ANNUAL PROGRESS REPORT 2014-15

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

Compiled and edited by

B. Ramanujam
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ICAR - National Bureau of Agricultural Insect Resources
Bangalore 560 024

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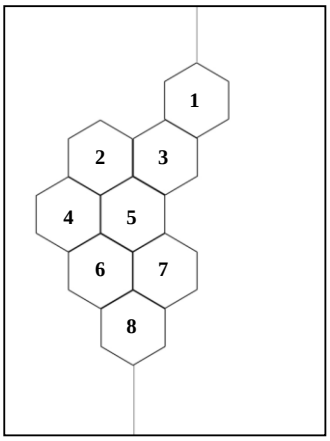

Cover page

1. *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae)
2. *Pseudococcus jackbeardsleyi* Gimpel and Miller (Hemiptera: Pseudococcidae)
3. *Trichacoides ranganabettensis* Veenakumari and Buhl (Hymenoptera: Platygastridae)
4. *Anisopteromalus indicus* Gupta and Sureshan (Hymenoptera: Pteromalidae)
5. *Calvia explanata* Poorani (Coleoptera: Coccinellidae)
6. *Opisina arenosella* Walker (Lepidoptera: Oecophoridae)
7. *Aleurodicus dispersus* Russell (Hemiptera: Aleyrodidae)
8. *Beauveria bassiana* infected *Leptocorisa acuta* (Thunberg) (Hemiptera: Alydidae)

Photo credits: Photographs 1,2,5,6,7 - J. Poorani; 3 - K. Veenakumari; 4 - Ankita Gupta; 8 - KAU

Cover design: Sunil Joshi

Programme for 2014-15

I. Basic research

1. National Bureau of Agriculturally Important insects

1. Taxonomic studies on parasites & predators of insect pests
2. Biodiversity of economically important Indian Microgastrinae (Braconidae)
3. Biodiversity of oophagous parasitoids with special reference to Scelionidae (Hymenoptera)
4. Biosystematics of Trichogrammatoidea (Hymenoptera)
5. Biodiversity of aphids, coccids and their natural enemies

6. Molecular characterization and DNA barcoding of agriculturally important parasitoids and predators
7. Diversity and predator-prey interactions with special reference to predatory anthocorids and mites
8. Introduction and studies on natural enemies of some new exotic insect pests and weeds
9. Biosystematics and diversity of entomopathogenic nematodes in India.
10. Mapping of the *cry* gene diversity in hot and humid regions of India
11. 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. To carry out surveys and collection of *Trichogramma* strains from different agro-climatic zone of India.
2. To evaluate the collected *Trichogramma* strains for searching efficiency, temperature tolerance and fecundity.
3. To breed the better performing strains under laboratory conditions

2.1.3. Biodiversity of Biocontrol Agents from Various Agro Ecological Zones

1. Survey, Collection and diversity analysis of biocontrol agents from various agro ecological zones (AAU-A, AAU-J, ANGRAU, KAU, MPKV, PAU, SKUAST, TNAU, YSPUHF, CAU, OUAT, UAS R, IARI, CTRI, CISH, Dir. Sorghum Res and Dir. Rice Res.)
2. Mapping of EPN diversity (AAU-A, PAU)
3. Surveillance for alien invasive pests in vulnerable areas (all centres)

2.2 Biological Suppression of Diseases in Field

1. Field evaluation of promising *Trichoderma/Pseudomonas* isolates for the management of soil-borne diseases of Rice, Wheat and Chickpea (GBPUAT).
2. Efficacy of promising copper tolerant *Trichoderma/Pseudomonas* isolates against seed and seedling mortality of chickpea in glasshouse (GBPUAT).
3. Biological control of chilli anthracnose disease (GBPAT, PAU & AAU-A).
4. Management of brinjal bacterial wilt with an isolate of *Pseudomonas florescence* (CAU)

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1. Monitoring the sugarcane woolly aphid (SWA) incidence and impact assessment of natural enemies on its bio suppression (MPKV, PJTSAU, TNAU)

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1. Monitoring diversity and outbreaks for invasive mealy bugs on cotton (MPKV, PAU, PJTSAU, TNAU, UAS-R).
2. Monitoring the diversity and outbreaks of sap sucking pests, mirids and their natural enemies in *Bt* cotton (MPKV, PAU)
3. Bioefficacy of microbial insecticides against sucking pests in *Bt* cotton (AAU-A)

2.5. Tobacco

1. Field evaluation of *Pochania chlamydosporia* against root-knot nematode in FCV tobacco (CTRI)

2.6. Rice

1. Seasonal abundance of predatory spiders in rice ecosystem (PAU)
2. Laboratory and field evaluation of fungal pathogens on gundhi bug, *Leptocorisa acuta* (KAU)

2.7. Maize

1. Evaluation of *Trichogramma chilonis* against maize stem borer, *Chilo partellus* (PJTSAU)

2.8. Sorghum

1. Field evaluation of NBAII entomopathogenic fungal strains against stem borer, *Chilo partellus* (Swinhoe) in kharif sorghum (Dir. Sorghum Res.)

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2.10. Oil Seeds

1. Biological suppression of safflower aphid, *Uroleucon compositae* on safflower (MPKV, PJTSAU)
2. Biological control of groundnut pest complex (PJTSAU)
3. IPM in groundnut in Rajasthan and Haryana (NCIPM)
4. Field Evaluation of entomofungal pathogens against soybean defoliators (Dir. Soybean Res.)
5. Evaluation of entomopathogens and botanicals against soybean pest complex (MPKV)

6. Validation of IPM module in soybean (MPUAT)
7. Biological control of pests of gingelly (OUAT)
8. Biological suppression of mustard aphid, *Lipaphis erysimi* (MPKV)

2.11. Coconut

1. Survey and collection of natural enemies of coconut black headed caterpillar, eriophyid mite and red palm weevil (CPCRI)
2. Surveillance and need-based control of coconut leaf caterpillar, *Opisina arenosella* in Kerala (CPCRI)
3. Scaling up utilization of *M. anisopliae* through technology transfer (CPCRI)
4. Entomopathogenic nematodes for management of red palm weevil (*Rhynchophorus ferrugineus*) (CPCRI)

2.12. Tropical Fruits

1. Field evaluation of *Metarhizium anisopliae* against mango hoppers (KAU, MPKV, TNAU, IIHR)
2. Field evaluation of Beauveria bassiana liquid formulation against Tea Mosquito Bug in guava (TNAU)
3. Laboratory & field evaluation of entomopathogens against banana pseudostem weevil (KAU)
4. Bio-efficacy of EPNs against citrus trunk borer *Anoplophora versteegi* (CAU)
5. Laboratory and field evaluation of entomopathogens against pineapple mealybug *Dysmicoccus brevipes* (Cockerell) (Hemiptera: Pseudococcidae) (KAU)
6. Laboratory evaluation of entomopathogens against banana root mealybugs (KAU)
7. Laboratory evaluation of entomopathogens against pepper root mealybugs (KAU)
8. Monitor and record of incidence of papaya mealy bug and its natural enemies on papaya and other alternate hosts (AAU-A, MPKV, KAU, OUAT, TNAU, IIHR, NBAII)

2.13. Temperate Fruits

1. Evaluation of entomopathogenic fungi and EPNs for the suppression of apple root borer, *Dorysthenes hugelii* under field conditions. (YSPUHF)
2. Survey for identification of suitable natural enemies of codling moth (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 on apple (SKUAST)

2.14. Vegetables

1. Field demonstration of BIPM package for the management of key pests of tomato (TNAU)
2. BIPM against *H. armigera* in tomato (MPUAT)
3. Demonstration of biointensive pest management package for the tomato pests AAU-J)
4. Large-scale demonstration of BIPM technology for management of *Helicoverpa armigera* in tomato (AAU-A)
5. Biological suppression of shoot & fruit borer in brinjal (MPKV)

6. Validation of different BIPM modules against shoot and fruit borer, *Leucinodes orbonalis* in brinjal fruit borer (MPKV, PAU)
7. Biological control of brinjal mealy bug *Coccidohystrix insolitus* (TNAU)
8. Bioefficacy of microbial insecticides against *Spodoptera litura* in cabbage (AAU-A)
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10. Evaluation of commercial formulations of *Bacillus thuringiensis* and potential microbial isolates against cabbage butterfly, *Pieris brassicae* (PAU)
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12. Evaluation of fungal pathogens against sucking pests of hot chilli (*Capsicum sinensis*) (AAU-J)
13. Validation of BIPM of thrips on onion (IIHR)
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15. Evaluation of local and NBAII entomopathogenic strains against soil insects in potato (AAU-J)
16. Biological suppression of fruit borer, *Erias vitella* in okra (MPKV)
17. BIPM in Okra (OUAT)
18. Evaluation of biointensive IPM module against *Aleurodicus dispersus* on cassava (TNAU)
19. Evaluation of predatory mites *Blaptostethus pallescens* against saffron thrips (SKUAST)

2.15. Tea Mosquito Bug

1. Evaluation of *Beauveria bassiana* against tea mosquito bugs in tea (AAU-J)

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1. Monitoring the biodiversity and outbreaks of invasive mealy bugs on major horticultural crops (TNAU, IIVR)

2.17. Biological Suppression of Polyhouse crop pests

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2. Evaluation of entomopathogenic fungi against mite, *Tetranychus urticae* on capsicum/bell pepper under protected conditions (PAU)
3. Evaluation of anthocorid predators against spider mites under insect net cage condition in brinjal, chilli & okra (PAU)
4. Biological management of red spider mite *Tetranychus urticae* infesting rose in Poly house conditions (MPKV)
5. Evaluation of efficacy of predators against cabbage aphids in polyhouse (SKUAST)
6. Evaluation of predatory mite, *Neoseiulus longispinosus* against phytophagus mite in carnation under polyhouse condition. (YSPUHF)
7. Evaluation of biocontrol agents against sap sucking insect pests of ornamentals/ vegetables in polyhouse. (YSPUHF)
8. Validation of BIPM of thrips on capsicum under polyhouse (IIHR)
9. Identification & evaluation of predatory mite potential on *Tetranychus* spp. in tomato under Green house condition (UAS-R)

2.18. Storage Pests

1. Evaluation of *Uskana* sp. against *Callosobruchus* sp. on storability of pigeon pea seed (Dir. Seed Res.)

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1. Biocontrol of *Chromolaena odorata* in forest area & waste lands of Chattishgarsh utilizing *Cecidochares connexa* by inoculative release (DWSR)

2.20. Enabling large scale adoption of proven bio control technologies

1. Rice- AAU-J; KAU (Adat model); OUAT; PAU, GBPUAT

2. Sugarcane (OUAT, PAU)

i. Large-scale demonstration on the use of *T.chilonis* against early shoot borer and internode borer of Sugarcane in farmers' field (OUAT)

ii. Enabling large scale adoption of proven biocontrol technologies against early shoot borer, top borer & stalk borer of sugarcane in collaboration with sugar mills (PAU)

3. Maize

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

4. Coconut

i. Large area field validation of integrated biocontrol technology against *Oryctes rhinoceros* (CPCRI)

5. Brinjal

i. BIPM in brinjal (OUAT)

6. Pea (GBPUAT)

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3. Promoting BIPM in rice & vegetables in Buska tribal belt in U.S Nagar district of Uttarakhand (GBPUAT)
4. Management of insect pests in horticultural /plantation crops in Maharastra (MPKV)
5. Popularization of BIPM module in kharif maize against stem borer in Rajasthan (MPUAT)
6. BIPM of apple codling moth in J& K. (SKUAST)
7. Biocontrol methods of vegetable pest management in Tamil Nadu (TNAU)
8. IPM in paddy in north Karnataka (UAS-R)
9. BIPM practice for cabbage pest management in Arunachal Pradesh (CAU)
10. Eco-friendly pest management practices for insect pest management in apple and vegetables in Himachal Pradesh (YSPUHF)
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2. EXPERIMENTAL RESULTS

2.1 Basic Research

2.1.1. National Bureau of Agricultural Insect Resources

Biosystematic studies on agricultural insects

I. Taxonomic studies on parasites and predators of insect pests

Calvia explanata Poorani and *Micraspis pusillus* Poorani (Coccinellidae) were described from north-eastern India. *Platynaspis flavoguttata* (Gorham) (Coleoptera:Coccinellidae), a rare species from Karnataka, was red scribed and the male genitalia were illustrated for the first time. It was found to be associated with ants and is probably myrmecophilic. *Anagyrus amnestos* Rameshkumar *et al*. (Encyrtidae), a potential parasitoid of the invasive Madeira mealybug, was found to have established well in and around Bangalore.

