	IV	14.1	5.2	97	69	0.4	0	2.9
February, 2016	I	20.5	7.6	93	52	3.0	1	6.4
	II	21.4	8.2	89	48	0.8	0	6.5
	III	22.1	7.5	89	41	0.6	-	7.8
	IV	24.2	11.7	94	53	7.4	1	8.1
March, 2016	I	28.1	12.9	94	42	00	0	7.9
	II	26.7	14.5	90	47	23.0	2	7.8
	III	24.2	14.2	91	56	14.9		6.5
	IV							

YSPUHF, Solan

Year/Month	**Av. Max. T (□ C)**	**Av. Min. T (□ C)**	**RH (%)**		**Total RF (mm)**	**Total Rainy (days)**
			M	**E**		
April,2015	25.4	11.9	68	48	71.8	7
May, 2015	31.3	15.7	50	40	16.1	5
June, 2015	29.3	17.5	68	42	91.1	8
July, 2015	28.1	20.2	83	75	294.4	16
August, 2015	28.2	19.7	86	74	102.2	12
September, 2015	28.7	16.1	76	59	41.6	4
October, 2015	28.6	11.1	70	46	34.6	3
November, 2015	23.8	7.1	73	42	7.6	3
December, 2015	19.4	3.2	74	50	18.8	3
January, 2015	19.4	2.3	73	39	4.0	1
February, 2015	21.0	5.1	72	39	35.6	5

4.2. Visitors

AAU-Jorhat

1. Director Research (Agri), Director of DBT Centre AAU, Jorhat and Professor & Head, Department of Entomology visited Biological control laboratory, Department of Entomology, AAU, Jorhat on 10. 09.2015
2. A group of progressive farmers of Golaghat district (8Nos) visited the mass production laboratory on 14.09.2015

GBPUAT-Pantnagar

1. Dr. A. N Mukhopadhyay, Ex. Vice Chancellor, Jorhat Agriculture University.
2. Dr. Chirantan Chattopadhyay , Director- NCIPM, Pusa , New Delhi.
3. Dr. R. K. Khetrapal, Director, CABI, New Delhi.
4. Dr. U. S. Singh, Coordinator, South East Asia, STRASA Project, IRRI.
5. Dr. A. S. Ninawe, Advisor Scientist –G, Department of Biotechnology

KAU, Thrissur

1. Dr. Bonam Ramanujam, I/C.AICRP on BCCP & W, NBAIR, Bangalore visited the Scheme on 17th to 19th March 2016.

MPKV, Pune

1. Fifty five Students and Two teachers of Agril. Buisness management, Narayangaon visited the biocontrol laboratory on 24.07.2015.
2. Dr. Jalali S.K, Head, Division of Molecular Technology and Dr. T.S. Shivalingaswamy, Research and Farm Incharge, NBAIR, Bangalore visited the Biocontrol laboratory on 20th Sepember, 2015 and taken the review of research programme.
3. Dr. K.P. Vishwanatha, Hon. Vice- Chancellor, visited the Biocontrol laboratory on 5th January, 2016.
4. Dr. B Ramanujam, I/C.AICRP on Biocontrol, NBAIR, Bangalore visited the Biocontrol laboratory on 22nd March, 2016 and also Visited Tribal sub plan programme implemented at Dalpatpur on 23rd March,2016 and interacted with tribal farmers.
5. Dr. S.k. Aherkar, Asso. Prof. of Entomology, College of Agriculture, Akola visited Biocontrol laboratory on 16.2.2016

PAU -Ludhiana

Sl. No.	Name	Date of visit
1.	Dr Chandish Ballal, Sr. Scientist, NBAIR, Bengaluru, India	April 16, 2015
2.	Dr Meena Agnihotri, Taxonomist, G P Pant Nagar University, Pant Nagar	September 2, 2015
3.	Dr Vridhi Sharma, Professor and Head, Department of Plant Pathology, RSKVV, Gwalior	September 3, 2015
4.	Tean of BSc Agriculture students, Department of Agriculture, Khalsa College, Amritsar Punjab	September 3, 2015

5.	Shri Suresh Kumar, Financial Commissioner Development, Govt. of Punjab	September 4, 2015
6.	Team of ADOs of Government of Punjab	December 17, 2015 and March 22, 2016
7.	Delegation from Ministry of Nepal	February 24, 2016
8.	Dr Gurcharn Singh Kalkat, Chairman, Punjab State Farmers Commission, Punjab	March 3, 2016

PJSTAU-Hyderabad

1. Dr. D. Raji Reddy, Director of Research, PJTSAU visited the Centre on 4.2.2016
2. Dr. Abraham Verghese, Director, NBAIR and Network Project Coordinator, AICRP on Biological control visited the Centre and field experiments on 18.3.2016
3. Dr. R. S. Tripathi, Coordinator, AINP on Vertebrate Pest Management visited the centre on 18.3.2016

SKUAST-Srinagar

1. Dr. Rajan Gopal, Hon'ble member of Board of Management, UAS, Dharwad
2. Dr. C.P. Mallapur, Professor of Entomology, UAS, Dharwad
3. Dr. Abraham Verghese, Director, NBAIR, Bangalore
4. Dr. T. N. Shivananda, Principal Scientist, Division of Soil Science, IIHR, Bangalore
5. 15 farmers to Bio control laboratory from Ganderbal on 16.3.2016.
6. 10 farmers to Bio control laboratory from Shalimar on 17.3.2016.
7. 10 farmers to Bio control laboratory from Anantnag on 18.3.2016.

TNAU-Coimbatore

1. At regular intervals, students were hosted to the Laboratory from all over the country in partial fulfillment of their curriculam regarding biological control.
2. Dr.C.A.Viraktamath, Emeritus Professor visited on 9.6.2015 and discussed about the biocontrol agents production.
3. Dr.Abraham Verghese, Director, NBAII, Bengaluru visited on 12.10.2015. Visited the AICRP Biocontrol experimental fields of tapioca and brinjal at Kunnathur, Annur block.
4. Dr.S.Sithanantham, Director, SABRC visited the department frequently to discuss with collaborative projects in biological control.

4.3. Miscellaneous Information

i. Awards/Honours/Recognition:

GBPUAT-Pantnagar

1. First prize in Poster Presentation in the 6th International Conference "Plant, Pathogens and People" Plant, Pathogens and People" with the mission "Challenges in Plant pathology to benefit human kind", Feb. 23-27, 2016, NASC Complex, New Delhi, India for the following papers:

2. "Triple combination of Copper Chitosan-*Trichoderma* for eco-friendly management of late blight of potato in poster session "Bio-prospecting in bio-control agents for sustainable agriculture" and
3. "A common minimum programme : an eco-friendly approach for the plant disease management for small farms" in poster session "Integrated plant disease management" in poster session "Challenges in Integrated crop management with respect to diseases
4. Third prize in Poster Presentation"Selection of growth promoting Trichoderma isolates for crop improvement under sustainable agriculture" in poster session "Bio-prospecting in bio-control agents for sustainable agriculture"
5. Prize for Poster Presentation "Compatibility of different weedicides with *Trichoderma harzianum* strain PBAT-21" in poster session "Bio-prospecting in bio-control agents for sustainable agriculture"

Technology developed

- Developed ecofriendly formulations involving a triple combination of low dose of copper hydroxide (500 ppm), Chitosan (500 ppm) and copper tolerant *Trichoderma asperellium* (TCMS 36) for the cost effective management of late blight disease of potato. The formulation is being validated.

PAU-Ludhiana

1. Dr K S Sangha and his student Gurlaz Kaur awarded third prize for best poster in 4th Congress on Insect Science held on April 16-17, 2015 at Punjab Agricultural University, Ludhiana, India.
2. Dr K S Sangha, student Gurlaz Kaur got Dr G S Dhaliwal gold medal for course work and thesis in MSc (Entomology).
3. Jasreet Kaur, student of Dr K S Sangha got INSPIRE Fellowship.

PJTSAU-Hyderabad

Dr. S. J. Rahman, Principal scientist & Head:

1. Expert Member for Telangana State Bio Diversity Board (TSBDB), Govt. of Telangana
2. Expert Member for Committee for developing Effective Vector Control practices by ICMR, New Delhi
3. Member of Review Committee on Genetic Manipulations (RCGM), Ministry of Science & Tech., Govt. of India
4. Member of High level Expert Committee on Environmental Risk Assessment (ERA), Ministry of Environment, Forests and Climate Change, Govt. of India

SKUAST-Srinagar

Dr. Jamal Ahmad

1. Received Appreciation letter from the Director NBAIR, Bangalore for excellent research work at Kargil (Ladakh) on management of Codling moth, *Cydia pomonella*
2. Acted as expert member of IPM Package of practices from SKUAST-K to the National Institute of Plant Health Management, Department of Agriculture & Cooperation, Ministry of Agriculture, Govt. of India.

3. Acted as Dean, P.G. Nominee for M. Sc. (Pathology) student of SKUAST-K.
4. Acted as Major Advisor of M.Sc. (Ag). Student for thesis entitled "Studies on Parasitism in Diamondback Moth, *Plutella xylostella* (L.) (Lepidoptera :Plutellidae) on *Brassica* spp. in Kashmir"
5. Acted as external examiner of M. Phil student of Zoology Deptt. University of Kashmir.
6. Acting as Major Advisor for Ph. D. student entitled "Studies on the taxonomy of hymenopteran parasitoids of agricultural pests of Kashmir".
7. Nominated as Resource person for district Anantnag for extension related issues during 2016-17.
8. Looked after as HOD, Entomology, SKUAST-K from 9-11 April' 2015 and 22.01.2016 to 5.02.2016.
9. Acted as Member expert in conducting Research Aptitude Assessment (RAA) for admission to Ph.D. in Entomology, SKUAST-K on 1-2. 02. 2016.

Dr. Sajad Mohi-ud-din

1. Received Appreciation letter from the Director NBAIR, Bangalore for excellent research work at Kargil (Ladakh) on management of Codling moth, *Cydia pomonella*
2. Involved in documenting the feedback from Division of Entomology for consolidating the Action plan for KVK, Malangpora
3. Nominated as Resource person for district Pulwama for extension related issues during 2016-17.
4. Acting as Major Advisor of Mr. Naveed Anjum, M. Sc. Student, Division of Entomology.
5. Acted as member of Advisory Committee of Mohd. Afaq Shair, M.Sc. (Sericulture).
6. Acting as Dean, P.G. Nominee of Qurat-ul-Ain, M.Sc. student Division of Vegetable Science
7. Acting as Advisor/Tutor of seven B.Sc. Horticulture students.

TNAU-Coimbatore

1. Shanmuga prema M. and S.Sridahran.2015. Acoustic sensors – A new automated early monitoring tool for stored grain pests. Paper presented in National seminar on whole grain for healthy life organised by Indian Institute of Crop Processing Technology, Thanjavur, Tamil Nadu.