The genus *Kikiki*, the smallest genus of flying insects, was collected from Arunachal Pradesh and Tamil Nadu. *Dicopus longipes* (Subba Rao) was recorded from India for the first time. *Paraphaenodiscus monawari* (Encyrtidae) was recorded on *Pulvinaria polygonata*, a new host. The species of *Aprostocetus* hitherto identified as *Aprostocetus gala* Walker on erythrina gall wasp (*Quadrastichus erythrinae*) in India was found to be a misidentification. Based on a recent publication on the parasitoids of erythrina gall wasp, the species commonly occurring in southern India was identified as *Aprostocetus* sp. (*causalis*-group). It was particularly close to *A. felix*, a parasitoid of erythrina gall wasp in southeast Asia. Further studies, including molecular characterization, are needed to identify this species positively as *A. felix.*

ii. Biodiversity of economically important Indian Microgastrinae (Braconidae)

Seven new species of microgastrinae were described.

Monograph published: A comprehensive list of microgastrine genera, host caterpillar species, host plants, cocoon colour, structure and spinning pattern and hyper parasitoids was provided. Numerous photographs of parasitized caterpillars, cocoons (number/arrangement), associated host plants and adult wasps are also provided. Rearing records of nearly 3,500 specimens of microgastrine wasps (Hymenoptera: Braconidae) were compiled across India, covering 16 States and one Union Territory (Andaman & Nicobar islands) and deposited at the National Bureau of Agricultural Insect Resources Bangalore, India. The caterpillar inventory recovered over two hundred morpho-species within 22 families of Lepidoptera and yielded more than 90 morpho-species of microgastrine wasps, distributed among 13 genera *viz.*, *Apanteles* Förster, *Buluka* de Saeger, *Cotesia* Cameron, *Diolcogaster* Ashmead, *Distatrix* Mason, *Dolichogenidea* Viereck, *Fornicia* Brulle, *Glyptapanteles* Ashmead,

Microgaster Latreille, *Microplitis* Förster, *Neoclarkinella* Rema & Narendran, *Parapanteles* Ashmead and *Protapanteles* Ashmead.

Records of hyperparasitoids were also included. The present study added eight new host records and provided illustrations for 40 species of wasps (including types). The Indian species *Deuterixys ruidus* (Wilkinson, 1928) is transferred to *Cotesia ruidus* (Wilkinson). *Microgaster carinicollis* Cameron is transferred to *Microplitis* based on the shape and sculpture of the first and second mediotergites.

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

Surveys were conducted for Platygastroidea in the states of Arunachal Pradesh, Assam, Himachal Pradesh, Sikkim, Uttar Pradesh, Tamil Nadu, Kerala and Karnataka. The genus *Apteroscelio* (Scelioninae) is reported for the first time from India. The genus *Heptascelio*, was recorded only from Kerala and Himachal Pradesh. The genus *Embidobia* initially reported in 1912 from Kumoan, Himalayas is now reported for the first time from S. India (Karnataka and Tamil Nadu).

No Platygastridae were reported from Sikkim so far. Recent surveys conducted revealed presence of 30 genera. Forty five genera of Platygastridae are reported from Arunachal Pradesh, from where till now only a single genus *Protelenomus* was reported. A new genus *Chakra*, with type species *Chakra sarvatra* was described from Andaman Islands. Twelve new species of Platygastroidea were described as new to science. Five new species of *Phanuromyia*, *viz Phanuromyia andamanensis sp. n., P. kapilae sp. n., P. koenigi sp. n., P. nabakovi sp. n.* and *P. jarawa sp. n.* were described.

iv. Biosystematics of Trichogrammatidae (Hymenoptera)

Surveys for trichogrammatids were conducted in Northeast (Arunachal Pradesh:Pasighat, Ayeng, Simenchapri ; Assam: Dimu, Depakum ; Sikkim: Tadong, Pakyong, Ranka, Rumtek), North (Uttar Pradesh: Aligarh;Himachal Pradesh: Dundi, Gulaba-Marhi, Shimla, Naggar) and South India (Tamil Nadu: Palani Hills, Hosur, Dindigul, Yercaud; Kerala: Kasargod ; Karnataka: Vittal, Kidu, Tumkur, Mandya, Maddur, Hessaraghatta, Attur etc.). Over 900 specimens were collected and slides prepared.

Ten genera of Trichogrammatidae (*Prestwichia, Prestwichia, Chaetogramma, Burksiella, Lathromeris, Lathromeromyia, Pseudoligosita, Paracentrobia, Aphelinoidea, Mirufens* and *Tumidiclava)* were added to the collections of the Bureau. *Trichogramma flandersi, T.achaea, T.manii, Trichogrammatoidea cryptophlebiae* and *T. nana* were recorded for the first time from the Andaman islands. *Oligosita giraulti,* a South American species was collected for the first time from India which extends its range to South and Southeast Asia. SEM studies were extended to four more species of *Trichogramma*. *Mymaromma ignatii,* a new species of *Mymarommatoidea* was described from S. India. This is the first record of a mymarommatoid from India.

v. Biodiversity of aphids, coccids and their natural enemies

A survey was conducted to collect aphids, coccids and their natural enemies from Sikkim, India. Forty one species of aphids, five species of mealybugs, four species of soft

scales, three species of armoured scales and a species of orthezid were recorded. Out of these, seventeen species of aphids, a species of soft scale and mealybug each were reported for the first time from Sikkim. Two species of aphids were recorded for the first time from India.

Among natural enemies of aphids and coccids, twelve species of coccinellids and two species of braconids, one species each of Aphelinidae and Pteromalidae were recorded during the survey **(Table 1).** Four new host associations of coccinellid predators were reported. New records of host association were observed, such as *Oenopia mimica* (Weise) on *Taoia indica* (Ghosh and Raychaudhuri) *Calvia explanata* Poorani and *Calvia sykesii* Crotch on *Taoia indica* (Ghosh and Raychaudhuri), and *Alloneda dodecaspilota* (Hope) on *Macrosiphoniella artemisiae* (Boyer de Fonscolombe).

Table 1. Natural enemies of aphids collected at Sikkim

Natural enemy	Order: Family	Host insect	Location
Oenopia sexareata (Mulsant)	Coleoptera: Coccinellidae	*Eutrichosiphum raychaudhurii* (Ghosh)	Tadong
Oenopia mimica (Weise) *	Coleoptera: Coccinellidae	*Taoia indica* (Ghosh and Raychaudhuri)	Tadong
Propylea luteopustulata (Mulsant)	Coleoptera: Coccinellidae	*Brachycaudus helichrysi* (Kaltenbach)	Rumtek
Calvia explanata Poorani *	Coleoptera: Coccinellidae	*Taoia indica* (Ghosh and Raychaudhuri)	Pakyong
Calvia sykesii Crotch *	Coleoptera: Coccinellidae	*Taoia indica* (Ghosh and Raychaudhuri)	Pakyong
Alloneda dodecaspilota (Hope) *	Coleoptera: Coccinellidae	*Macrosiphoniella artemisiae* (Boyer de Fonscolombe)	Bulbulay
Micraspis pusillus Poorani	Coleoptera: Coccinellidae	Collected on *Bambusa* sp.	Chi-che
Scymnus posticalis Sicard	Coleoptera: Coccinellidae	*Aphis fabae* Scopoli	Pakyong
Harmonia sedecimnotata (F.)	Coleoptera: Coccinellidae	*Aphis craccivora* Koch	Tadong
Cryptogonus quadriguttatus (Weise)	Coleoptera: Coccinellidae	*Aphis* (*Toxoptera*) *citricidus* (Kirkaldy)	Tadong
Jauravia quadrinotata Kapur	Coleoptera: Coccinellidae	Collected on *Bambusa* sp.	Chi-che
Coccinella septempunctata Linnaeus	Coleoptera: Coccinellidae	Several plants without any insects	Rumtek
Aphidius sp.	Hymenoptera: Braconidae	*Brevicoryne brassicae* (Linnaeus)	Banjakri
Diaeretiella rapae (M'Intosh)	Hymenoptera: Braconidae	*Brevicoryne brassicae* (Linnaeus)	Banjakri
Aphelinus sp.	Hymenoptera: Aphelinidae	*Aphis* (*Toxoptera*) *citricidus* (Kirkaldy)	Tadong
Pachyneuron sp.	Hymenoptera: Pteromalidae	*Brevicoryne brassicae* (Linnaeus)	Banjakri

*New host associations

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

Molecular characterization using cytochrome oxidase 1 gene (CO1) was done for the following parasitoids namely Encyrtid *Aenasius advena* (KJ850498), *Blepyrus insularis* (KJ850500), *Neastymachus axillaris* (KM095502); Aphelinid *Myiocnema comperei* (KJ955498); Eulophid *Diglyphus isaea* (KM016074); Braconid *Aphidius ervi* (KM054518), *Aphidius colemani* (KM054519) *Cotesia* sp (KM875666), *Glyptapanteles* sp (Bidar) (KM887912), *Glyptapanteles* sp (Valparai) (KM887913), *Apanteles phycodis* (KP055616), *Bracon greeni (*KP055617), *Micropilitis macullipennis* (KP759288); Vespid *Ropalidia* sp (KM054517); Scelionid *Macrotelia* sp (KM095503), *Idris* sp (KP271246); Ichneumonid *Pristomerus sulci (*KM875667) and Chalcidid, *Brachymeria tachardiae* (KP055618).

Molecular characterization of 21 species of trichogrammatids was characterized using CO-1 and ITS-2 regions and the species identified based CO-1 and ITS-2 regions are *Trichogrammatoidea armigera*, *Tr. bactrae*, *Tr. robusta*, *Trichogramma achaeae*, *T. pretiosum* (Colombia), *T. pretiosum* (France), *T. pretiosum* (Germany), *T. chilonis*, *T. cacoeciae*, *T. embryophagum*, *T. evanescens* (Arrhenotokous), *T. evanescens* (Thelytokous), *T. semblidis*, *T. danausicida*, *T. cordubensis*, *T. japonicum*, *T. brassicae* (Italy), *T. brassicae* (Canada), *Trichogramma mwanzai*, *T. chilotraeae*, *T. pieridis*, *T. dendrolimi*, *T. hebbalensis*, *T. danaidiphaga*. GenBank Acc. Nos obtained for all the identified species. Molecular characterization using cytochrome oxidase 1 gene (CO1) was also done for the following exotic biocontrol agents *Aphidius ervi*, (KM054518), *Aphidius colemani (*KM054519), *Orius laevigatus* (KM016075), *Phytoseiulus persimilis* (KM035535), *Diglyphus isaea (*KM016074), *Amblyseius swirskii* (KM035534) and *Cryptolaemus montrouzieri* (KM0160730).

vii. Diversity and predator-prey interactions with special reference to predatory anthocorids and mites

New records for India

Orius minutus (Linnaeus 1958) collected from Pasighat, *Physopleurella pessoni* Carayon 1956 and *Rajburicoris stysi* Carpinetro and Dellapé from Palani hills are new records for India.

a. *Xylocoris* complex in India

Xylocoris (*Arrostelus*) *flavipes* was the only species under the genus *Xylocoris* known from India, till recently. Three more *Xylocoris* spp. were recently documented as new records for India, viz., *Xylocoris* (*Proxylocoris*) *afer* (Reuter 1884) collected from dry fruits of *Ficus*, *Lagerstromia; Xylocoris* (*Proxylocoris*) *confusus* Carayon, 1972 and *Xylocoris* (*Arrostelus*) *ampoli* Yamada and Yasunaga 2013 collected from maize ecosystem.

b. Egg characters used for differentiating *Cardiastethus exiguus* Poppius from *Cardiastethus affinis* Poppius

Male genitalia characters are normally used to differentiate between the two *Cardiastethus* spp., *Cardiastethus exiguus* Poppius, 1913 and *Cardiastethus affinis* Poppius, 1909 (predators of coconut black-headed caterpillar). The differences in the structure of the

eggs of the above two species can also be used to differentiate them. The length of the eggs of *C. exiguus* was more than that of *C. affinis* and the surface has a speckled appearance with distinct hexagonal cells in the central region of the operculum, while the eggs of *C. affinis* are smooth with very faint cellular markings on the central region of the operculum.

c. Utilisation of anthocorid predators

i. Evaluation of *Amphiareus constrictus* (Stål, 1860) against brown plant hopper (BPH) infesting paddy

Anthocorid predator *Amphiareus constrictus* was evaluated in cages against BPH on paddy. The adult and nymphal counts in treatment cages were 1.8 and 1.4 respectively after five releases of the predator, compared to 6.3 and 3.3 respectively in the untreated control. Therefore, *A. constrictus* could be a potential predator of BPH.

ii. Infestation by *Aleurothrixus trachoides* (Back) on capsicum and natural predation

The whitefly *Aleurothrixus trachoides* Back was originally described as **(***Aleurotrachelus trachoides* Back (solanum whitefly). *A. trachoides* is reported for the first time in India. The whitefly was primarily found to attack *Duranta* spp. in Bangalore and later widening of host range is observed. Natural predation of the whitefly by the coccinellid *Axinoscymnus puttarudriahi* Kapur and Munshi was observed on capsicum. Highly significant correlation was recorded between the population of the predatory grubs and the eggs, nymphs and pupae of *A. trachoides*.

d. Studies on the new invasive pest *Tuta absoluta* (Meyrick, 1917)

Tuta absoluta infestation was observed to be severe in Karnataka and Tamil Nadu and infestation was observed in all growth stages of tomato plant. The natural enemies, recorded from the infested fields were *Nesidiocoris tenuis* Reuter, *Trichogramma achaeae* Nagaraja and Nagarkatti, *Neochrysocharis formosa* (Westwood), *Habrobracon* sp. and *Goniozuz* sp. Four species of *Trichogramma* were evaluated for their ability to parasitize *T. absoluta* eggs. *T. achaeae, Trichogramma pretiosum* Riley and *Trichogrammatoidea bactrae* Nagaraja could parasitise the eggs of *T. absoluta* and maximum emergence was from eggs parasitized by *T. pretiosum* and *Tr. bactrae.*

e. Parasitism of eggs of banana skipper *Erionota thrax* Linnaeus by *Trichogramma chilonis* Ishii

Trichogramma chilonis Ishii could parasitise 10.5% eggs of *Erionota thrax,* however the parasitoid adults could not emerge from the parasitized eggs.

f. Studies on parasitoids of litchi stink bug *Tessaratoma javanica* Thunberg

Eggs of Eri silkworm (ESM) can be stored in the deep freeze for 2 to 6 days and used for rearing *Anastatus acherontiae* Narayanan *et al.* and *Anastatus bangaloriensis* Mani and Kurian; percent parasitism was 41.4 to 63.3% in the case of the former and 39.3 to 55% parasitism in the latter. Biological parameters of *A. bangaloriensis* were recorded. ESW eggs parasitized by *A. acherontiae* were stored for 7, 15 and 21 days and the per cent adult emergence recorded were 85.7, 72.5 and 63.8 respectively.

g. Charging of *Corcyra* boxes with lower dosage of eggs (0.125cc per box) to improve production efficiency

The fecundity of *C. cephalonica* emerging from boxes charged with a lower dosage of 0.125 cc per box was 467 in comparison to the fecundity of adults emerging from the boxes with higher dosage (0.5 cc per box), recorded as 279. By reducing the dosage, the total utilisation of eggs for charging in one year was 106 cc and the yield recorded was 17.02 cc per box, while with the higher dosage (253 – 377 cc/year) the yield recorded was significantly lower (8.87 to 12 cc per box). A lower dosage of 0.125 cc of *Corcyra* eggs for charging each box, can improve the production efficiency significantly.

h. Mass rearing of *Trichogramma chilonis*

Large cages (3ft x 2ft) can be used for large scale production of Tricho cards. Thirty to forty cards can be exposed to adult Trichogrammatids (emerging from three mother cards) in large cages and parasitism ranging from 79 to 81% could be recorded.

i. Live insect germplasm maintenance and supply

A total of 139 live insect cultures were maintained, in the ICAR-NBAIR live insect repository. About 148 consignments of live insect cultures were supplied and revenue of Rs. 5,50,931 was generated during the period.

viii. Introduction and studies on natural enemies of some new exotic insect pests and weeds

a. Monitoring of papaya mealybug and its natural enemies on papaya and other alternate hosts .

Based on the survey conducted in different parts of Karnataka state and also the feedback from various AICRP (BC) centers, it was observed that the papaya mealybug *Paracoccus marginatus* did not reach pest status in any of the crops like Papaya, Plumeria, Parthenium, Hibiscus, Mulberry, and butter fruit (Avocado). However, very low incidence (< 5%) was recorded on Tapioca in Salem and Dharmapuri areas. It was also recorded in New Delhi in the polyhouse at IARI, and supply of two consignments of 500 number of *Acereophagus papayae* reduced the infestation of the mealybug.

b. Papaya mealybug (PMB) on mulberry

Infestation in mulberry was surveyed in the districts of Maddur, Hassan, Tumkur, Mandya, Chamarajnagar, Ramanagar, Kollegal, Kolar and Chikballapur areas. There was no occurrence of PMB in the surveyed areas. PMB was found associated with *Meconellicoccus hirsutus* at Chamarajnagar and Kunigal, which was also below pest level (<025%). The number of sericulture farmers requesting for supply of parasitoids was negligible in the entire year which indicated the complete suppression of PMB in mulberry.

c. Occurrence of papaya mealybug on papaya, weeds and other host plants in Karnataka

Incidence of PMB was very low in almost all the locations surveyed in Karnataka. Damage score of 1 (1- 5 scale) and below only were observed sporadically in homesteads. Survey in about 41 orchards of papaya in Bangalore, Kanakapura, Mysore, Chamarajanagar, Nelamangala, Devanahalli, Kunigal, Mandya, Kolar, Tumkur road, Kollegal, Maddur and Hassan revealed no incidence of PMB even on a single tree. In the homesteads > 85 % parasitism was by *Acerophagus papayae* and *Pseudleptomastix mexicana* was found in all the places where ever PMB was observed. *Spalgius apius* was also recorded as one of the major factor for reduction of the pest.

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

d. Classical biocontrol of PMB

No incidence of papaya mealybug in Karnataka, Kerala, Andhra Pradesh, Maharashtra and Tamil Nadu was observed. Incidence reported in polyhouse from New Delhi and Gujarat, where the pest was effectively suppressed by *A. papayae* supplied. Very high incidence of hyper parasitoids *Chartocerus sp.* was recorded in Bangalore (up to 15% per sample).

e. Managment of erythrina gall wasp

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.* 7-15% parasitism was observed in the field. The parasitoid *Aprostocetus gala* (a non gall former in *Erythrina*), was always found associated with *Q.erithrinae.*

f. Establishment of *C. connexa* gall fly

The gall fly *Cecidochares connexa,* a biocontrol agent on *Chromolaena* weed, released at different places established upto 15 galls per 5 minutes search in 450 m around the released spot. In Puttur area it has spread around 8 km from the released spot and in Tataguni estate it has spread to the nearby forest area. At GKVK, the gall fly was localised due to the availability of host insects. Parasitsim by*Ormyrus* sp. was upto 7% in GKVK.

g. Host range of invasive Jack Beardsley mealybug (*Pseudococcus jackbeardsleyi* Gimpel and Miller in Karnataka:

Survey for invasive insects in South India revealed the occurrence of *P. jackbeardsleyi* in Tamil Nadu, and Karnataka. It was found associated with PMB on papaya and with Madeira mealybug in hibiscus, *Cordyline terminalis* (Agavaceae), *Defembekia sp.* In the recent survey it was found to be severe on cocoa.