YSPUHF-Solan

1. A grant of Euro 500/ was sectioned by IFOAM Organics International to present Paper entitled "Comparative Impact of Monoculture and polyculture farming system on the biodiversity of natural enemies of arthropod pests in horticulture ecosystems" in Regional Conference on Marketing and Innovation in Organic Farming to be held at GoesanCounty,South Korea w.e.f.2nd to 3rd October,2015.
2. Awarded Crawford fund in 2015 to attend and present paper in the Five days Regional symposium cum training on Market Access for Small Farmers through Direct Marketing in Bangkok *w.e.f.* 14th September to 18th September, 2015.

ii. Education and Training

AAU-Anand

P.G. TEACHING

The Scientists working under the AICRP on Biological Control are also engaged in Post Graduate teaching and as well as acting as guide. Following courses are taught to the P.G. students.

Sl. No.	Name of Teacher	Courses taught	PG Students Guiding
1.	Dr. D. M. Mehta	Immature Stages of Insects	3 (Ph.D.)
		Recent Trends in Biological Control	
		Advances in Integrated Pest Management	
		Insect Vectors of Plant Viruses and other Pathogens	
2.	Dr. P. H. Godhani	Seed Entomology	1 (M.Sc.)
		Biological Control of Crop Pests and Weeds	

Advisory and extension services

Technical guidance on "Biological control" was provided to the farmers, extension officers, students and other visitors visited Biocontrol Research Laboratory.

Number of visitors visited

Sl. No.	Visitors	Total
1	VIPs	2*
2	Govt. officers	10
3	Farmer	210
4	Student	402
Total		**624**

- Technical guidance regarding Biological Control of crop pests was provided through lectures to the extension officers and farmers in various training programs organized by Directorate of Extension Education, AAU, Anand, State Department of Agriculture, Govt. of Gujarat and NGOs.
- Participated and arranged exhibition during Krushi mela, farmer's meeting and other special occasions as per the directives received from Directorate of Extension Education, AAU, Anand and Extension education Institute.

Extension activities

1. Exhibition in the Krishi mela during Krishi Mahotsav-2015 organized by DEE, AAU, Anand at Lunawada during 30.04.2015 to 01.05.2015

2. Exhibition in the Krishi mela during Ravi Krishi Mahotsav-2015 organized by DEE, AAU, Anand at Devgadhbaria on Dt. 02.01.2016
3. Farmers' day (*Trichogramma* day) was organized at Runaj (Tarapur) on 20.01.2016. Guidance regarding Biological Control of crop pests was provided through lectures and trichocards were distributed to 100 farmers.
4. Participation in *Krushi Mahotsav* 2015 at Kheda

Details of Khedut Shibirs arranged during 2015-16

Sl. No	Date	Village & Taluka	No. of farmers attended
1	21.02.2015	Devghadh bariya	57
2	20.01.2016	Runaj	100

Following talks were delivered to farmers/ extension workers/ students by Dr. D. M. Mehta, Dr. P. H. Godhani and Dr. Raghunandan B. L.

Sl. No	Date	Topic	Trainee	Trainee details
1	26.08.2015	Biological control of crop pests and visit of Biological Research Laboratory	RAWE Students (40 nos.)	College of Agriculture, AAU, Vaso
2	01.09.2015	Biological control of crop pests and visit of Biological Research Laboratory	Farmers (40 nos.)	Co-operative Rural Dev. Trust, Gandhinagar
3	02.09.2015	Biological control of crop pests and visit of Biological Research Laboratory	RAWE Students (40 nos.)	College of Agriculture, AAU, Vaso
4	13.10.2015	Biological control of crop pests and visit of Biological Research Laboratory	RAWE Students (48 nos.)	College of Agriculture, Bharuch, NAU
5	19.10.2015	Biological control of crop pests and visit of Biological Research Laboratory	RAWE Students (48 nos.)	College of Agriculture, Waghai, NAU
6	21.10.2015	Biological control of crop pests and visit of Biological Research Laboratory	RAWE Students (117 nos.)	NMCA, NAU, Navsari
7	18.12.2015	Biological control of crop pests and visit of Biological Research Laboratory	Students (13 nos.)	BRS college, Kubiyani, Rajkot

8	04.03.2016	Biological control of crop pests and visit of Biological Research Laboratory	Farmers (24 nos.)	GSFC, Vadodara
9	16.03.2016	Biological control of crop pests and visit of Biological Research Laboratory	Students (75 nos.)	ASPEE college of Horticulture and Forestry, NAU

AAU-Jorhat

- Dr.D.K.Saikia, Principal Scientist conducted a training programme on "Production and use of Trichogrammatid egg parasitoid" for the lab. Technicians under Programme on biopesticide and Biofertilizers, DBT-AAU centre from 21st Aug to 10th September,2015
- Dr.D.K.Saikia, principal Scientist conducted a training programme on organic farming organized by the Department of Agriculture, SDAO, Bokakhat on 16 November,2015
- Dr.D.K.Saikia, Principal Scientist conducted an advance course of Biological Control (ENT 507), Classification of Insects (ENT 504) to P.G.Studies
- Five M.Sc (Agri) student is being carried out P.G. research work under the guidance of Dr. D.K.Saikia,
- Dr. D.K.Saikia is guiding three Ph.d students.
- Dr. D.K.Saikia , Principal Scientist act as a course instructor for Experiential learning programme (Bio-control agents and bio-pesticide) offered to B.Sc. (Agri) student**s**
- Dr. D.K.Saikia , Principal Scientist impart coaching to UG students for JRF examination
- Dr. D.K.Saikia act as a Co- investigator in the Biopesticides programme under DBT –AAU, Centre
- R. N. Borakati, Jr. scientist, act as a resource person in a training programme on "Production and use of Trichogrammatid egg parasitoid" for the lab. Technicians under Programme on biopesticide and Biofertilizers, DBT-AAU centre from 21st Aug to 10th September,2015
- R. N. Borakati, Jr. scientist, act as a course leader of UG course, Pests of crops, stored grain and their management (Ent 323) and a member of PG courses like Pest of Field Crops (Ent 511), Biological Control (ENT 507) and IPM (Ent 510).
- R. N. Borakati, Jr. scientist, act as a course instructor for Experiential learning programme (Bio-control agents and bio-pesticide) offered to B.Sc. (Agri) student**s**
- R. N. Borakati, Jr. scientist attended XXIII Biological worker's group meeting held at TNAU, Coimbatore on 2nd & 3rd June, 2015.

Training Imparted

Sl. No.	Programme	Place	Resource person	Date	Trainee
1	IPM of Horticultural crops	Grameen Vikash Bank, Jorhat	Dr.D.K.Saikia	26.08.2015	Farmers (25 Nos)
2.	IPM of Vegetables	Borboruah, Dibrugarh	Dr.D.K.Saikia	18.09.2015	15 nos. of farmers.
3.	Farmers Scientist Interaction	Farmers Day, SRS, Buralikson	Dr.D.K.Saikia	21.11.2015	Farmers

4	Biological control of important crop pests	Conference hall, DoEE, AAU	Dr. D.K.Saikia	7. 03.2016	SMSs, KVK (12 Nos)
5	Recent advances in Insect Pest Management	Conference hall, DoEE, AAU	Dr.D.K.Saikia	18.03.2016	SMSs, KVK (16 Nos)
6.	Farmers Scientist Interaction	Farmers Day, Rice Research Station, Titabar, AAU, Jorhat	R. N. Borakati	06.11.2015	Farmers

Television/ Radio Programme

SL. NO.	TITLE	NAME OF RESOURCE PERSON	RECORDING DATE	BROADCASTING DATE
1	INTERECTIVE PROGRAMME WITH FARMERS	Dr. D.K.Saikia	25.9.2015	26.9.2015
2	Hellow Kishan Vani	R. N. Borkakati	16.07.2015	23.07.2015

F.8 TV PHONE IN PROGRAMME BY DD, NE

SL. NO.	TITLE	NAME OF RESOURCE PERSON	TELECAST TIME
1	Sientific management of Sali paddy	R. N. Borkakati	23.07.2015 (5.30 pm)

ANGRAU-Anakapalle

Radio Talks, Phone in live, TV Programmes, TV live programmes:

- Dr.M.Visalakshi delivered radio talk about Kobbari mariyu arati nasinchu cheedapeedalu-sasyarakshana paddathulu on 20.4.15 at All India Radio, Visakhapatnam
- Dr.M.Visalakshi delivered radio talk about Cherakulo Verupurugu Chedalaku Yazamanyam on
- 10.08.15 at All India Radio, Visakhapatnam.
- Dr.M.Visalakshi participated in TV live programme about Biological control in Sugarcane on 20.4.15 recorded by ETV Jaikisan.
- Dr.M.Visalakshi participated in TV phone in live programmes about Paddy Varieties and Seed treatment organized by Reliance foundation at Anakapalle for farmers of 19 mandals on 29.06.2015 at City Cable TV , Anakapalle

Promoting sugarcane technology as a team member:

Dr.M.Visalakshi participated as a team member in promotion of sugarcane production technology in sugar factory operational areas. Identified problems in sugar factory operational area and initiated the demonstrations on improved sugarcane production technology at Navabharath ventures, Samalkota, East Godavari during rabi, 2015-16

Compilation of Information for ANGRAU:

- Dr.M.Visalakshi compiled data on Compatibility of insecticides and fungicides in sugarcane was compiled and submitted to University along with Compatibility charts during 2015.
- Dr.M.Visalakshi compiled information on digitization of ongoing research projects of research stations in North coastal zone.

Orientation courses/ Refresher courses/ Trainings attended

Dr.M.Visalakshi undergone training programme on Laboratory quality system management and internal audit as per ISO/IEC 17025-2005 at NIPHM, Rajendranagar for 6 days during 18-23 May, 2015.

GBPUAT-Pantnagar

Farmers training and other extension activities:

ETv coverage at farmers fields on the use and application of bio-control agents was made. The programme was broadcast on September 4, 2015 in Annadata programme.

IGKV-Raipur

- Dr. J. L. Ganguli, delivered lecture in the ICAR short course on "Beneficial microbes for sustainable agriculture production" held from 5-14th October, 2015 at IGKV, Raipur.
- Dr. J. L. Ganguli, delivered lecture in the Directorate of Extension for the SMS.
- Dr. J. L. Ganguli, delivered lecture about the utility of various bio-agents for eco-friendly management of insect pests in the Samiti, department of State Agriculture, Raipur.

Training attended:-

- Smt. Rashmi Gauraha, Co-PI, attended 11 days training on "Production protocol of Bio-control agent" at NIPHM, Hyderabad from 5th to 15th June, 2015.