This invasive mealybug was found to be a slow establisher. The local natural enemies like *Cryptolaemus montrouzieri* Mulsant, *Spalgis epius* West Wood and an indeterminate species of gnats have kept the spread of the Jack Beardsley mealybug under check. *Nephus regularis* was found to be a major predator on eggs of *P. jackbeardsleyi.*

h. New invasives /and host extensions

- *Tuta absoluta* recorded in Karnataka, Tamilnadu, and Gujarat. Zoophytophagus plant bug *Nesidiocoris sp*.(Miridae) was recorded associated with the pest.
- Western flower thrips *Frankliniella occidentalis* (Pergande) reported from Bangalore by ZSI.
- Banana skipper *Erionota thrax* (Hespiridae: lepidoptera) has become severe in Kerala, Karnataka, Mizoram, Assam, and other states.
- Bruchid on seeds of *Hibiscus subdariffa* (to be identified)
- *Pseudococcus jackbeardsley* recorded on Cocoa in South canara dist.
- *Phenacoccus madeirensis* recorded on Cashew in Malur area,
- Root mealybugs *Formicococcus polysperes* Williams on Pepper

ix. Biosystematics and diversity of entomogenous nematodes in India

A total 220 soil samples were collected randomly from vegetable, banana, forest land of Andhra Pradesh, Belgaum, Harugeri, Sagar, Sorab, Humcha, Hosanagar, Humchadakatte, Thirthahalli, Devanhalli, GKVK Bangalore, NBAIR research farm Yelahanka, Guduvanahalli, Vijipur, Thottibhavi, Bathalapalli, Kunigal, Goudgiri, Jariwar, Chikadnur, Chickhadaganahalli, Hulase, Kannive, Madihalli, Naikara, Kadaba, Kallahaali, Chanarayapattana, Jakkahanalli and Chintamani in Karnataka, Thenmale from Kerala and Hosur, Manjalgiri, Singiri, Sanamavu, Ooty in Tamil Nadu. Five insect associated nematodes were isolated from these places. One more insect associated nematode, *Oscheius* Sp was isolated from Utthanapalli village of Tamil Nadu.

The soil texture varied in all the locations. Sandy loam, laterite and red soils were found in the locations and the crops grown in these soils in different locations included vegetables (beans, brinjal, cabbage, chilli, cucumber and tomato), cereals maize, fruit crops (mango), plantations (arecanut, coconut) and sugarcane.

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

A dose of 200 IJs/pupae of *Oscheius sp.* on *Bactrocera cucurbitae* resulted in 80% pupal mortality after 48th inculcation.

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

A total of 80 *Bacillus thuringiensis* isolates were purified from soil and insect cadaver samples of Almora region. Forty of these isolates were screened for cry gene diversity using degenerate primers. All of them harboured *cry*1 and *cry*2 genes.

Cloning and expression studies of vip3A gene for broad spectrum activity were carried out. The vip3a gene was amplified using by PCR and the product was sequenced and confirmed.PCR amplicon (~2.3Kb) was successfully cloned into a cloning vector (pUC29) at NdeI andXhoI restriction sites. Sub-Cloning of sequence confirmed vip3a gene in pET21a was again confirmed by PCR amplification**.**

The VIP3A protein was purified from the *pET21a-Vip3a* clone by IPTG induction for 4 and 16 h. and the induced protein collected at 4h exhibited an LC_{50} value of 1.9 µg/ml against *Plutellaxylostella*. Induced protein collected at 16h exhibited an LC_{50} value of 0.423 µg/ml. Bioassay of purified cloned vip3A protein was also studied against *Spodoptera litura*. At 72h the protein collected at 4h of induction with IPTG exhibited an LC_{50} value of 12.35 µg/ml and at 96h the LC_{50} value was 6.87 µg/ml.

Degenerate primers were designed for partial *cry1* gene (277 bp), *cry2* gene (689–701 bp), *cry3* gene (589-604bp), *cry4* gene (439 bp), *cry* 5, 12, 14, 21 genes (474-489 bp), *cry 7-8* gene (420 bp), *cry*9 genes (351-359 bp), *cry*11 genes (305 bp), *vip3* genes (1000 bp), *cyt1* genes (522-525 bp) and *cyt2* genes (469 bp). Degenerate primers were also designed to detect *cry* gene sub types like *cry1Aa, cry3Aa, cry4Aa, cry7Aa, cry8Aa, cry9Aa, cry2Aa, cry11Aa* and *cry14Aa*

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

a. Screening of *Beauveria bassiana* isolates against maize stem borer, *Chilo partellus* (Laboratory Bioassay)

Bioassay studies were conducted with 87 isolates of *B. bassiana* against second instar larvae of *Chilo partellus.* Among the 87 isolates tested, five isolates (Bb-7, 14, 19, 23 and 45) showed significantly higher mortality (86.4.-100%). Among these five isolates, Bb-14, 23 & 45 isolates showed significantly higher mycosis (84.4-97.8%). Dose and time mortality studies at different conidial concentrations (10^4, 10^5, 10^6, 10^7 and 10^8 spores/ml) indicated that Bb-45 showed the lowest LC_{50} (5.02 $x10^4$ conidia ml^{-1}) and LT_{50} (136.25 hr). The LC_{50} of other isolates ranged from $1.11X10^6$ to 4.33 $x10^7$ conidia ml^{-1}.

b. Establishment of *B. bassiana* as endophyte in maize

Pot culture studies with six promising isolates of *B.bassiana* (Bb-5a, 7, 14, 19, 23 & 45) were tested for their ability to establish as endophytes in maize through seed treatment/foliar spray on two susceptible varieties of maize viz., COH(M)10) and Bio9681 obtained from Directorate of Maize Research Hyderabad.

In case of foliar application, colonization of Bb-45 isolate was observed in the leaf tissues up to 60 days after treatment (DAT), whereas Bb-23 isolate colonized the leaf tissues up to 30DAT of the maize variety-COH(M)10 as indicated in plating technique and PCR studies. No colonization of these isolates was observed in stem/root tissues. In untreated control plant tissues, *B. bassiana* was not detected by Plating and PCR methods at 15/30/45/60DAT. No colonization of the six isolates tested in root/stem/leaf of the seed-treated plants was observed till 90DAT. In case of Bio-9681 maize variety, colonization of Bb-19 isolate was observed in stem & root tissues for a period of 30 DAT and in leaf tissues only for 15 DAT. In untreated control plant tissues, no *B. bassiana* colonization was detected by plating and PCR at 15/30/45 DAT.

A field trial was conducted with three isolates of *B. bassiana* (Bb-14, 23 & 45) at NBAIR, Attur farm on a commercial maize hybrid (Nityashree) during December 2014-March 2015. These isolates have been applied by foliar application ($1x10^8$spores/ml)/ crown application (1gm/plant) at 30 days of crop age. In case of foliar application, Bb-14 and Bb-45

isolates showed colonization in stem and leaf tissues for a period of 15 DAT and their colonization was not detected in root tissues. No further colonization of these two isolates was observed in 30 and 45 DAT in root/stem/leaf tissues. In crown application method, Bb-23 and Bb-45 isolates colonized in leaf tissues for a period of 15 DAT and no further colonization was observed at 30/45 DAT.

2.1.2 Indian Agricultural Research Institute New Delhi

1. Ecotoxiclogical studies on Egg Parasitoids, *Trichogramma chilonis* and *Trichogramma japonicum*

The contact toxicity of insecticides *viz*., Chlorantranilprole (18.5% SC) and Sulfoxaflor (21.8% SC) was evaluated against the egg parasitoids *Trichogramma chilonis* Ishii and *Trichogramma japonicum* (Ashmead). The egg parasitoids *T. chilonis* and *T. japonicum* were maintained on eggs of *Corcyra cephalonica* Stainton under laboratory condition. Preliminary tests were carried out to fix the test concentrations that caused 10% to 90% mortality of the parasitoids. IOBC/WPRS working group standardized protocols of toxicity testing (Hassan *et al.*,1998) was followed with slight modification, to evaluate toxicity.

Differential response was observed in the adults of *T. chilonis* and *T. japonicum* for both the insecticides. The LC_{50} value for sulfoxaflor and chlorantranilprole was 0.00146 and 0.00174 mg a.i/l against *T. chilonis* and 0.00242 and 0.00261 mg a.i-L for *T. japonicum* respectively (**Table 2**). Chlorantranilprole (18.5% SC) was found to be less toxic to both the parasitoids. The mean percentage emergence and parasitism was higher in *T. japonicum* against both the insecticides (14.0-89.0%). This insecticide can be better utilised for the management of insect pests.

Table 2: Effect of Sulfoxaflor and Chlorantranilprole on survival of *T.chilonis* and *T.japonicum*

Insecticides	**df**	***T. chilonis* (LC_{50} mg a.i-L)**	**Confidence Interval**	
Sulfoxaflor 21.8% SC	5	0.00146	0.000487	0.00365
Chlorantranilprole 18.5% SC	5	0.00174	0.00058	0.00435
		T. japonicum (LC_{50} mg a.i-L)		
Sulfoxaflor 21.8%SC	5	0.00242	0.00081	0.00605
Chlorantranilprole 18.5% SC	5	0.00261	0.00087	0.006525

2.1.3. Biodiversity of biocontrol agents from various agro ecological zones

i. AAU-Anand

The populations of the biocontrol agents, *viz*., *Trichogramma, Chrysoperla, Cryptolaemus,* Spiders and Entomopathogenic nematodes (EPNs) were collected from different crop ecosystems at Anand, Kheda, Baroda and Ahmedabad districts, during *Kharif* 2014

Sentinel cards with eggs of *Corcyra cephalonica* were placed in Tomato, castor, groundnut and cotton fields to collect *Trichogramma,* while *Chrysopids, Cryptolaemus* and spiders were obtained from five geographic populations (at least 20 each per population). EPNs were obtained from soil samples (250 cc) from root zone. Isolation of antagonistic was also carried out from soil samples collected. Sentinel cards of *C.cephalonica* parasitized by *Trichogramma* were collected after 3 days of placement from the crop ecosystems and cards were observed in the laboratory for emergence of the parasitoid**.** The eggs of host insects were also collected at fortnightly interval from castor (*A. janata*).*Trichogramma chilonis* was the only *Trichogramatid* recorded (**Table- 3**) and the numbers of *Trichogramma* collected were very low during the period (**Table 3**).

Table 3 : Biodiversity of *Trichogramma* around Anand area in different crops

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

Among the predators, *Chrysoperla zastrowisillemi* (Esben-Peterson) was found in all the populations. Similarly the activity of coccinellids and *Cryptolaemus* was studied. No anthocorids were recorded during the period. About 23 spiders were collected from paddy ecosystem and sent to NBAIR, Bengaluru for identification. Soil samples for EPNs collected from different regions showed no EPN infectivity. *Bt* isolates were obtained from 49 soil samples out of the 300 samples collected from six taluks of Ahmedabad districts.

ii. AAU-Jorhat

a. Trichogramma

Sentinel egg cards of Corcyra *cephalonica* were placed in rice, sugarcane, castor , tea and vegetables (okra, brinjal, tomato and cole crops) from July 2014 to January 2015 at Jorhat and Golagha for parasitisation by *Trichogramma* in different geographical areas. The cards were collected after 2 days from the fields and observed in the laboratory for the emergence of *Trichogrammatid* spp.

The different stages of insect pests (egg, larvae, adult) were collected from different crop ecosystems (paddy, sugarcane, papaya, cabbage, chilli, brinjal, tea) and kept in the laboratory for emergence of natural enemies (**Table 4**).

Table 4: Bioagents collected from different crop ecosystem

Crop	Name of Insect	Natural enemies	
		Parasitoids	**Predator**
Paddy	Eggs of *Scirpophaga incertulas*	*Trichogrammatids* spp.(unidentified)	Coccinellids (*Micraspis* sp.) and spiders like *Oxyopes* spp., *Tetragnatha* spp., *Lycosa* spp. were collected from rice ecosystem.
Sugarcane	1.Wooly aphid, *Ceratovacuna lanigera* 2. Larvae of Plassy borer, *Chilo tumidicostalis* 3. Larva of early shoot borer, *Chilo infuscatellus*	- *Cotesia flavipes* *Sturmiopsis inferens* -	*Dipha aphidovora*, *Micromus igorotus*, *Encarsia flavoscutellum* *Crhrysoperla* spp. -
Papaya	Mealybug, *Paracoccus marginatus*	-	Anthocorids (Unidentified) *Spalgius epius*, Chysopids and Spiders (Unindentified).
Cabbage	Cabbage caterpillar, *Pieris brassicae*	*Cotesia* spp.	*Cocinella septempunctata* *C. transversalis*
Hot chilli	*Aphis gossypi*	-	*Cocinella septempunctata* *C.transversalis*
Brinjal	-	-	Predatory mite(Unidentified) *C.transversalis*
Tea	Eggs of *Helopeltis theivora*	*Telenomus* spp.	Spiders, *Oxyopes* spp
Okra	-	-	*Coccinella septempunctata* *C. transversalis*
Potato	-	-	*Micraspis spp.*

b. Other biocontrol agents (*Cryptolaemus*, coccinellids, spiders, anthocorids and antagonistic organisms):

Collection of *Cryptolaemus* sp. in different crops like papaya, sugarcane and in *kharif* as well as *rabi* vegetables during 2014-2015 in Jorhat district. But the natural population of predator, *Cryptolaemus* predator was not found in any of the locations.

Coccinellids collected on different *rabi* vegetables infested by aphids and whiteflies were *Coccinella septempunctata*, *C. transversalis* and *Micraspis* sp.

Twenty five of different spiders collected from different types of habitat such as grasses, moist places, under stones , pebbles, dead leaves, humus, bushes, on the bark and branches of trees, houses and huts were sent to NBAIR, Bangalore for identification. The most dominant spiders collected from rice ecosystem were *Oxyopes* sp. *Tetragnatha* sp. *Lycosa pseudoannulata* and *Argiope catenulata*. No anthocorid predators could be detected from thrips and mite infested crops (chilli, okra, brinjal, tomato and French-bean). An anthocorid predator collected on papaya mealybug was sent to NBAIR for identification.

Soil samples were collected from different vegetables fields of Jorhat was sent to NBAIR, Bangalore for isolation of antagonistic organisms.

iii. PJTSAU- Hyderabad

Survey, collection and diversity analysis of *Trichogramma* and *Chrysoperla* from various agro ecological zones of Telangana & Andhra Pradesh

Bio Control Agents from various crop ecosystems like rice, sunflower, maize, castor, cabbage and chilli, cotton, red gram, sugarcane, sunflower, sorghum, brinjal and bottlegourd were collected as per the standard protocols provided by NBAIR.

Collection of *Trichogramma* from rice, sunflower, maize, castor, cabbage and chilli crops by using sentinel cards showed that the natural parasitization varied among individual crop eco systems. The parasitization ranged from nil in chilli & sunflower to a maximum of 7.9 per cent in castor. Rice crop recorded 6.05 per cent while in maize it was 2.6 per cent and in cabbage it was as low as 0.9 per cent. It is also inferred that the parasitization is found to be marginally more in *Kharif* as compared to *Rabi*. Similar trend was noticed in the abundance of *Chrysoperla* where *Kharif* recorded more predators population than *Rabi*. In *Kharif*, bitter gourd recorded maximum population (9.0) and minimum was recorded in castor (2.0), Brinjal (3.0), cotton (6.0) and cabbage (5.0). *Chrysoperla* population in *Rabi* was maximum (8.0) in red gram while it was least (4.0) in bitter gourd.

iv. KAU-Thrissur

Survey and collection of natural enemies of banana weevils, banana aphid, root mealybug of pepper and entomopathogens

1. Banana pseudo stem weevil - *Odoiporus longicollis* (Oliv.)

A survey was carried out in Thrissur, Ernakulam, Palakkad, Wayand, Kozhikode, Malappuram and Ernakulam districts. Earwigs were collected from the areas where pest incidence was noticed. The earwigs were identified as *Auchenomus hincksi* Ramamurthi (Dermaptera: Labiidae) and were found feeding on eggs of banana pseudo stem weevil.

2. Banana rhizome weevil-*Cosmopolites sordidus* Germ.

Earwigs. *Paralabis dohrni* (Kisby) (Dermaptera: Labiidae), *Charhospania nigriceps* (Kisby) and *Euborellia shabi* Dohrn were collected as predators of the rhizome weevil. These were found predating on the eggs and early instar grubs of the rhizome weevil.

3. Banana aphid *Pentalonia nigronervosa* Coq.

Survey on natural enemies of banana aphid was carried out in Thrissur, Ernakulam and Kozhikode districts. The coccinellids predators collected were *Pseudaspidimerus trinotatus* (Thunberg), *Scymnus pyrocheilus* (Mulsant), *Jaurovia soror* Weise , *Scymnus* sp. *Cheilomenes sexmaculata* (Fab.) and *Sticholitis* sp.

4. Pepper root mealybug: *Formicoccus polysperes* Williams.

Survey was carried out in Wayanad district. The incidence was observed in Ambalavayal and Meenangadi areas. The mealybugs were found occurring in the roots of the nearby weeds also. No natural enemies were noticed during the period.

5. Entomopathogens

Diseased grass hoppers, brown plant hoppers and rice bugs were collected from rice fields. The fungus isolated from rice bug was identified as *Beauveria bassiana* at NBAIR, Bangalore.

6. Collection of insect biocontrol agents from the agro ecosystems

a) Insect pests

All the insects collected from different agro ecosystems of Kerala were sent to NBAIR, Bangalore during September November, 2014 and January, February 2015.

b) Spiders

Spiders collected from rice and vegetable fields were identified by Dr. Sudhikumar, Asst. Professor, Christ College, Irinjalakuda, Thrissur. The spiders identified were *Pardosa pseudoannulata* (Fam: Lycosidae), *Neriene sundaica* (Fam: Linyphidae), *Oedignatha carli* (Fam: Corinnidae), *Althepus* sp. (Fam: Ochyroceratidae), *Callilepis chakanensis* (Fam: Gnaphosidae), *Zelotes* sp. (Fam: Gnaphosidae), *Hippasa agelenoides* (Fam: Lycosidae), *Lycosa tista* (Fam: Lycosidae), *Pardosa sumatrana* (Fam: Lycosidae), *Hippasa holomerae* (Fam: Lycosidae), *Oxyopes javanus* (Fam: Oxyopidae), *Corinnomma comulatum* (Fam: Corinnidae) and *Lutica deccanensis* (Fam: Zodaridae).

v. MPKV- Pune

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

The natural enemies *viz*., parasitoids (*Trichogramma*), predators (*Chrysoperla, Cryptolaemus*) and microorganisms (entomopathogenic nematodes) associated with insect pests of crops were collected from field and horticultural crops around Pune. The collections were identified at NBAIR, Bangalore.

The other 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 mealybug colonies on custard apple, *Acerophagus papayae* N

and S and *Pseudleptomastix mexicana* N. and S. and *Mallada boninensis* Okam and *Spalgis epius* on papaya mealybug.

The parasitism of *Trichogramma* was record in crops like cotton, pigeon pea, 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 zastrowi sillemi* Esb. was recorded in cotton, maize, pigeon pea, French bean, *Rabi* jowar and brinjal while *Mallada boninensis* Okam on cotton, sunflower, French beans, mango and papaya. The *Cryptolaemus* adults were recovered from the pre-released plots of custard apple and papaya. The cadavers of *S. litura* and *H. armigera* infected with *Nomuraea rileyi, Metarhizium anisopliae, Sl*NPV, *Ha*NPV were collected from soybean, potato, pigeon pea and army worm larva infected with NPV in rabi jowar and fungal infected sugarcane woolly aphids are also collected from farmer's fields. The *Icerya* sp. on fan palm was collected from RFRS, Ganeshkhind, Pune which is generally observed in temperate climatic region of Maharashtra.

vi. PAU-Ludhiana

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

The seasonal incidence of sucking as well as lepidopteran pests was recorded on rice variety PR 114 at Punjab Agricultural University, Ludhiana. The crop was kept unsprayed throughout the cropping season. Observations were recorded from 20 randomly selected plants at weekly interval for leaf folder damage, dead hearts (DH), plant hoppers population starting after 30 days of transplanting. The data on number of white ears (WE) were recorded once at crop maturity. The population of predators was recorded on whole plant basis. 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 3.1 larvae per plant. The incidence of damaged leaves due to leaf folder ranged from 0.0 to 5.6 per cent throughout the cropping season. There was no incidence up to 32nd standard week (1st week of August), with highest incidence (5.6%) during 37th standard week (2nd week of September). The overall incidence of stem borers in terms of dead hearts remained low throughout the cropping season and it ranged from 0.00 to 2.16 per cent. The incidence of white ears was 2.39 per cent which was recorded at maturity. There was no incidence of plant hoppers (brown plant hopper and white backed plant hopper) during the season. However, very low population of grass hoppers (0.1-0.2/plant) was recorded.

Among the predators, population of dragonflies, damselflies, coccinellids and spiders were recorded. The population of dragonflies, damselflies and coccinellids varied from 0.0 to 0.1, 0.0 to 1.6 and 0.0 to 0.1 per plant, respectively. The population of spiders was quite high (0.1 to 2.0 spiders/plant) during the season with maximum population (2.0 spiders/plant) during 38th SMW (3rd week of September). Among the species collected from the rice fields of different locations of Ludhiana and Nabha, there were eight and six species of spiders found. All the specimens of these spiders were sent to NBAIR, Bangalore for identification.

Among the parasitoids, 10 species of parasitoids were found associated with stem borer and leaf folder. Three species of egg parasitoids, namely, *T. chilonis, T. japonicum* and *Telenomus* sp were recorded from stem borer only. *Stenobracon nicevillei* was recorded from

stem borer larvae and *Cotesia* sp was recorded from leaf folder larvae, while *Bracon* sp (larval parasitoid) was associated with both stem borer and leaf folder. Among the pupal parasitoids, *Brachymeria* sp, *Tetrastichus* sp and *Xanthopimpla* sp were recorded from the pupae of stem borer whereas *Brachymeria* sp. and *Tetrastichus* sp were recorded from leaf folder.

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

Twenty one soil samples were collected from different areas were processed for isolation of EPF, EPN and bacteria. Entomopathogenic fungi were isolated from soil samples, collected from turmeric, potato, rice (organic), carrot, barseem, wheat, sugarcane and rice fields of Khanna, Pathankot, Bathinda, Ludhiana, Amritsar and Patiala, while one *Bacillus* bacteria was isolated from soil samples collected from cauliflower field of Ludhiana. However, no EPN was isolated from these soil samples. The native isolates were sent to NBAIR, Bengaluru for repository and identification.

vii. 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.