KAU-Thrissur

1. Mass production and sale of biocontrol agents: The Centre has produced and sold biopesticides worth Rs. 16 lakhs during the financial year 2015-16.
2. Need based intervention for bio control of black headed caterpillar of coconut through mass production and release of the parasitoid, *Goniozus nephantidis.*

Release of *Goniozus nephantidis* against coconut black headed caterpillar

Sessions on biocontrol and IPM have been handled as per the details given below

Sl. No	Date	Topic	Venue	Beneficiaries
1	05-02-16	Biocontrol of pests in vegetables	Angamaly	Agril. Officers & Farmers
2	24-03-16	Research extension interface	Palghat	Farmers
3	28-02-16	Pest management in banana	Thamarassery	Farmers

4	04-03-16	Climatic change and pest management	Varandarappilly	Farmers
5	29-03-16	Climatic change and pest management	College of Horticulture, Vellanikkara	Farmers

MPKV, Pune

Trainings

1. Dr. R.V. Nakat worked as Senior Supervisor for conducting the Semester end theory examination of UG at D. Y. Patil College of Agriculture, Akurdi during 8-20 May, 2015.
2. Dr. S. M. Galande worked as Senior Supervisor for conducting the Semester end theory examination at College of Agriculture, Baramati during 13-20 May, 2015.
3. Dr. S. M. Galande worked as Senior Supervisor conducting the Semester end theory examination at College of Agriculture, Wadala Dist. Solapur from 17.10.2015 to 30.10. 2015
4. Dr. S. M. Galande Conducted practical examination of Course no ENT 505 as External Examiner on 4.3.2016 at College of Agriculture, Dhule.
5. Shri. N. D. Tamboli worked as Jr. Supervisor for the theory examination of Agril. Polytechnic at ManjriDist. Pune during 15th to 20th March, 2016

Extension development activities / Training Imparted: (MPKV, Pune)

1. Pamphlet on 'Protect the predators, parasitoids and pollinators' is released during Joint Agresco Meeting held at MPKV, Rahuri on 28th May, 2015.
2. Dr. S. M. Galande attended *Krushi Din* programme and guided regarding tree planting in Waghapur and Rajewadi and participated in Tree planting programme in which 75 and 55 samplings were planted on 1.7.2015.
3. Dr. S. M. Galande Delivered lecture on IPM of Cutard apple, Fig and pomegranate at Guroli on 4.7.2015.
4. Dr. S. M. Galande Delivered lecture on IPM of Pomogranate and vegetables in *Krushi Din* programme held at Kawadewadi on 6.7.2015.
5. Dr. S. M. Galande Delivered lecture on IPM of Pomogranate and vegetables in *Krushi Din* programme held at Malsirus on 6.7.2015.
6. Dr. S. M. Galande delivered lecture on IPM of Mango and Cashew nut special reference to the Biological control to the tribal youth of Dalpatpur on 1.12.2015
7. Dr. S. M. Galande delivered the lectures to the tribal farmers on integrated pest management of Mango and cashew nut with help of PPT special reference to the Bio control aspect the tribal farmers at Dalpatpur on 19.2.2016.
8. Organized one day training programme at Dalapatpur of Trimbakeshawar Tahsil of Nasik district and distributed the Biopesticides, Biofertilizers to the 50 farmers under TSP on 19th Feb. 2016.
9. Dr. S. M. Galande Conducted the demonstration on use of Biopesticide and biofertilizer under TSP on 19.2.2016
10. Conducted the survey of Insect pests in Saudane, Sonand village of Malegaon Tahsil, Visited grape and onion and garlic plots of Grape and Onion research station, Pimpalgaon Baswant. Conducted survey Sayakheda, Chatori Naygaon villages of Niphad Tahsil. Visited wheat plot at Bota of Sangamner Tahsil Visited tomato plot at Manjarwadi in Junnar Tahsil and Avsari of Ambegaon Tahsil on 20.2.2016 and discussed the pest problems with the farmers.

PAU-Ludhiana

Post/under graduate teaching

Teacher	No. of courses taught	
	PG	UG
Dr K S Sangha	5	3
Dr Neelam Joshi	2	4
Dr Parminder Singh Shera	-	3
Dr Rabinder Kaur	1	1
Dr Sudhendu Sharma	1	2
	No. of PG Students Guiding/Guided	
	Ph. D.	M.Sc.
Dr K S Sangha	1	1
Dr Neelam Joshi	1	4
Dr Parminder Singh Shera	-	1
Dr Rabinder Kaur	-	2
Dr Sudhendu Sharma	-	-

Lectures delivered

Title of Lectures	Event, Date and Venue
Dr Kamaldeep Singh Sangha	
Management of insects of poplar	Research Extension Specialist workshop on August 27-28, 2015
Scope of sericulture in Punjab	Research Extension Specialist workshop on August 27-28, 2015
Status of insects of agroforestry trees and silvicultural control of poplar leaf defoliators	-Do-
Management of Sugarcane insect pests with coragen 18.5 SC, Goldban 20 EC and Rippen 0.3 GR	-Do-
Biological control in sugarcane	Training programme for Cane inspectors and supervisors of sugar mills of Punjab organized by Deptt of Plant breeding & Genetics and Sugarfed Punjab on 21 March, 2016
Insect pests of forest nursery trees	Training for forest guards organized by PAU & State forest department Govt. of Punjab. on 25 March 2016
Scope of Lac production & Cultivation in Punjab	Training for forest guards organized by PAU & State forest department Govt. of Punjab. on 25 March 2016
Scope of sericulture in Punjab	Training for forest guards organized by PAU & State forest department Govt. of Punjab. on 25 March 2016

Dr Sudhendu Sharma	
Management of insect pests of *Kharif* crops	District level training camp organized by Dept. of Agriculture, Punjab at Jagraon on April 3, 2015

Trainings/ training camps organized

Programme	Dates
Training on "Mass production of *Trichogramma* spp. for use in biological control programmes" held at PAU, Ludhiana for the technical staff of Punjab sugar mills and KVKs of PAU Ludhiana	14.5.2015

PJTSAU-Hyderabad

Education:

B.Sc. (Ag.), M.Sc. (Ag.) and Ph.D. students of College of Agriculture, Rajendranagar, Hyderabad were trained different methodologies in rearing of different natural enemies and culturing & field use of microbial formulations.

Guiding M.Sc. (Ag) and Ph.D. students for their Research work in the capacity of Member of Advisory Committee

Fifth Batch of AELP on Biological Control is being trained for entrepreneurship on mass production of Bio agents as part of B.Sc. under graduation programme.

Trainings

Dr. S. J. Rahman, Principal scientist & Head:

First batch of Young Progressive Farmers of Telangana State were trained in Bio Control technologies under Govt. Telangana programme, *Yuva Rythu Saagu Badi* (YRSB).

Rural Women Self Help Groups (SHGs) were trained to establish decentralized Bio Agent Production units.

SKUAST-Srinagar

Training imparted

Dr. Jamal Ahmad & Dr. Sajad Mohi-ud-din

Involved in teaching of eight different courses to under graduates of Horticulture, Forestry and Post graduates, M. Sc. and Ph.D. students of Agriculture and Horticulture.

Dr. Jamal Ahmad

1. Attended ATIC duty fortnightly, interacted with farmers and suggested remedial process for the management of insect pests

2. Acted as Resource person to the farmers visiting to bio control laboratory on the "Importance of Biological Control and methods of integrating bio agents in different crops in Kashmir" on 16.3. 2016.
3. Acted as Resource person to the farmers visiting to bio control laboratory on "The kinds of biological control agents of pests of fruit and vegetable crops in Kashmir, and their field uses" on 17.03.2016.
4. Acted as Resource person to the farmers visiting to bio control laboratory on "The importance of indigenous natural enemies and strategies of their conservation, for better tomorrow" on 18.03.2016.

Dr. Sajad Mohi-ud-din

1. Served as Resource person for training to farmers in various locations of District Kargil regarding "management of Codling moth infesting apple", on 8-9.06.2015.
2. Served as Resource person for training to farmers in different locations of District Kargil regarding "method and importance of bur-lapping in apple for managing overwintering larvae of Codling moth" on 12.09.2015.
3. Provided one day Training to farmers on "importance of bio control in management of different insect pests".
4. Gave T.V. talk on *IPM of San Jose scale* on apple on 07.03. 2016.
5. Participated in XXIV Biocontrol Workers Group Meeting On Biological Control of Crop Pests Tamil Nadu Agricultural University, Coimbatore, 2-3rd June, 2015.

TNAU-Coimbatore

UG courses:

1. EXP401 – commercial production of biocontrol agents (0+5) – Dr.S.Sridharan and Dr.P.A.Saravanan
2. EXP 301 – commercial beekeeping (0+5) – Dr.M.R.Srinivasan, Dr.R.Philip Sridhar, Dr.P.A.Saravanan

P.G.Courses:

1. ENT 607 – Biological control of crop pests and weeds (2+1) – Dr.P.A.Saravanan
2. ENT 609 – Biotechnological approaches in pest management (1+1) - Dr.P.A.Saravanan

Ph.D courses:

1. ENT 822 – Entomophages (2+1) - Dr.S.Sridharan
2. ENT 821 – Insect Pathology (2+1) - Dr.S.Sridharan
3. ENT 823 - Molecular applications in biological control (2+1)- Dr.S.Sridharan

iii. Trainings imparted

One day training on mass production of Trichogramma spp was imparted to selected farmers of Kuruvai in Vadekkenchery on 14/09/15.

First paid hands on one day training programme on "mass production of biological control agents" under Venture Capital Scheme was organised on 11.2.2016 and thirteen farmers from various parts of Tamil Nadu participated and got trained.

Regular hands on trainings were offered for extension functionaries, farmers and entrepreneurs on biocontrol aspects.

Training imparted / lectures delivered during the year

Sl. No	Date	Title of the Training	Beneficiary / Participants	Sponsor
1	21.4.2015	Mass production of biocontrol agents	Diploma Agri Students (65)	ADA, Karamadai, Dept. of Agriculture
2	21.5.2015	Mass production of biocontrol agents	Staff (4)	Staff from Parry Agro, Valparai
3	17.10.2015	Bio control agents in crop pest management and food safety	Women farmers (200)	Women Farmers Association,Chennai
4	5.10.15	Integration of Bio control agents with pesticides	CAFT trainees (17)	ICAR
5	25.11.15	Integarated pest management in Horticultural crops	Farmers (35)	ATMA, Dept. of Agriculture, Annur block
6	9.12.15 and 17.12.15	Integarated pest management in Horticultural crops	Farmers (80)	ATMA, Dept. of Agriculture, Namagiripettai and Tiruppur blocks
7	5.1.16	Mass production of biological control agents	B.Sc Zoology students (35)	U.C. College, Aluva, Kerala
8	8.1.2016 11.1.2016	Biological control of crop pests Ecological pest management in cotton	Agrl. Officers, (30) AO's Dept of Agriculture (30)	Dept. of Organic farming TNAU SAMETI, Kudumiyanmalai
9	29.1.2016 30.1.2016	Field application and consideration of parasitoids and predators against crop pests Perspectives of commercially exploiting Biocontrol agents in pest management	CAFT trainees	ICAR and Dept. of Agricultural Entomology TNAU
10	27.1.16, 29.1.16 15.2.16, 16.2.16	IPM package for fruit and vegetable crops	Horticultural officers (30)	SAMETI, Kudumiyanmalai
11	12.2.16 15.2.16	IPM in vegetables and fruits	Farmers (40)	Dept. of Horticulture, Madhukkarai, Thondamuthur
12	26.2.16	Mass production of biological control agents	Students (12)	MES Mampad college, Malappuram, Kerala