Surveys of different horticultural crops including apple, apricot, plum, pear, peach, cherry, walnut and almonds were conducted in Kashmir valley as well as Kargil from April 2014 to March 2015. Insect pests like San Jose scale, apple woolly aphids, mites, walnut aphids, apple aphids, mealybugs, cherry fruit worms, walnut weevil were collected. Among important natural enemies, aphelinid parasitoids, *Encarsia perniciosi*, *Aphytis proclia*, *Ablerus* sp. and coccinellid predator, *Chilocorous infernalis* were found on San Jose scale exclusively in unmanaged orchards. *Aphelinus mali* was found actively associated with woolly apple aphids, *Eriosoma lanigerum.* Unidentified predatory mites were found with spider mites on apple during July and coccinellid beetles *Harmonia* sp. on Pear Psylla on pear during March' 2015.

viii. TNAU

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

The natural enemies *viz*., *Trichogramma, Chrysoperla, Cryptolaemus,* and parasitoids of serpentine leaf miner, papaya mealybug and scales were collected and sent to NBAIR, Bengaluru for identification and documentation.

ix. YSPUHF

Survey and collection of natural enemies like *Trichogramma, Chrysoperla,* predatory mites, coccinellids, spiders and entomopathogens

Eggs of *Helicoverpa armigera* (from tomato, rose and antirrhinum), *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 placed in these fields for obtaining different species of *Trichogramma.* No *Trichogramma* sp. was collected from any of the cropping system by either of the method.

Chrysoperla zastrowi sillemi was collected on *Microsiphum rosaeformis, Trialeurodes vaporariorum* and *Eriosoma lanigerum* infested on rose, apple and cucumber at vegetative and fruit bearing stages from Solan Nerwa, Kotkhai, Kullu and Rekongpeo during April and July-November, 2014.

Predatory coccinellid and staphyilinid beetles feeding on nymphs and adults of aphids, mites and Sanjose scale of apple were collected during the period. The predators were collected from radish, apple and wild flora, cabbage, cauliflower, mustard, cucurbits, capsicum, tomato, okra, brinjal, carnation, Unimus, chrysanthemum, stone fruits, ashwagandha and weeds, from Kalpa, Sangla valley, Kullu valley, Nerwa and Solan. The predators included *Hippodamia varigieta, Coccinella septempunctata, Cheilomenes sexmaculata,Coccinella luteopicta, Pryscibrumus uropygialis, Pharoscymnus, Propylea lutiopustulata, Oenopiakirbyi, O. sauzeti, O. sexareata, Coelophora bisselata, Chilocorus infernalis, Scymnus posticalis*, *Stethorus aptus* and *Oligota sp.*

Predatory mites viz., *Euseius eucalypti, Ambluseius herbicolus, Amblyseius largoensis, Agistimus fleschneri, Amblyseius* sp., *Typhlodromus* sp., *Euseius alstoniae, Euseius finlandicus, Euseius prasadi, Typhlodromus mori, Typhlodromu shimalayensi* and *Neoseiulus paspalivorus* were collected from olan, Sunder Nagar, Kotkhai, Nerwa and Nakaura during March – December 2014. The mites were collected from brinjal, tomato, cucumber, rose, plum, apple, apricot and toona crops at vegetative stage.

Syrphid flies, *Episyrphus balteatus, Metasyrphus confrator, M. corolae, Eupeodes frequens, Melanostoma univitatum, Betasyrphus serarius, Sphaerophoria indiana, Ischiodon scutellaris* and *Scaeva pyrastri* were collected from Solan, Nerwa, Kullu and Rekongpeo, during March – November 2014 on different flowering plants.

Apart from biocontrol agents, insect pests such as adults and larvae of Apple root borer, *Dorysthenes hugelii* and thrips (*Thrips tabaci, T palmi, T. flavus, T flavidulus, T. carthami, T. alatus, T simplex, T hawaiiensis, T. florum, Taeniothrips sp, Scirtothrips dorsalis, Haplothrips tenuipennis, H. clarisetis, Francliniella sulphurea* and *Aeolothrips* sp.) were collected from Solan, Nerwa, Kotkhai, Jubbal, Rohru, Kullu and Rekongpeo.

Other insect pests like, *Zygogramma bicolorata,* Eriophyid mite, unidentified predatory midge, *Orius* sp. and *Anthocoris* sp. were also collected from parthenium, tomato and peach. *Annastatus* sp and *Trisolchus* sp was collected from the eggs of *Nezara viridula. Brachyscapus galactopus* and an unidentified pteromalid were collected as hyperpasitoids of *Cotesia glomerata. Diadegma* sp., *Cotesia vestalis* and *Diadromus collaris* were collected as parasitoids of *Plutella xylostella. Campoletis chloridae* was recorded as parasitoid of *Helicoverpa armigera. Oligota* sp collected from mites feeding on rose, apple and ashwagandha.

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 given by NBAIR, Bangalore, however, 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 and sent to NBAIR, Bangalore.

x. MPUAT-Udaipur

Bio diversity of parasitoids and predators.

The egg parasitoid *Trichogramma chilonis* was released as Trichocard during inundative release's against brinjal fruit and shoot borer, *Leucinodes orbonalis*. Study was undertaken to assess the fate of these cards in field after their release. It was found that the parasitoid migrated to nearby field of mint crop (as pesticides were sprayed on brinjal was given). Egg stage of *Helicoverpa* was observed and were parasitized by *Trichogramma* sp. The neuropteran predator , *Chrysoperla carnea* and coccinellids, *Menochilus, Brumus* and *Coccinella* species were found to control sucking pests of cowpea, okra and lucerne. Migration of predator from pulses to okra and lucerne field was observed.

xi. UAS-Raichur

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

Trichogramma spp were collected in cotton ecosystem. The associated parasitiods of tomato leafminer or pinworm, *Tuta absoluta* (Meyrick) were collected and sent to NBAIR, Bengaluru for identification.

xii. CISH- Lucknow

1. Survey, Collection, Identification and Mass Culturing of Trichogrammatids and Entomopathogenic Nematodes from Mango Ecosystem in Uttar Pradesh for evaluation against mango leaf webber (*Orthaga euadrusalis*)

1. Parasitoids and Predators:

A random survey was conducted in mango growing belts of Lucknow. About 20 different natural enemies have been collected from the mango ecosystem, which includes both parasitoids and predators. Predators mainly comprised of Coccinellids, Syrphids and spiders, whereas parasitoids belonged to three major families *viz*., Ichnuemoniids, Braconids and Chalcidids. Detailed identification of the collected natural enemies is yet to be ascertained. Five adult specimens of thread lace wing (Neuroptera: Nemopteridae: Crocinae) was collected specimens which measured 6-8 mm in length and had all the characteristic features of subfamily Crocinae. Hind wings modified as thread like structure and are four

times the length of body and 2.5 times as long as fore wings. The collected specimens closely resembled with genus *Croce* spp. This is the first report of Crocinae from Northern India.

2. Entomopathogenic nematodes:

A roving survey was conducted in Sitapur district of Uttar Pradesh for the isolation of entomopathogenic nematodes (EPN). Twenty soil samples were collected underneath mango trees. They were baited with last instar *Galleria mellonella* larvae and observed for mortality for a week. After which, they were placed on modified white traps for the extraction of EPNs. Out of the baited 20 samples, only one sample tested positive for the presence of EPN and it has been identified as *Heterorhabditis* sp. and designated as *Heterorhabditis* sp. (CISH EPN-05). Bioefficacy of *Steinernem abbasi* against mango leaf webber, *Orthaga euadrusalis* done under laboratory conditions. The results revealed that *S. abbasi* could cause cent percent mortality of *O. euadrusalis* at both 50 and 500 IJs/ml concentration within 48 hours. Further, infective juvenile emerged from all EPN infected cadavers, thus ascertaining its ability to recycle in the environment.

xiii. DRR- Hyderabad

Survey and collection of natural enemies of rice pests

Survey was made in different rice fields of Pattambi (Kerala) to record the pests and natural enemies. Samples were collected from sweep net and light trap. A total of 117 species belonging to 8 orders, 63 families of insects and spiders were collected and identified. Of which 45 were pest species, 44 predators, 24 parasitoids and 4 were in neutral or saprophagous group. Parasitoids collected belonged to families Sciomyzidae, Tachinidae (Diptera), braconidae, chalcidae, eulophidae, ichneumonidae, platygastridae, pteromalidae, trichogrammatidae and scelionidae. The predators belonged to families coccinellidae, hydrophilidae, reduvidae, libellulidae and tettigonidae.

Three stem borer species were observed in the field, the yellow stem borer, *Scirpophaga incertulus*, the white stem borer, *Scirpophaga fusciflua* and the pink stem borer, *Sesamia inferens*. Three speices of egg parasitoids were observed on eggs of *S. incertulus* and *S. fusciflua viz*., *Tetrastichus schoenobii*, *Trichogramma japonicum* and *Telenomus* spp. The yellow hairy caterpillar *Psalis pennatula* was found in large numbers and 10 per cent larvae were parasitized by *Brachymeria* sp.

In addition, natural enemies of rice pests have also been surveyed and collected from Chinsurah and Kalimpong in West Bengal. The red long winged planthopper, *Diostrombus polites* was abundant in research farm at UBKVV, Kalimpong. The dark headed borer, *Chilo polychrysus* and the grass web worm, *Herpetogramma* sp. were also recorded. The skipper *Parnara guttata* was prevalent with 75 per cent parasitisation by *Apanteles* sp. At DRR research farm, fortnightly collection by weep nets yielded 140 species of natural enemies of which 75 were predators and 65 parasitoids.

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

AAU-Anand

Periodic surveys were carried out for the occurrence alien invasives viz., *Brontispa longissima, Aleurodicus dugesii*, *Phenacoccus manihoti* and *Phenacoccus madeirens,* but none of the invasive pest was recorded.

AAU-Joharat

Periodic surveys were carried out during August, 2014 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 other invasive pests (*Brontisma longissima, Aleurodicus dugesii, Phenacoccus manihoti,* and *Phenacoccus madeirensis*) were recorded.

KAU-Thrissur

Following mealybugs were collected on different crops and were identified at NBAIR, Bangalore.

Mealybug	**Host plants**
Planococcus lilacinus	Mango, coffee, brinjal and cotton
Ferissia virgata	Coffee
Icerya sp.	Papaya, tapioca and anona
Paracoccus marginatus	Papaya and Pineapple
Ferissia virgata	Pineapple
Rastrococcus invadens	Tapioca
Crissicoccus hirsutus	Heliconia
Phenacoccus solenopsis	Mango

No invasive pests have been noticed.