13	7.3.16 22.3.16	IPM in vegetables and fruits	Farmers (60)	ATMA, Cuddalore ATMA, Ariyalur
14	2.3.16 7.3.16	Biological control in pest management	Farmers (80)	ATMA, Thanjavur ATMA, Cuddalore
15	28.3.16	Mass production of biological control agents	Students (18)	MPKV, Rahuri, Maharastra

i. Extension / Out reach programmes participated

Sl. No.	Date	Title of the Program	Beneficiary / Participants	Organisers
1	18.8.15 to 21.8.15	Exhibition AGRI INTEX 2014 - Exhibited the various biocontrol agents and explained its application and use in pest management	Farmers and students	CODISSIA and TNAU
2	8.1.2016	Exhibition – Regional Agricultural Fair and Farmer's Day 2016 Exhibited the various biocontrol agents and explained its application and use in pest management	Farmers	ICAR, Govt. of Tamil Nadu and TNAU
3	28.1.2016	Exhibition 4th Agricultural Science congress	Farmers and Stake holders	Govt. of Tamil Nadu and TNAU
4	24.3.2016	TV programme Interaction with farmers about pests management	Farmers	DD Kendra, Chennai

YSPUHF-Solan

Trainings

Sl. No.	Lecture delivered	Training programme	Date	Resource person
1	Ecofriendly management of apple and vegetable pests	Training for farmers under TSP at Ribba villages of Kinnaur district	13.05.2015	PL Sharma
2	Ecofriendly management of apple and vegetable pests	Training for farmers under TSP at Kamru, (Sangla) villages of Kinnaur district	14.05.2015	PL Sharma
3	Practical demonstration on the use of biocontrol agents in pest management	Integrated training on organic farming	06.08.2015	PL Sharma
4	Integrated insect-pest management in vegetable crops	Farmers training programme on vegetable production	04.12.2015	PL Sharma
5	Major insect pests of vegetable crops and their	Farmers training programme on off-season vegetable	05.12.2015	PL Sharma

	management with organic control measures	production		
6	Major insect pests of vegetable crops and their integrated management specifically with organic control measures	Farmers training programme on vegetable production	22.12.2015	PL Sharma
7	Major insect pests of vegetable crops and their management with organic control measures	Farmers training programme on off-season vegetable production	15.01.2016	PL Sharma
8	Major insect pests of vegetable crops and their management with organic control measures	Farmers training programme on off-season vegetable production	21.01.2016	PL Sharma
9	Practical demonstration of bio-control agents, formulations and their use	Training on organic farming for officers of State Horticulture Department	29.01.2016	PL Sharma
10	Bio-control agents, formulations and their use	Training on organic farming for officers of State Horticulture Department	05.02.2016	PL Sharma
11	Integrated pest management in winter vegetables	Farmers training camp on vegetable production at village Sainj, Sagrah dist. Sirmour	19.02.1016	PL Sharma
12	Integrated pest management in winter vegetables	Farmers training camp on vegetable production at village Keyodi, Nalagarh	25.02.1016	PL Sharma
13	Major insect pests of vegetables and their integrated mangement	Training on ‘Off season vegetable production’ for farmers of Sangrah	03.03.2016	PL Sharma
14	Practical demonstration on the use of biocontrol agents for suppression of pests of Horticultural crops	Training on ‘Green technologies for Horticulture Crop Production’ for KVK Scientists	09.03.2016	U Chauhan
15	Use of eco-friendly methods of pest management for apple, apricot and vegetable crop pests	Training programme for farmers of Poh village of Lahaul and Spiti district under TSP	02.11.2015	PL Sharma
16	Use of eco-friendly methods of pest management for apple, apricot and vegetable crop pests	Training programme for farmers of Tabo village of Lahaul and Spiti district under TSP	03.11.2015	PL Sharma
17	Use of eco-friendly methods of pest management for apple, apricot and vegetable crop pests	Training programme for farmers of Lari village of Lahaul and Spiti district under TSP	04.11.2015	PL Sharma

B. Demonstrations:

Sl. No.	Date	Topic	Place(s)	No of Orchards/No of farmers
1	13-5-15	Use of biopesticides and traps for the management of apple and vegetable pests (under TSP)	Ribba, dist. Kinnaur	70
2	14-5-15	Use of biopesticides and traps for the management of apple and vegetable pests (under TSP)	Kamru (Sangla) dist. Kinnaur	70
3	August 2015	Management of apple root borer	Nerwa and Kullu	2orchards
4	06.08.2015	Practical demonstration on the use of biocontrol agents in pest management	Nauni	30
6	02.11.2015	Use of eco-friendly methods of pest management for apple, apricot and vegetable crop pests	Poh village of Lahaul and Spiti district under TSP	53
7	03.11.2015	Use of eco-friendly methods of pest management for apple, apricot and vegetable crop pests	Tabo village of Lahaul and Spiti district under TSP	54
8	04.11.2015	Use of eco-friendly methods of pest management for apple, apricot and vegetable crop pests	Lari village of Lahaul and Spiti district under TSP	45
9	29.01.2016	Practical demonstration on the use of biocontrol agents in pest management	Nauni	30
10	05.02.2016	Bio-control agents, formulations and their use	Nauni	20
10	19.02.1016	Identification of common bioagents present in the field	Sainj, Sagrah dist. Sirmour	50
11	25.02.1016	Identification of common bioagents present in the field	Keyodi, Nalagarh	50

C. Radio Talks:

Radio Talk recorded on All India radio Shimla on 22/02/2016 and broadcasted on 23/02/2016 at 7pm in KrishiJagat on the topic "Bagwani phaslon ke keet tatha jeev ka jaivik niyantarn".

Academics

1. Acted as expert to evaluate thesis and conduct examinations at HPU, Shimla (DR Usha Chauhan).
2. Acted as internal Examiner, thesis evaluator and expert at CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur (PL Sharma)
3. Acted as Dean Nominee for conducting Viva Voce of M.Sc students at YS parmar UHF Nauni, Solan (HP) (PL Sharma and U Chauhan)
4. Associated with RAWE activities of UG students (PL Sharma)

UG/PG courses taught:

ENT 505: Insect Ecology (PL Sharma**)**
ENT 507: Biological control of crop pests and weeds (U Chauhan and PL Sharma)
ENT606: Recent trends in biological control (U Chauhan and PL Sharma)
ENT602: Immature stages of insects (U Chauhan)
ENT 604: Advanced Insect Ecology (PL Sharma)
ENT 609: Advanced Host Plant Resistance (PL Sharma)

Students guided for M.Sc and Ph D. degree:

Sl. No.	Student Name	Degree	Title of thesis	Guided By
1	Vijay Singh	Ph.D.	Phytophagous mites and their natural enemies in different horticultural ecosystems of Himachal Pradesh.	Usha Chauhan
2	Gavkare Omkar	Ph.D.	Studies on Zoophytophagy of *Nesidiocoris tenuis on tomato*	PL Sharma
3	Anamika Saini	M. Sc.	Parasitization potential of *Cotesia vestalis* (Haliday) against *Plutella xylostella* (L.) and its interaction with *Diadegma* sp	PL Sharma
4	Sarawati Negi	Ph. D.	Bio-ecology and management of invasive leafminer, *Tuta absoluta* (Lepidoptera: gelechidae) on tomato	PL Sharma
5	Manohar TN	M.sc.	To be decided	PL Sharma

Teaching: Scientist of the Project have been handling classes on biocontrol and IPM for U.G, P.G. and Ph.D programmes as well as guiding M.Sc and Ph.D students on regular basis.

UAS-R

Training Programme

Village: Kadamagadoddi

In Kadamagadoddi village farmers awareness training programme was organised on new invasive pest, tomato pinworm. More than 75 farmers from Kadamagadoddi and nearby villages like Kapur, Katlekur, Singanoddi and Hosur tomato farmers were participated in the training programme. Filed visit along with farmer was made before the start of training programme. Dr. Mohan S. Principal Scientist explained the management strategies to the farmers. Dr. Shylesh A.N. Principal Scientist highlighted the mode of invasion and biology of this pest to the farmers. Dr. Ramanajum Project co- ordinator explained the famers about importance of Biological control and advised farmers not to relay on pesticides alone**.**

iii. Participation of Scientists in conference, meetings, seminars, workshops, symposia, training extension etc. in India and abroad

ANGRAU-Anakapalle

1. Dr.M.Visalakshi participated in International Academic and research conference, 2015 during 9-10 October, 2015IMRF under UNESCO at Vijayawada and presented Oral paper on Effect of chemical insecticides on termites in sugarcane under various methods of application.
2. Dr.M.Visalakshi participated in International rice Symposium, 2015 during 18-20 November, 2015 organised by ICAR- IIRR, Hyderabad and presented paper on Adoption status of direct seeding paddy using drum seeder- application during Poster session.
3. Dr.M.Visalakshi participated in EID Parry Ltd field staff training on Integrated Crop management on 28.5.15 organised by EID Parry Ltd., Sankili, Srikakulam at RARS, Anakapalle and delivered lecture on IPM in paddy, sugarcane, maize and pulses.
4. Dr.M.Visalakshi participated in farmers training programme on nursery management in paddy organised by DAATTC, Visakhapatnam at RARS, Anakapalle on 23.6.15 and delivered lecture on IPM practices for nursery management in paddy.
5. Dr.M.Visalakshi participated in Orientation on Basic Content making on major crops of North coastal districts organized by Reliance Foundation at RARS, Anakapalle on 16.7.15 and delivered lecture on Pest diagnosis and IPM of Major crops of the Zone.
6. Dr. M.Visalakshi participated in District level training cum workshop Department of Agriculture, Visakhapatnam organized by at RARS, Anakapalle on 6.8.2015 and delivered lecture on Pests of major crops, IPM practices with special emphasis on Biocontrol organized by at RARS, Anakapalle.
7. Dr. M.Visalakshi participated in Distrci level training cum workshop organised by Department of agriculture, Visakhapatnam on 6.8.15 and delivered lecture on integrated pest management in paddy, maize, sugarcane, groundnut and pulse crops under integrated crop management concept in polambadi.
8. Dr.M.Visalakshi participated in growers training programme in factory zone area organized by SVGC Sugars, Bhimasingi at RARS, Anakapalle on 19.08.15 and delivered lecture on sugarcane pests and integrated pest management practices.
9. Dr.M.Visalakshi participated in management of Production technology management in bud chip technology in sugarcane organised by RARS, Anakapalle, Agricultural extension Department on 21.08.15 and delivered lecture on biocontrol methods under Management of sucking complex in sugarcane.
10. Dr.M.Visalakshi participated in growers training programme in factory zone area organised by
11. SVGC Sugars, Bhimasingi on 24.08.15 and delivered lecture on sugarcane pests and integrated Dr.M.Visalakshi participated in growers training programme in factory zone area organised by SVGC Sugars, Bhimasingi on 03.09.15 and delivered lecture on sugarcane pests and integrated pest management practices
12. Dr.M.Visalakshi participated in training and visit programme on sugarcane to field staff of IFFCO organised by IFFCO, Kakinada on 10.12.15 and delivered lecture on IPM in sugarcane, rice and maize.
13. Dr.M.Visalakshi participated in training programme on farmers on zero tillage maize and pulses production technology under ATMA at RARS, Anakapalle on 17.2.16 and delivered lecture on Pests And their management in Zero tillage maize.