MPKV-Pune

Field crops, horticultural crops, ornamental crops and plantations were surveyed in western Maharashtra covering five agro-ecological zones and orchards in Pune region to record the occurrence of pests species *viz.*, coconut leaf beetle *Brontispa longissima,* spiralling white fly *Aleurodicus duress,* mealybugs *Phenacoccus manihoti, Paracoccus marginatus, Phenacoccus madeirensis, Pseudococcus jackbeardsleyi* and other alien invasive pests. The stages of *Pseudococcus jackbeardsleyi* and *Paracoccus marginatus* W. and G. were collected for record of natural enemies and also the infested fruits and vegetables collected from city market yards were investigated for alien invasion of pest species and natural enemies.

Amongst the target pests, *Pseudococcus jackbeardsleyi* was recorded on custard apple in the vicinity of Pune. Papaya mealybug, *Paracoccus marginatus* W. and G. was observed in the papaya orchards on main host papaya in western Maharashtra along with the encrypted parasitoid, *Acerophagus papayae* N. and S., *Pseudleptomastix mexicana* N. and S.

and *Spalgis epius*, and nine coccinellids, anthocorids, chrysalides, syrphids and spiders in Pune region. The identification was done at NBAIR, Bangalore and IARI, New Delhi and the predators recorded were *Bergius maindroni* Grouvelle, *Hyperaspis maindroni* Sicard, *Cybocephalus* sp. and *Phrynocaria perrotteti.*

The spiralling white fly (*Aleurodicus dispersus*) was also recorded on papaya, cotton, pomegranate, acalypha, wild almond and mulberry.

A new parasitoid *Aprostocetes* nr. *purpureus* was reported for the first time from PMB colonies in Rahuri region.

New species of leaf miner on tomato, the South American tomato pin worm, *Tuta absoluta* Meyrick 1917 (Lepidoptera : Gelechiidae) was observed for the first time infesting tomato crop in Maharashtra during the month of February, 2015. The pest cause the loss to the extent of 40 to 90 per cent.

TNAU-Coimbatore

Survey was conducted in different districts of Tamil Nadu for the occurrence of the invasive insect pests viz., *Brontispa longissima*, *Aleurodicus dugesii*, *Phenacoccus manihoti*, *Paracococcus marginatus* and *Phenacoccus madeirensis*. Survey for invasive pests of fruits and vegetables in the market yards was also done.

During the study period**,** the papaya mealybug *Paracoccus marginatus* and Jack Beardsley mealybug *Pseudococcus jackbeardsleyi* were recorded and all the other alien invasives were not recorded.

YSPUHF- Solan

Different vegetable and fruit ecosystems at Solan, Sundernagar, Mandi, Kullu, Manali, Kotkhai, Nerwa, Rajgarh, Rekongpeo, Kalpaand and Sarahan were surveyed for the collection of pests like, *Aleyrodicus digessi, Phenacoccus manihoti, Paracoccus marginatus* and *Phenacoccus madeirensis* but none of the aforesaid pests were encountered in any of the ecosystem.

2.2. Biological Control of plant diseases using antagonistic organisms (GBPUAT, CAU, PAU, AAU-A)

1. Field evaluation of promising *Trichoderma/ Pseudomonas* isolates for the management of soil-borne diseases of Rice, Wheat and Chickpea (GBPUAT-Panthnagar)

i. Rice (variety Pant Dhan-4)

Date of nursery: June 3, 2014
Date of transplanting: June28, 2014
Date of harvesting: November 12, 2014

A field experiment was conducted at Crop Research Centre, Pantnagar to evaluate 21 potential *Trichoderma* isolates on rice (var. Pant Dhan - 14) to improve crop vigour and reduce impact of soil borne diseases of rice. The *Trichoderma* isolates were applied as seed bio-priming treatment (10g/kg seed), seedling root dip treatment (10g/L) and as two foliar sprays (10 g/L), 1st at 60 DAS and 2nd at the time of panicle formation. The experiment was laid in a randomized block design in three replications with a plot size of 2x3m.

Seedling biomass & length: In nursery beds, TCMS 43, Th 17, Th 3, TCMS 9, TCMS 2 & TCMS 36 showed significantly maximum fresh weight (6.0-6.7g/seedling) compared to the fresh weight in control (3.3g/seedling). Significantly, maximum seedling length (52.2-54.6 cm) was observed with TCMS 43, TRSRc 8, Th-3, Th-17, TCMS 9, Th 89, TCMS 4 & Th 82 isolates compared to the length in control (46.1cm). (**Table 5**).

Occurrence of diseases: During the cropping season, sheath blight (*Rhizoctonia solani*) was the major problem, however occurrence of brown spot (*Drechslera oryzae*) was also observed. Significantly minimum disease incidence of sheath blight was observed in TCMS 43 (26.2%) & TCMS 15 (37.6%) as compared to the incidence in check (67.8%). Significantly minimum sheath blight disease severity (34.7-45.8) was recorded in Th-75, Th-3 Th-82, TCMS 9 and TCMS 15 with 24.9-43.1% reduction of disease severity as compared to the check (61.0). Significantly minimum brown spot disease severity (1.6-3.6) was recorded in TCMS 9, TCMS 43, Th-69, Th-56, Th 75 TCMS 36 and TCMS 65 with 55-80% reduction of disease severity as compared to check (8.0). Occurrence of bacterial blight (*Xanthomonas compestris* pv. o*ryzae*) was very low. Sheath rot (*Sclerotium rolfsii*) disease incidence was not observed (**Table 6)**.

Plant growth and Yield: Among various *Trichoderma* isolates tested, significantly maximum number of tillers/plant was observed in TCMS 75 (10.9 tillers/plant), followed by Th-14 (10.7 tillers/plant) TCMS 43 (10.7 tillers/plant) and TCMS 36 (10.6 tillers/plant), as compared to control (9.1 tillers/plant). However, significantly maximum plant height was observed in Th-56 (95.5 cm) followed by TCMS 4 (95.0 cm) and TRSRc 4 (94.0 cm) as compared to control (86.0 cm) (**Table 7)**. Significantly maximum yield was obtained with TCMS 43 (57.8 q/ha) followed by TCMS 9 (54.6 q/ha), TCMS 36 (53.4 q/ha) and Th-14 (53.4q/ha) as compared to control (44.3 q/ha) (**Table 7**).

Of all the 21 *Trichoderma* isolates, TCMS 43, TCMS 9, TCMS 36 and Th-14 were found to be better in improving plant health, reducing diseases and increasing yield.

Table 5: Efficacy of promising *Trichoderma* isolates on the growth of rice seedlings (var. Pant Dhan-4) in the nursery

***Trichoderma* isolate**	**Fresh weight (g/seedling)**	**Length (cm)**
TCMS 2 (*T. asperellum*)	6.3	46.5
TCMS 4 (*T. asperellum*)	4.8	52.4
TCMS 5 (*T. koningii*)	5.7	49.3
TCMS 14a (*T. asperellum*)	5.4	49.3
TCMS 14b (*T. koningii*)	5.1	49.0
TCMS 15 ((*T. asperellum*)	5.7	49.8
TCMS 16 (*T. harzianum*)	3.0	47.4
TCMS 36 (*T. asperellum*)	6.0	51.1
TCMS 43 (*T. harzianum*)	6.7	54.6
TCMS 9 (*Hypocrea lixii*)	6.3	53.3
TCMS 65 (*T. harzianum*)	4.8	50.7
Th 56 (*Trichoderma* sp.*)*	5.2	50.5
Th 69 (*Trichoderma* sp.*)*	4.5	47.2
Th 75 (*Trichoderma* sp.*)*	4.2	44.5
Th 82 (*Trichoderma* sp.*)*	5.1	52.2
Th 89 (*Trichoderma* sp.*)*	5.7	53.3
Th 14 (*T. harzianum*)	1.8	50.5
Th 3 (*Trichoderma* sp.*)*	6.6	54.3
Th 17 (*Trichoderma* sp.*)*	6.7	53.4
TRSRc 4 (*T. asperellum)*	4.5	49.2
TRSRc 8 (*T. asperellum)*	5.4	54.4
Control	3.3	46.1
CD (0.05)	0.9	2.37
CV (%)	10.8	2.85

Data average of 10 seedlings

Table 6: Efficacy of promising *Trichoderma* isolates against sheath blight and brown spot diseases of rice (variety Pant Dhan-4)

***Trichoderma* isolate**	**Sheath blight**			**Brown spot**	
	Disease incidence (%)	**Disease severity (%)**	**Disease reduction (%)**	**Disease severity (%)**	**Disease reduction (%)**
TCMS 2	38.5 (38.34)	54.3 (35.2)	10.9	5.0 (12.7)	37.5
TCMS 4	52.8 (46.63)	50.9 (48.1)	16.5	7.3 (15.5)	8.7
TCMS 5	41.0 (39.89)	55.8 (47.4)	8.5	7.3 (15.5)	8.7
CMS 14a	41.2 (39.8)	57.4 (49.3)	5.9	4.6 (12.3)	42.5
TCMS 14b	43.2 (41.0)	52.1 (48.4)	14.5	4.3 (11.9)	46.2
TCMS 15	37.4 (37.6)	45.8 (41.1)	24.9	4.3 (11.9)	46.2
TCMS 16	50.0 (44.9)	60.8 (50.5)	0.3	4.3 (11.7)	46.2
TCMS 36	59.7 (50.6)	60.4 (50.3)	0.9	3.3 (10.3)	58.7
TCMS 43	26.2 (30.6)	57.6 (49.4)	5.5	2.3 (8.5)	71.2
TCMS 9	42.0 (40.3)	44.2 (48.2)	27.5	1.6 (7.1)	80.0
TCMS 65	51.9 (46.1)	50.8 (43.8)	16.7	3.6 (10.5)	55.0

Th 56	46.5 (42.9)	55.2 (46.4)	9.5	3.0 (9.9)	62.5
Th 69	52.3 (46.3)	57.7 (50.4)	5.4	2.3 (8.5)	71.2
Th 75	43.7 (41.3)	34.7 (36.2)	43.1	3.0 (9.5)	62.5
Th 82	51.8 (46.0)	35.3 (39.2)	42.1	5.6 (13.7)	30.0
Th 89	56.3 (48.6)	52.3 (45.5)	14.2	5.6 (13.7)	30.0
Th 14	44.6 (41.8)	50.5 (42.4)	17.2	5.0 (12.9)	37.5
Th 3	48.4 (44.0)	35.0 (40.0)	42.6	5.0 (12.9)	37.5
Th 17	52.0 (46.1)	51.0 (44.9)	16.3	5.6 (13.7)	30.0
TRSRc 4	48.4 (44.0)	54.8 (49.6)	10.1	5.6 (13.7)	30.0
TRSRc 8	59.9 (50.7)	55.6 (47.0)	8.8	5.6 (13.7)	30.0
Control	67.8 (55.4)	61.0 (50.6)	-	8.0 (16.3)	-
CD (0.05)	14.4 (8.4)	13.8 (12.1)		2.3 (3.5)	-
CV (%)	18.2 (11.6)	15.8 (15.9)		30.4 (17.4)	-

Values in parentheses are angular transformed values.