iii. Participation in Kisan mela/ AICRP meetings / R&D meeting / T&V meetings / Rythukopsam Chandranna Yatra Program etc:

ANGRAU

i. Dr.M.Visalakshi participated in Kisan mela on Farm mechanization and Post harvest technology on 14th May, 2015 at RARS, Anakapalle.
ii. Dr.M.Visalakshi participated in 58th Farmers Day Celebrations of Regional Agricultural research station on 26th & 27th February, 2016 at RARS,Anakapalle
iii. Dr.M.Visalakshi participated in AICRP on Biocontrol Annual workshop organised by TNAU, Coimbatore during 2-5 May, 2015.
iv. Dr.M.Visalakshi participated in 26th R & D meet of Sugarcane Research and development workers of Andhra Pradesh during 21-22 September 2015 at Andhra University Campus, Visakhapatnam.
v. Dr.M.Visalakshi Participated in T&V monthly meetings during 2015-2 016 at RARS Anakapalle organised by ANGRAU with Department of agriculture, Visakhapatnam.
vi. Dr.M.Visalakshi Participated in Rythukosam Chandranna Yatra Program Rythukosam Chandranna Yatra Program on 11.09.15 at Sabbavaram, Visakhapatnam

GBPUAT-Pantnagar

International:

Attended by Dr. J. Kumar & Dr. A. K. Tewari

- Half annual Cu-chi-BCA consortium meeting of Indo-German Project from Aug. 28-29, 2015. Muenster, Germany
- International Conference on Chitin and Chitosan from Aug.30-Sept. 02, 2015. Muenster, Germany
- 6th International Conference on "Plant pathogens and people" with the mission "Challenges in Plant pathology to benefit human kind" from Feb. 23-27, 2016. NASC Complex, New Delhi

National:

- Half annual Cu-chi-BCA consortium meeting of Indo-German project from March15-16, 2015. NASC complex, New Delhi.Attended by Dr. J. Kumar & Dr. A. K. Tewari
- 24th Annual Group Meeting of AICRP on Biological control of crop pests from June 2-3, 2015. TNAU, Coimbatore. Attended by Dr. A. K. Tewari

IGKV-Raipur

1. Participated and demonstrated bio-agents in the "Soil health day" on 5th Dec'2015 at IGKV, Raipur.
2. New Bio-Control laboratory was inaugurated on 21/01/2016, under "Centre of Excellence - Agro- Industrial Biotechnology as a separate unit of "Bio-Control agents utpadan evam prashikshan.
3. The AICRP on Bio-control team participated in the "National Kisan Mela" held at IGKV, Raipur and exhibited live demonstration of bio-agents to the farmers and public held from 26-28 Dec'2015.

KAU-Thrissur

Dr. Madhu Subramanian, Asst. Professor attended XXIV Biocontrol Workers Group Meeting held on 2nd and 3rd June, 2015 at Tamil Nadu Agricultural University, Coimbatore.

MPUAT-

National Conference: Attended the State level **Tilhan Krishi Vigyan Mela** at Mewar University, Rajasthan on 4 March 2016. Organized at RCA, MPUAT

MPKV-Pune

Resarch Meetings:

i. Dr. R.V. Nakat, Dr. S. M. Galande and N. D. Tamboli attended Research Planning Meeting at MPKV, Rahuri on 8and 9thApril, 2015.
ii. Dr. R.V. Nakat, Dr. S. M. Galande and N. D. Tamboli attended Pre Research Finding Release Committee Meeting at Department of Entomology, MPKV, Rahuri on 23th April 2015.
iii. Dr. R.V. Nakat and N. D. Tamboli attended Research Finding Release Committee Meeting on 28-29th April 2015 and submitted the proposal of recommendation for Joint Agresco Meeting will be held at MPKV, Rahuri.
iv. Dr. R.V. Nakat attended Joint Agresco Meeting held at MPKV, Rahuri during 29-30 May, 2015.
v. Dr. R.V. Nakat, Dr. S. M. Galande attended XXIV AICRP Biocontrol workshop at TNAU, Coimbatore during 2-5 June 2015 and presented the research report of the work done under AICRP on Biological Control of Crop Pests and Weeds during the year 2014-15.
vi. Dr. S. M. Galande attended product testing meeting on 16.12.2015 in the office of Directorate of Research, MPKV., Rahuri and presented the report in meeting
vii. Dr. S. M. Galande attended Pre Research Review meeting in Agricultural Entomology on 7.1.2016 and presented the report in meeting in Department of Entomology MPKV, Rahuri.
viii. Dr. S. M. Galande, attended the Research Programme Planning Meeting in Agricultural Entomology on 11.3.2016 and presented the Technical programme in meeting in Conference hall of Director of Research, MPKV, Rahuri.

PAU-Ludhiana

1. Drs K S Sangha, Neelam Joshi, Parminder Singh Shera, Rabinder Kaur and Sudhendu Sharma participated in 4th Congress on Insect Science on April 16-17, 2015 at PAU Ludhiana.
2. Drs K S Sangha, Neelam Joshi, Parminder Singh Shera, Rabinder Kaur and Sudhendu Sharma participated in Research and Extension Specialist's Workshop for Vegetables, Horticulture and Sericulture along with Post-harvest Management, Farm Power and Machinery, Food Technology and Agricultural Economics on May 22-23, 2015 at PAU Ludhiana.
3. Drs K S Sangha, Neelam Joshi, Parminder Singh Shera, Rabinder Kaur and Sudhendu Sharma participated in XXIV Biocontrol Workers' Group Meeting held on 2nd and 3rd June, 2015 held at TNAU Coimbatore.

4. Drs K S Sangha, Neelam Joshi, Parminder Singh Shera, Rabinder Kaur and Sudhendu Sharma participated in Research and Extension Specialists Workshop for *Rabi* crops on August 27-28, 2015 at PAU Ludhiana.
5. Drs K S Sangha, Neelam Joshi, Parminder Singh Shera, Rabinder Kaur and Sudhendu Sharma participated in *Kisan Mela* held on September 25-26, 2015 and March 18-19, 2016 at PAU Ludhiana.
6. Dr Sudhendu Sharma participated in advanced training on "Ecologically based pest management for quality food production" under Centre of Advanced Faculty Training (October 15 to November 4, 2015) at CCSHAU, Hisar.
7. Drs K S Sangha and P S Shera participated in six monthly review meeting of Network Project on Conservation of Lac Insect Genetic Resources held on January 28-29, 2016 at CFRI Jabalpur.
8. Drs K S Sangha, Neelam Joshi, Parminder Singh Shera and Sudhendu Sharma participated in Research and Extension Specialists Workshop for *Kharif* crops on February 23-24,2016 at PAU Ludhiana
9. Drs K S Sangha and P S Shera participated in Regional Kisan Mela on 15.9.2015 and 15.3.2016 at Ballowal Saunkhari and Gurdaspur, respectively.
10. Dr Sudhendu Sharma participated in Regional Kisan Mela on 30.9.2015 and 11.3.2016 at Gurdaspur and Rauni (Patiala), respectively.
11. Drs Parminder Singh Shera and Sudhendu Sharma participated in Sugarcane Research and Development Sub Committee Meeting organized by Director of Research, PAU, Ludhiana on March 14, 2016.

PJTSAU-Hyderabad

Dr. S. J. Rahman, Principal scientist & Head:

1. Participated in ZREAC (*Kharif*) at Z.P.Hall, Mahabubnagar, Telangana.
2. Participated and presented Work Done Report (2014-15) and Tentative Technical Programme for 2015-16 in State Level Technical Programme (SLTP) at University Auditorium, PJTSAU Rajendranagar, Hyderabad.
3. Participated and presented the work done in Biological Suppression of pests of Pulse Oilseed crops during 2014-15 and discussed proposed Technical Programme for 2015-16 at Bio Control Workers Group Meeting held on 2-3 June, 2015 at TNAU, Coimbatore.

SKUAST-Srinagar

Dr. Jamal Ahmad

1. Attended meeting with Registrar, SKUAST-K regarding teaching allotment, on dataed 15. 09.2016.
2. Attended Review meeting with HOD, Entomology regarding Sale-cum- Exhibition mela on 15.02.2016.
3. Participated in Sale-cum- Exhibition mela, from 6-7th March' 2016, organized by SKUAST-K, Shalimar, and displayed exhibits of bio control agents and results of some Biocontrol Programme for common awareness of farmers, students and other visitors.

Dr. Sajjad Mohiuddin

1. Attended 21 days training on "Recent advances in Integrated Pest Management" at National centre for Integrated Pest Management, New Delhi, from 26th Feb. to 18th March' 2015.
2. Attended 21 days training on "Ecologically based pest management for quality food production, at CCS, Haryana Agricultural University, Hissar, from 15th Oct. to 4th Nov.' 2015.
3. Attended 4 days training on "National Conference on Temperate Fruits and Nuts- A way forward for enhancing productivity and quality" at Central Institute of Temperate Horticulture, Rangreth, Srinagar, from 6-9 Nov.'2015.
4. Attended Scientific Advisory Committee Meeting Organised by KVK, Bandipora (SKUAST-K, Shalimar) on dated 20.02.2016.
5. Participated in Exhibition cum seed mela at SKUAST-K, Shalimar, from 6-7.03.2016.

TNAU-Coimbatore

1. Participated in "International conference on Natural Resource Management Ecological perspectives held at Jammu" 18-20 Feb 2016 and presented research papers.

iv. List of publications

1. Research papers:

A AU-Jorhat

1. D. K. Saikia, R. N. Borkakati and Purnima Das (2016). Comparative Study of BIPM Package of Rice Over Farmers' Practice. Pestology. **XL (2):56-58**

ANGRAU-Anakapalle:

1. M. Visalakshi and A. Sireesha 2015. Study on influence of tillage methods on productivity of maize.
2. Indian Journal of Agricultural Research. 49 (5) : 452-455
3. Visalakshi M, Bhavani B and Prasada Rao K 2015. Efficacy of insecticide + fungicide combinations in the management of early shoot borer and smut in sugarcane. *Pestology* 39(10): 39-41.
4. Visalakshi Mahanthi 2015. Knowledge, Adoption and economics of Intergrated Pest Management in paddy in Vizinagaram district, Andhra Pradesh.The Andhra Agricultural Journal, ANGRAU Vol. 61 (4), 879-884.
5. M.Visalakshi, B. Bhavani and S.Govinda Rao 2015. Field Evaluation of Entomopathogenic fungi against White grub, *Holotrichia consanguinea* Blanch in Sugarcane. Journal of Biological control 29(2): 103-106
6. M. Visalakshi and A. Sireesha 2015. Successful Zero Tillage Maize cultivation through Farmers Field School programme – A Case Study.The Andhra Agricultural Journal, ANGRAU accepted for publication.
7. M.Visalakshi, B. Bhavani and S.Govinda Rao 2015. Ecofriendly and Biointensive approach for the Management of sugarcane shoot borers under Organic farming. Journal of Ecofriendly Agriculture.

8. Visalakshi M and Bhavani B 2015. Field efficacy of *Beauveria bassiana* and *Metarhizium anisopliae* against white grub damaging sugarcane in Andhra Pradesh.Sugar Journal 2015: 153-157

GBPUAT-Pantnagar

1. Pandey, V., Ansari M.W., Tula, S.,Yadav, S., Sahoo, R.K., Bains, G., Badal, S., Chandra, S., Gaur, A.K., Kumar, A., Shukla, A., Kumar, J., and Tuteja, N. 2016. Dose-dependent response of Trichoderma harzianum in improving drought tolerance in rice genotypes. Planta. DOI 10.1007/s00425-016-2482-x, pp1-14.
2. Negi, Y., Prabha, D., Garg, S.K. and Kumar, J. 2015. Biological control of ragi blast disease by chitinase producing *Pseudomonas fluorescens* strains. Organic Agriculture : DOI 10.1007/s13165-015-0142-2
3. Rai, D.; Tewari, A.K.*and Bisht, K.S. (2015). Evaluation of different concentrations of Jaggery (as a cheaper carbon source) for growth and sporulation of *Trichoderma harzianum. Trends in Biosciences.*18 (8): 4868-70
4. Rai, D.; Bisht, K.S and Tewari, A.K. *(2016). *In-vitro* effect of newer fungicides on mycelial growth in Biocontrol fungus *Trichoderma* (Th14). *Journal of Hill Agriculture, Environment & Food Science.* 7(1):

IGKV-Raipur

1. Chandrawanshi, Hemkant; Chandrakar, Okesh; Raichandani, Prakash; Kushwaha, Randeep and Ganguli, Jayalaxmi (2016). Beneficial insects: Key component in IPM program. Abstract published in "National Seminar on climatic change and its impact on agriculture in Chhattisgarh state. Organized by Department of Geography, Chaitanaya College Pamgarh, District- Janjgir champa, Chhattisgarh.pp 53.
2. Chandrawanshi, Hemkant; Ganguli, Jayalaxmi; Singh, Gajendra and Raichandani, Prakash (2016). Impact of climate change on pests and their natural enemies. Abstract published in Agrivision souvenir in the National convention on challenges in Indian agriculture & future strategies for sustainability held from 13-14 February, 2016 at JNKVV, Jabalpur (M.P.) pp 02.
3. Nirmal, Akash; Ganguli, Jayalaxmi; Chandrawanshi, Hemkant; Sharma, Sanjay and Bisen Singh Manmohan (2015). Testing of non-electrical low cost light trap. Abstract published in Annals of plant and soil research. pp 38-39.
4. Chandrawanshi, Hemkant; Ganguli, Jayalaxmi, Kushwaha, Randeep, Gupta, Shimla and Mukherjee Deepanshu (2015). Collection, identification and classification of various insect fauna under agro-forestry ecosystem of IGKV, Raipur, Chhattisgarh. Abstract published in "Proceedings of National Conference on Harmony with Nature in context of bio resources and environmental health (Hormony-2015) organized by Department of Zoology, Dr. Babasaheb Ambedkar Marathwada University Aurangabad (Maharashtra).pp273-278.
5. Sahu, C.M.; Nirala, Y.P.S.; Ghirtlahre, S. K.; and Ganguli, J. L. (2015). Bionomics of predatory red stink bug, *Euthyrhynchus floridanus* Linnaeus (Hemiptera: Pentatomidae) on turmeric leaf skipper butterfly, *Udaspes Folus* at Raipur (C.G.). Abstract published in Journal of Plant Development Sciences. Pp653-656.
6. Devi, Payal and Ganguli, J. L. (2016). Level of infestation of tamarind fruit borer at Bastar, Chhattisgarh, in abstract of XV AZRA International Conference on "Recent Advances in Life Sciences", 11-13 February, 2016 at Ethiraj College for Women, Chennai pp.111.
7. Dash, D.; Deole, S. and Ganguli, J. L. (2016). Biocontrol in the rhizosphere with the context of soil microbial interactions, in abstract of XV AZRA International Conference on "Recent

Advances in Life Sciences", 11-13 February, 2016 at Ethiraj College for Women, Chennai pp.122.

8. Sahu, Chandramani; Ganguli, J. L. And Ganguli, R.N. (2016). Screening of various provenances of karanj, *Pongamia pinnata* L. Against *Hasora chromus* Cramer (Lepidoptera: Hesperiidae) at Raipur Chhattisgarh in abstract of XV AZRA International Conference on "Recent Advances in Life Sciences", 11-13 February, 2016 at Ethiraj College for Women, Chennai pp.94.
9. Bhardwaj, Jyotiraama Ganguli, J. L. and Gauraha, Rashmi (2016). Biology and bionomics of the rice meal moth, Corcyra cephalonica (Stainton) reared under laboratory condition on different diets. In abstract of XV AZRA International Conference on "Recent Advances in Life Sciences", 11-13 February, 2016 at Ethiraj College for Women, Chennai pp.160.
10. Send for publication in Current Biotica in Vol.21 (2) Rashmi, G.; Ganguli, J. L.; and Jayaram, C.S. (2016) - Ability of the Reduviid bugs, *Rhynocoris* sp. (Hemiptera: Reduviidae) to kill *Corcyra* larva.

IIVR, Varanasi

1. Jaydeep Halder and A.B.Rai. 2016. Suitability of different prey aphids on the growth, development and reproduction of *Chrysoperla zastrowi sillemi* (Esben-Petersen) (Chrysopidae: Neuroptera), *Proceedings of the Zoological Society*. 69(1):89–95. (DOI 10.1007/s12595-014-0131-6).
2. Jaydeep Halder, A.B. RaiandDebjaniDey. 2016. Occurrence of *Phenacoccus solenopsis* (Tinsley) in vegetable ecosystem and host-mediated effects on its dominant parasitoid Aenasius bambawalei. *Vegetable Science* (Accepted)

KAU-Thrissur

1. Aswin, T. Bhaskar, H. and Subramanian, M. 2015 Efficacy of novel acaricide molecules and botanicals against rice leaf mite *Oligonychus oryzae* (Hirst) (Prostigmata: Tetranychidae) *J. Trop. Agri*. 53(2) 187-190 p.

MPUAT-Udaipur

1. R.K. Kalyan, O.P. Ameta, G.S. Ameta, B.S. Rana and H.K. Jain. 2015. Estimation of losses in soybean due to insect pests. *Indian Journal of Applied Entomology*. Pp 30.
2. K.C. Ahir, B.S. Rana, O.P. Ameta and A. Mordia. 2015. Seasonal incidence of major insect pests of groundnut. *Indian Journal of Applied Entomology*. Pp 55.
3. Arti Saini, B.S.Rana, O.P. Ameta and A. Mordia. 2015. Seasonal incidence of major insect pests infesting Chilli. *Indian Journal of Applied Entomology*. Pp 78.

TNAU-Coimbatore

1. Ranjith, M., D.R.Bajya, T.Manoharan, S.Sridharan and S.Kuttalam .2015. Repellent efficacy of *Crotalaria burhia* and *Anacardium occidentale* against *Odontotermes obesus* (Isoptera: Termitidae) under laboratory condition. *Indian J.Agric.Sci. 85(9):1234-6*
2. Sridharan, S. K.Chandrasekhar and N.Ramakrishnan, 2015. Effect of mineral oil and its combinations against leafhopper, *Amrasca biguttala biguttala* in okra. Indian journal of plant protection. Vol.43, No.2, 133-142

3. Sridharan, S., M.R.Khan, P.A.Saravanan, S.Shahid, N.S.Awasthi and A.M.Manoj. 2015. Book chapter: Integrated management of fruitflies. In: Mango production and protection fruit flies. Eds.M.R.Khan, F.A.Mohiddin and Zia ul Haque. PP 244-263
4. Ramakrishnan, N.and S.Sridharan. 2015. Eco-safe biopesticides to manage psyllids, *Diaphorina citri* in curry leaf, *Murraya koenigii*. *Indian Journal of Plant Protection*, 43(3), 294-298
5. Nikita, S. Awasthi, Sridharan.S and B.Padmanban. 2015. Analysis of Technology gap and relative importance of banana pseudostemborer *O.longicullus* oliver in Tamil Nadu. Indian Journal of Ecology 43 (Special issue-1) 2016. 506-511
6. Nikita S Awasthi and S.Sridharan.2015. Screening of botanicals for their repellent properties to banana pseudostem borer *Odoiporus longicollis* oliver. The Ecoscan VII (Special issue 2015) 147-152
7. Sridhar, K. Sridharan.S and M.Muthukumar.2016. Screening of Bioenergy sweet sorghum Genotypes for their resistance to Shootfly *Atherigona Soccata* (Rodani) under field conditions. Trends in Biosciences 8(21) 5866-5883
8. Sridhar.K, Sridharan.S, and M.Mutukumar. 2016. Screening of Sweet sorghum genotypes for their resistance to stem borer *Chilo partellus* (Swinhoe) under field condition. Progressive Research 10 (Special V) 759-766.
9. Shanmuga Prema, M., S.Sridharan, and S.Kuttalam. 2016. Fipronil 80 WG A promising Phenyl pyrrozole insecticide to manage thrips damage in grapes. Annals of Plant protection sciences. 2016.24 (1):61-66
10. Shanmuga Prema, M., S.Sridharan. 2016. Management of rice leaf folder with fiprnil 80 WG – a novel phenyl pyrrosole pestsicide. Progressive Research. 2015: ISSN :0973-6417, Vol.10 (special II): 1019-1022

PAU-Ludhiana

1. Devi M Soniya and Kaur R (2015) Effect of different artificial diets on the adult's biological attributes of sugarcane stalk borer, *Chilo auricilius* Dudgeon and evaluation of their costs. *Journal of Applied and Natural Science* **7 (1)**: 88-81. (NAAS- 5.08)
2. Kaur G, Bansal M and Sangha K S (2015) Comparative efficacy of different insecticides against aphids (Aphididae: Homoptera) and thrips (Thripidae: Thysanoptera) of chilli. *Ecology, Environment and Conservation*. (Accepted) (NAAS- 5.02)
3. Kaur G, Bansal M, Sangha K S and Kumar A (2015) Comparative Efficacy of Different Insecticides Against Mites, *Polyphagotarsonemus latus* (Banks) (Tarsonemidae: Acari) Whitefly, *Bemisia tabaci* (Gennadius) (Aleyrodidae: Hemiptera) and Fruit Borer, *Helicoverpa armigera* (Hubner) (Noctuidae: Lepidoptera) of Chilli. *The Bioscan*: Accepted (NAAS- 4.57)
4. Kaur R, Joshi N, Virk J S and Sharma S (2016) Effect of biocontrol modules for the management of early blight and fruit borer in tomato. *Journal of Environmental Biology* **37**: (accepted). (NAAS- 6.55)
5. Kaur S and Joshi N (2015) Evaluation of *Bacillus thuringiesis* for the management of cabbage caterpillar, *Pieris brassicae*. Journal of Insect Science (Accepted (NAAS: 3.44)
6. Sharma S and Aggarwal N (2015) Dispersal ability and parasitisation performance of *Trichogramma* spp (Hymenoptera: Trichogrammatidae) in organic *basmati* rice. *Journal of Environmental Biology* 36: 1345-48 (NAAS- 6.55)
7. Shera P S and Arora R (2016) Comparative study on oviposition and larval preference of spotted bollworm, *Earias vittella* on *Bt* and non-Bt cotton. *Journal of Environmental Biology* 37 (1): 121-127 (NAAS- 6.55)

8. Shera P S and Arora R (2016) Comparative survival and development of spotted bollworm, *Earias vittella* (Fabricius) on *Bt* and isogenic non *Bt* cotton genotypes under field cage conditions. *Journal of Cotton Research and Development* 30 (1): 97-103 (NAAS- 4.57)
9. Shera P S and Arora R (2016) Survival and development of spotted bollworm, Earias vittella (Fabricius) (Lepidoptera: Nolidae) on different transgenic *Bt* and isogenic non-Bt cotton genotypes. *Phytoparasitica* DOI 10.1007/s12600-016-0505-6 (NAAS- 6.90)
10. Shera P S and Sarao P S (2016) Field efficacy of an insect growth regulator, Buprofezin 25 SC against planthoppers infesting paddy crop. *The Bioscan* (Accepted) (NAAS- 4.57)

YSPUHF-Solan

1. Omkar Gavkare and P. L. Sharma 2015. New record of *Nesidiocoris tenuis* (Reuter) (Hemiptera: Miridae) associsted with *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae) on tomato from Maharastra, India. *Journal of Biological Control*, 28(2): 117-118
2. Omkar Gavkare, P. L. Sharma, and George Japoshvili 2015. Parasitization of the Potato Aphid, *Macrosiphum euphorbiae* (Thomas), by *Aphelinus asychis* Walker in Greenhouses in India. *Journal of Agricultural and Urban Entomology*, 31(1):47-51
3. Sharma PL, Chauhan U and Sharma KC. 2015. Studies on the diversity of predatory coccinellid beetles (Coleoptera) in different agro-climatic zones of Himachal Pradesh. *The Bioscan*, 10(3): 981-985.
4. Sanjta Suman and Chauhan Usha. 2015. Survey of thrips (Thysanoptera) and their natural enemies in vegetables from mid hills of Himachal Pradesh. *The Ecoscan*. 9(3&4): 713-715.
5. Sanjta Suman and Chauhan Usha. 2015. Survey of thrips fauna and their theirnatural enemies in different fruit crops under mid hills of Himachal Pradesh. *Journal of Insect Science* 28(2): 202-207.
6. Sharma PL and Kumar R. 2015. New Record of *Quadrastichus plaquoi* (Hymenoptera: Eulophidae) as Parasitoid of Chromatomyia horticola (Diptera: Agromyzidae). *National Academy Science Letters* (accepted)
7. Urvi Sharma, RPS Chandel and PL Sharma. 2015. Effect of botanicals on fertility parameters of *Myzus persicae* (Sulzer). *The Bioscan* **(**Submitted)

2. Papers presented in symposia/ seminar/workshops:

ANGRAU-Anakapalle

1. M. Visalakshi and B. Bhavani 2015. Effect of chemical insecticides on termites in sugarcane under various methods of application. In: Proceedings of International Academic and research conference India, 2015 held at Vijayawada during 9-10 October, 2015, 1 pp.
2. M. Visalakshi and A. sireesha 2015. Adoption status of direct seeding paddy using drum seeder- application. In: Compendium of abstracts of International rice Symposium, 2015 held at PJTSAU, Hyderabad during 18-20 November, 201, 613 pp.
3. M. Visalakshi and B. Bhavani 2015. Effect of chemical insecticides on termites in sugarcane under various methods of application. Life Sciences International research Journal, 2015 inVolume 2 Spl Issue, 1-4 pp.

GBPUAT-Pantnagar

1. P.K. Sajeesh; R. Balodi; A.K.Tewari; N.R.Bhardwaj; J.Purohit and J. Kumar**.** (2015) Chitosan in combination with copper and *Trichoderma* enhances quality of potato tubers. **In:**

Proceedings International Conference on Chitin and Chitosan from Aug.30-Sept. 02, 2015. Muenster, Germany.

2. P.K. Sajeesh; R. Balodi; A.K.Tewari N.R.Bhardwaj; J.Purohit; L. Rawat; and J. Kumar.(2015)Field evaluation of Chitosan in a triple combination with Copper and *Trichoderma*for management of late blight disease of potato.. **In:** Proceedings International Conference on Chitin and Chitosan from Aug.30-Sept. 02, 2015. Muenster, Germany.
3. N.R. Bhardwaj; R. Balodi; J.Purohit; L. Rawat; A.K. Tewari and J. Kumar. (2016).Triple combination of Copper Chitosan-*Trichoderma* for eco-friendly management of late blight of potato in poster session "Bio-prospecting in bio-control agents for sustainable agriculture.. **In:** Proceedings "Plant, Pathogens and People" with the mission"Challenges in Plant pathology to benefit human kind.6th International Conference Feb. 23-27, 2016, NASC Complex, New Delhi, India. 470 pp.
4. N.R. Bhardwaj; R. Balodi; A. K.Tewari and J. Kumar. (2016). Characterization of chitosinase enzyme from Cu tolerant *Trichoderma* isolates. **In:** Proceedings "Plant, Pathogens and People" Plant, Pathogens and People" with the mission"Challenges in Plant pathology to benefit human kind.6th International Conference Feb. 23-27, 2016, NASC Complex, New Delhi, India. 518 pp
5. R. Balodi; N. R. Bhardwaj; P.K. Sajeesh; A. K. Tewari and J. Kumar*. (2016).Chitosan mediated induction of N-acetyl-β-D-glucosaminadase gene in Cu tolerant *Trichoderma* isolates. **In:** Proceedings "Plant, Pathogens and People" Plant, Pathogens and People" with the mission "Challenges in Plant pathology to benefit human kind. 6th International Conference Feb. 23-27, 2016, NASC Complex, New Delhi, India. 514 pp
6. Kabdwal, B.C.; Roopali Sharma; Rashmi Tewari and J. Kumar*. (2016). A common minimum programme : an eco-friendly approach for the plant disease management for small farms" Plant, Pathogens and People" with the mission "Challenges in Plant pathology to benefit human kind" in poster session " Challenges in Integrated crop management with respect to diseases.6th International Conference Feb. 23-27, 2016, NASC Complex, New Delhi, India. 395 pp.

IIVR

1. Jaydeep Halder, M.H.Kodandaram, A.B.Rai and Sunil Gupta. 2016. Ecofrineldy management of hadda beetle, *Epilachnadodecastigma* (Wied.): a serious pest in organically grown cowpea. In. National Symposium of "Vegetable legumes for soil and human health" held at Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh on 12-14thFebruary, 2016, pp-355.
2. Jaydeep Halder, Deepak Khushwaha, A.B.Rai and B.Singh. 2016. Bioefficacy of biopesticides as affected by host-mediated interactions of *Phenacoccus solenopsis* Tinsley. Indian Ecological Society International Conference-2016: Natural Resource management: Ecological perspective held at SKUAST-Jammu during 18-20th February, 2016. Pp-728-729.

PAU-Ludhiana

1. Joshi N, Sharma N and Meenu (2015) Pathogenicity of *Beauveria bassiana* isolates against *Spodoptera litura*. pp 192 In: Sharma D R, Kumar S and Singh B (eds) In: *Proceedings of 4th Congress on Insect Science*, April 16-17 2015, PAU, Ludhiana.
2. Kaur G and Sangha K S (2015) Efficiency of yellow sticky trap shapes for capturing alate insects in agroecosystem. In: *Proceedings* of *4th Congress on Insect Science*. Punjab Agricultural University, Ludhiana, India.

3. Kaur G and Sangha K S (2015) Incidence of *Myzus Persicae* (Aphididae: Homoptera) and Efficiency of Yellow Sticky Trap Shapes for their Monitoring on *Capsicum annuum* L. In: *Proceedings Exploring Basic and Applied Sciences for Next Generation Frontiers*. Lovely Professional University, Punjab, India.
4. Kaur R and Virk J S (2015) Development of bio-control based IPM module against cabbage butterfly, *Pieris brassicae* (Linnaeus) on cauliflower. Pp 79-80. In: Sharma D R, Kumar S and Singh B (eds) *Abstracts proceedings of 4th Congress on Insect Science*, April 16-17 2015, PAU, Ludhiana.
5. Kumar R, Jindal, J, Shera, P S and Sharma S (2015). Evaluations of some biopesticides as pyrethroid alternative for the management of maize stem borer *Chilo partellus* in *kharif* maize. In: Sharma D R, Kumar S and Singh B (eds.) *Entomology for Sustainable Agriculture. Proceedings of the 4th Congress on Insect Science*: Abstracts, April 16-17, 2015, INSAIS, PAU, Ludhiana, India. pp 185-186 (Abstract).
6. Sharma S and Aggarwal N (2015). Parasitism of lepidopteran pests in organic and conventional *basmati* rice in Punjab. In: Sharma D R, Kumar S and Singh B (eds.) *Entomology for Sustainable Agriculture. Proceedings of the 4th Congress on Insect Science*: Abstracts, April 16-17, 2015, INSAIS, PAU, Ludhiana, India. p 189 (Abstract).
7. Shera P S and Arora R 2015. Relative survival and development of *Earias vittella* (Fabricius) on *Bt* and isogenic non-Bt cotton under field cage conditions. In: Sharma D R, Kumar S and Singh B (eds.) *Entomology for Sustainable Agriculture. Proceedings of the 4th Congress on Insect Science*: Abstracts, April 16-17, INSAIS, PAU, Ludhiana, India. pp 139-140 (Abstract).

PJTSAU-Hyderabad

1. Sunil Kumar, G.V., Vijaya Bhaskar, L., Satish, Y. and Rahman, S.J**.** 2016. Evaluation of liquid formulations of *Bt* against gram pod borer, *Helicoverpa armigera* (Hubner) and spotted pod borer, *Maruca vitrata* (Geyer) in pigeonpea. *J.Applied Biol. and Bio Tech.* 4(1):39-42

S**KUAST-Srinagar**

1. Sajad Mohi-ud-din, N. A. Wani, A. R. Wani (2015). Field screening of pomegranate varieties for resistant reaction against Anar butterfly. *Enviroment and Ecology* (Accepted)
2. Sajad Mohi-ud-din, Zaki, F. A., Wani, R. A, M. Jamal Ahmad (2015). Development of IPM module against fruit borer *(Deudorix epijarbas)* on pomegranate. Paper presented in "National Conference on temperate fruits and nuts- a way forward for enhancing productivity and quality" from 6-9, November.
3. Wani, R. A., Sajad Mohi-ud-din, and Nehru, R.K. (2015). Species Diversity of White Grub, effect of different Colour Regimes and height of light traps on attraction of Chaffer Beetles in Royal Spring Golf Course Chesmashahi of Kashmir Valley. Paper presented in "National Conference on temperate fruits and nuts- a way forward for enhancing productivity and quality" from 6-9, November.
4. Sajad Mohi-ud-din, N. A. Wani, M. Jamal Ahmad and Mir, G.M. (2016). Seasonal incidence of Anar butterfly and its correlation with weather parameters. *The Bioscan.* (Accepted)
5. Sajad Mohi-ud-din (2016). Managing Anar butterfly-the worst enemy of pomegranate. State English Newspaper, *Greater Kashmir* on 4th of March.

TNAU-Coimbatore

1. Shanmuga prema, M. and S. Sridahran.2015. Acoustic sensors – A new automated early monitoring tool for stored grain pests. Paper presented in National seminar on whole grain for healthy life organised by Indian Institute of Crop Processing Technology, Thanjavur, Tamil Nadu. P.94.
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UAS-R

1. Technical Bulletin on Importance of natural enmies of paddy insect pests
2. Technical Bulletin on invasive pest, tomato pinworm, *Tuta absoluta*

v. Bioagents maintained in Biocontrol Laboratory

AAU, Jorhat

1. *Trichogramma japonicum*
2. *T. chilonis*
3. *T. mwanzai*
4. *T. pieridis*
5. *Blaptostethus pallescens*
6. *Trichogramma pretiosum*
7. *Telenomus sp* recovered from tea
8. *Neochetina eichhorniae and N. bruchi*

The biocontrol agents (parasitoids and predators) produced and maintained in the laboratory are being utilized for teaching and training of farmers, extension workers, entrepreneurs and also students of P.G. Research. Cultures of parasitoids (*Trichogramma japonicum, T. chilonis, T. pieridis)* and water hyacinth beetle *Neochetina eichhorniae and N.*

bruchi have been supplied to different regional research stations of AAU, KVKs and Agricultural officers, Govt. of Assam for their field demonstration against pests of rice sugarcane and vegetables.

ANGRAU-Anakapalle

1. Around 250 million egg parasitoids, *Trichogramma chilonis* in the form of 1250 Trichocards and host insect *Corcyra cephalonica* 180 cc eggs were supplied to Sugar factories, Department of Agriculture, Horticulture University and individual farmers on cost basis and income of rupees 70,750.00 was generated under revolving fund during 2015-16.
2. Nucleus culture of *Trichogramma chilonis* (mother cards) and *Corcyra cephalonica* eggs were supplied to Biocontrol labs established by Department of Agriculture; Sugar factories and Horticulture University on cost basis.

MPKV-Pune

Following cultures of bioagents and host insects were maintained in the Biocontrol laboratory and used for experimental purposes as well as supplied to other Biocontrol laboratories in the State. Besides, *Trichogramma* spp., *Cryptolaemus montrouzieri, Ha*NPV, *Sl*NPV, *Metarhizium anisopliae* and *Nomuraea rileyi* were mass cultured and used for action research demonstrations on research farms of University, research stations and farmers' fields. These were also distributed to needy farmers.

Parasitoids:
Trichogramma chilonis Ishii
Trichogramma chilonis TTS
Trichogramma chilonis SAS
Trichogramma japonicum Ashmead
Trichogramma pretiosum Riley
Trichogramma pretiosum arrhenotokous strain
Trichogramma pretiosum thelytokous strain
Chelonus blackburni Blanchard
Acerophagus papayae Noyes & Schauff

Predators:
Cryptolaemus montrouzieri Mulsant
Chrysoperla zastrowi sillemi (Esben-Petersen)
Xylocoris flavipes (Reuter)

Microbial agents:
Nomuraea rileyi
Metarhizium anisopliae
Beauveria bassiana
Lecanicillium lecanii

Laboratory hosts:
Phthorimaea operculella Zeller
Corcyra cephalonica Stainton
Maconellicoccus hirsutus Green
Paracoccus marginatus Williams and Granara de Willink

Mass production and sale of bioagents:

Name of bioagents	Quantity produced	Quantity sold	Receipt realized (Rs.)
1. *Trichogramma* sp. (Trichocards)	710	45	2350/
2. *Chelonus blackburni*	4,000	-	-
3. *Cryptolaemus montrouzieri*	15,000	650	1300/ Demonstration
4. *Metarhizium anisopliae*	50 kg	-	- Demonstration
5. *Nomuraea rileyi*	50 kg	-	- Demonstration

PAU-Ludhiana

Name of biocontrol agents being reared

- *Trichogramma chilonis* (temperature tolerant strain)
- *T. japonicum* (temperature tolerant strain)
- *T. pieridis*
- *T. brassicae*
- *Bracon hebetor*
- *Chrysoperla zastrowi sillemi*
- *Coccinella septempunctata*
- *Cheilomenes sexmaculatus*
- *Blaptostethus pallescens*

Name of host insects reared

- *Helicoverpa armigera*
- *Spodoptera litura*
- *Galleria mellonela*
- *Corcyra cephalonica*
- *Phenacoccus solenopsis*

Activities of Biocontrol Group at PAU Centre

- Rechristening the name of State-of-Art Bio-control Laboratories as Dr Gurcharn Singh Kalkat Laboratories on March 3, 2016 at Entomological Research Farm, Punjab Agricultural University, Ludhiana.

PJTSAU-Hyderabad

List of Bio Agents being maintained and Mass Produced:

Sl. No.	Bio Agent being cultured and mass produced	Type of Bioagent
1	*Trichogramma japonicum*	Egg parasitoid
2	*Trichogramma pretiosum*	Egg parasitoid
3	*Trichogramma chilonis*	Egg parasitoid
4	*Trichogramma achae*	Egg parasitoid
5	*Trichogramma brasilensis*	Egg parasitoid
6	*Trichogrammatoidea bactre*	Egg parasitoid
7	*Chelonus blaclburni*	Egg larval parasitoid
8	NPV of *Helicoverpa*	Bio Pesticide
9	NPV of *Spodoptera*	Bio Pesticide

SKUAST-Srinagar

Establishment of Mass Production Unit

The culture of following bio agents (obtained from NBAII, Bangalore) including parasitoids and predator, along with their actual/ fictitious hosts, was maintained for the purpose of mass production mainly for distribution to farmers/ experimental purposes, teaching, training to P.G.students, farmers, FCLAs, extension workers and exhibitions in Kisan melas etc.

1. *Trichogramma brassicae* (from NBAIR)
2. *Trichogrammatoidea bactrae* (-do-)
3. *T. chlionis* (-do-)
4. *T. cacoeciae* (-do-)
5. *T. embryophagum* (-do-)
6. *Blaptostethus pallescens* (-do-)
7. *Coccinella septempunctata* (Local strain)
8. *Coccinella undecimpunctata* (Local strain)
9. *Chrysoperla zastrowi* (Local strain)
10. *Quadraspidiotus perniciosus* (Local strain)
11. *Corcyra cephalonica* (Local strain)

TNAU-Coimbatore

Mass production and sale of biocontrol agents under venture capital scheme:

New venture capital scheme (VCS) for mass production of insect biocontrol agents was sanctioned as per the reference NO.CPPS/CBE /AEN 14 S147 /2014 dt: 22.07.2014 in biocontrol laboratory, Dept. of Agrl. Entomology, Coimbatore. The total revenue generated by the sale of biocontrol agents upto March 2016 is Rs.93000/- The agents commercially produced and supplied to farmers are *Trichogramma, Bracon brevicornis, Goniozus nephantidis, Acerophagus papayee, Cryptolaemus* and *Chrysoperla.*

vi. Technology assessed/ transferred

Technology assessed

Seedling root dip treatment with *Pseudomonus fluorescens* @ 2 % solution, Two sprays of *Beauveria bassiana* @ 10^{13} spores/ha against sucking pests, erection of bird perches @ 15 nos /ha, six releases of *Trichogramma japonicum* @ 1,00,000 /ha at ten days interval starting from 30 DAT against *Scirpophaga* spp. and *Cnaphalocrocis* spp., spray of Botanicals (Pestoneem @ 5 ml/lit) against foliar as well as sucking pests at ETL and spray of *P. fluorescens* 10 g/lit against foliar diseases could suppress the yellow stem borer, leaf folder, geeen leaf hopper and contributing higher yield in BIPM package. The technology has been transferred to the farmers through KVKs under AAU, Jorhat.

Mass production procedure for natural enemies has been demonstrated and transferred the technology through training to the unemployed youth to develop entrepreneurship. Balaji chemicals, Dibrugarh, Assam has come forward to establish the mass production unit of trichogrammatids.

5. ACRONYMS

AAU-A	Anand Agricultural University, Anand
AAU-J	Assam Agricultural University, Jorhat
ANGRAU	Acharya N.G.Ranga Agricultural University, Anakapalle
CPCRI	Central Plantation Crops Research Institute, Kayangulam
CTRI	Central Tobacco Research Institute, Guntur
CAU	Cental Agricultural University, Pasighat
CISH	Central Institute of Sub-Tropical Horticulture
Dir. Soyben Res	Directorate of Soybean Research, Indore
Dir. Sorghum Res	Directorate of Sorghum Research, Hyderabad
Dir. Seed Res	Directorate of Seed Research, Mau
Dir. Weed Sci. Res	Directorate of Weed Sciences Research, Jabalpur
GBPUAT	Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar
IARI	Indian Agricultural Research Institute, New Delhi
ICAR	Indian Council of Agricultural Research, New Delhi
IGKV	Indira Gandhi Krishi Viswa Vidyalaya, Raipur
IIHR	Indian Institute of Horticultural Research, Bangalore
IIRR	Indian Institute of Rice Research, Hyderabad
IISR	Indian Institute of Sugarcane Research, Lucknow
IIVR	Indian Institute of Vegetable Research, Varanasi
KAU	Kerala Agricultural University, Thrissur
MPKV	Mahatma Phule Krishi Vidyapeeth, Pune
MPUAT	Maharana Pratap University of Agriculture & Technology, Udaipur
NBAIR	National Bureau of Agricultural Insect Resources, Bangalore
NCIPM	National Centre for Integrated Pests Management, New Delhi
OUAT	Orissa University of Agriculture & Technology, Bhubaneswar
PAU	Punjab Agricultural University, Ludhiana
PJTSAU	Pandit Jayashankar Telangana State Agricultural University, Hyderabad
SKUAST	Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar
TNAU	Tamil Nadu Agricultural University, Coimbatore
UAS-R	University of Agricultural Sciences, Raichur
YSPUHF	Y.S. Parmar University of Horticultural and Forestry, Solan