Table 7: Efficacy of promising *Trichoderma* isolates on plant growth and yield of rice (variety Pant Dhan 4)

***Trichoderma* isolate**	**Plant vigour**		**Yield**		
	Plant height	**Tiller/hill (90DAT)**	**Yield/plot (6 m^2)**	**Yield/ha**	**Yield increase**
	(cm)	**(no.)**	**(kg)**	**(q)**	**(%)**
TCMS 2	93.4	9.7	3.2	49.9	12.6
TCMS 4	95.0	9.4	2.9	49.8	12.3
TCMS 5	93.2	9.8	2.8	47.1	6.3
TCMS 14a	93.7	10.2	3.0	49.9	12.7
TCMS 14b	93.9	9.3	2.7	46.3	4.5
TCMS 15	92.7	9.1	3.0	50.1	13.1
TCMS 16	91.8	9.8	3.1	51.8	16.9
TCMS 36	90.9	10.6	3.2	53.4	20.6
TCMS 43	87.0	9.9	3.4	57.8	30.4
TCMS 9	89.6	9.5	3.2	54.6	23.3
TCMS 65	86.0	10.7	3.1	52.6	18.7
Th 56	95.5	9.8	3.1	52.9	19.5
Th 69	90.2	9.3	3.1	52.3	18.0
Th 75	89.4	10.9	3.0	49.9	12.7
Th 82	88.3	10.1	3.1	52.4	18.4
Th 89	90.	9.3	3.1	51.6	16.5
Th 14	92.0	10.2	3.2	53.4	20.6
Th 3	88.6	10.2	3.1	52.9	19.5
Th 17	93.1	10.4	3.0	51.1	15.4
TRSRc 4	94.0	10.7	2.9	49.1	10.8
TRSRc 8	93.8	9.9	3.1	52.6	18.7
Control	92.2	9.1	2.6	44.3	-
CD(0.05)	1.5	8.2	0.1	-	-
CV (%)	9.5	5.4	3.6	-	-

ii. Wheat (Variety UP 2338)

A field experiment was conducted at Crop Research Centre, Pantnagar during *Rabi* 2014-15 to evaluate the efficacy of potential *Trichoderma/Pseudomonas* isolates, along with bio-products (chitosan @ 500 ppm & cow urine (10%) for crop health and yield of wheat (variety UP 2338). The experiment was laid in a randomized block design in three replications with a plot size of 3x2 m.

Sowing time: Dec. 2, 2014

Methods of application:

a. Soil application

Trichoderma: 30 g *Trichoderma* colonized sorghum seeds/ plot
Pseudomonas: 30 ml culture broth mixed in one kg soil/plot

b. Seed treatment

10 g or 10 ml of bioagents culture per kg seed
Carbendazim (1g/kg seed)-Standard Check

c. Foliar spray: Three foliar sprays @10g or 10 ml of bio-agent culture per lit of water.1st spray at 45 DAS with bioagents alone; 2nd spray at 60 DAS with Bioagents + chitosan (500 ppm) and 3rdspray at 75 DAS with bioagents+ cow urine (10%) as disease pressure of yellow and brown rust was quite high. Three foliar sprays 1st with carbendazim, 2nd& 3rd with propiconazole @ 0.1% as above (standard check).

Occurrence of diseases: During the crop season, no soil borne disease problem was observed. However, among foliar diseases the disease pressure of yellow rust and brown rust disease was high. Significantly minimum disease severity of yellow rust (46.3-57.2) was observed followed by TCMS 16 (46.3), TCMS 14a (51.3), Psf 173 (53.0), TCMS 5 (53.3) and TCMS 65 (54.6), Psf 28 and TRS Wh 8 (56.0) and these isolates were on par with propiconazole fungicidal treatment (46.0). Un-treated control has recorded disease severity of 71.0. With regard to brown rust disease, significantly minimum disease severity was recorded with Propiconazole (42.0) followed by TCMS 16 (48.6), TCMS 65 (50.3), Psf 3 (51.0) and TCMS 14a (51.3) and were at par with each other but significantly different from control (60.3) (**Table 8**). Off all the isolates **TCMS 16 and TCMS 65 in combination with chitosan (500ppm) and cow urine (10%)** were found better in reducing yellow and brown rust of wheat as compared to other isolates**.**

***Trichoderma* populations in rhizosphere and rhizoplane of wheat:** Significantly maximum population of *Trichoderma* in rhizosphere was observed in Th-14 (13.6x10^{3}CFU/g) at 45 DAS, followed by TCMS 2 (11.3x10^3 CFU/g) and Th- 82 (10.6x10^3 CFU/g) as compared to control (2.06x10^3 CFU/g). Significant maximum population of *Trichoderma* on rhizoplane was found at 45 DAS in TCMS 5 (12.3x10^{3}CFU/g) followed by Th-14 (10.6x10^3 CFU/g) and TCMS 4 (7.6x10^3 CFU/g) as compared to control (1x10^3 CFU/g) (**Table 9**). Yield data will be recorded during 2ndweek of April.

Table 8: Efficacy of promising *Trichoderma/Pseudomonas* isolates against yellow and brown rust of wheat

Treatment	Yellow rust		Brown rust	
	Disease severity (%)	**Disease reduction (%)**	**Disease severity (%)**	**Disease reduction (%)**
TCMS 2	63.0 (52.5)	11.2	56.3 (48.6)	6.6
TCMS 4	68.3 (55.9)	3.7	58.6 (50.0)	2.7
TCMS 5	53.3 (48.1)	24.9	52.0 (46.1)	13.8
TCMS 14a	51.3 (45.7)	27.7	51.3 (45.7)	14.9
TCMS 14b	63.6 (52.9)	10.3	58.3 (49.8)	3.3
TCMS 15	70.6 (57.2)	0.4	60.3 (50.9)	0.0
TCMS 16	46.3 (42.8)	34.7	48.6 (44.2)	19.3
TCMS 36	60.0 (50.7)	15.4	58.6 (49.9)	2.7
TCMS 43	69.3 (56.4)	2.3	54.6 (47.7)	9.3
TCMS 9	70.0 (56.8)	1.4	56.0 (48.4)	7.1
TCMS 65	54.6 (47.6)	23.0	50.3 (45.1)	16.5
Th 56	63.6 (53.0)	10.3	59.0 (50.2)	2.2
Th 69	60.3 (50.9)	15.0	59.3 (50.4)	1.6
Th 75	65.6 (54.2)	7.5	52.0 (46.1)	13.8
Th 82	67.3 (55.2)	5.1	56.6 (48.8)	6.0
Th 89	62.6 (52.4)	11.7	60.0 (50.8)	0.5
Th 14	59.3 (50.4)	16.4	59.3 (50.4)	1.6
Th 3	63.6 (52.9)	10.3	54.0 (47.2)	10.4
Th 17	70.6 (57.2)	0.4	59.0 (50.1)	2.2
TRSWh 8	56.0 (48.4)	21.1	52.6 (46.5)	12.6
TRPWh 4	69.3 (56.4)	2.3	58.6 (50.0)	2.7
Psf 3	70.6 (57.7)	0.4	51.0 (45.5)	15.4
Psf 28	56.0 (48.4)	21.1	58.3 (49.8)	3.3
Psf 173	53.0 (46.7)	25.3	53.3 (46.9)	11.6
Propiconazole	46.0 (42.6)	35.2	42.0 (40.3)	30.3
Control	71.0 (57.5)	-	60.3 (51.0)	-
CD (0.05)	11.2 (6.8)		9.6 (5.5)	
CV (%)	11.1 (8.0)		10.5 (7.0)	

Table 9: Population of *Trichoderma* isolates in rhizosphere and rhizoplane of wheat

***Trichoderma* isolate**	**cfu at 45 DAS**	
	Rhizosphere ($x10^3$ cfu/g)	**Rhizoplane ($x10^3$ cfu/g)**
TCMS-2	11.33	5.00
TCMS-4	6.00	7.67
TCMS-5	10.67	12.33
TCMS-14a	8.33	1.67
TCMS-14b	7.33	4.33
TCMS-15	1.33	1.00
TCMS-16	1.67	2.67
TCMS-36	5.00	1.67
TCMS-43	7.67	7.67
TCMS-9	2.00	1.67
TCMS-65	2.33	3.33
Th-56	6.33	1.67
Th-69	7.00	3.00
Th-75	10.33	4.33
Th-82	10.67	5.33
Th-89	3.33	2.00
Th-14	13.67	10.67
Th-3	3.67	1.67
Th-17	2.33	1.33
TRSWh 8	9.00	2.33
TRPWh 4	1.33	1.67
Control	2.00	1.00
CD (0.05)	1.12	0.90
CV (%)	11.30	14.4

iii. Chickpea (variety PG-186)

A field experiment was conducted at Crop Research Centre, GBPUA&T, Pantnagar during Rabi 2014-15 to evaluate the efficacy of bioagents for crop health and yield of chickpea. The experiment was laid in a randomized block design in three replications with a plot size of 3x2 m

Sowing date: Dec. 2, 2014

Methods of application:

Soil application

Trichoderma: 30 g *Trichoderma* colonized sorghum seeds/ plot

Pseudomonas: 30 ml culture broth mixed in one kg soil/plot

Seed treatment

10 g or 10 ml of bioagents culture per kg seed

Carbendazim (1g/kg seed)-Standard Check

Foliar spray
Three foliar sprays @10g or ml of bio-agent culture per lit of water were given at 45, 75 and 90 DAS. Three foliar sprays of carbendazim @ 0.1% as above were given as fungicidal check).

Occurrence of diseases: During the crop season seedling and young plant mortality was observed. However, occurrence of foliar diseases was not observed. At 30DAS, significantly minimum seed mortality was observed with TRPCh-4 (13.1%) followed by Th-75 (14.0%), and Psf-3 (14.4%), TCMS- 65 (17.5%), Th-17 (17.9%), TRPCh-3 (18.1%), TCMS-36 (18.6%) that were at par with each other but significantly differed from other isolates, including carbendazim (29.7%) and control (32.5%) (**Table 10).** At 30-90 DAS, significantly minimum plant mortality was observed with TCMS-9 (3.3%), followed by Th-75 (4.2%), Th-69 (5.1%) Th-3 (5.3%) and TRPCh-4 (5.6%) as compared to carbendazim (6.8%) and control (8.0%). Of all the isolates, **Th-75, Th-3, TRPCh-4** were found very promising in reducing seed as well plant mortality in field**.**

***Trichoderma* population in rhizosphere and rhizoplane**: Significantly maximum population of *Trichoderma* in rhizosphere was recorded with Th-75 & Th-14 ($10.3x10^3$ CFU/g) followed by TRPCh-3 ($7.6 x10^3$ CFU/g) and TCMS- 4 ($6.0 x10^3$ CFU/g) as compared to control ($1x10^3$ CFU/g) at 45 DAS. Significantly maximum population of *Trichoderma* on rhizoplane at 45 DAS was observed in TCMS-65 ($20.6 x10^3$ CFU/g) followed by TCMS-2 ($18.3 x10^3$ CFU/g), Th-75 ($17.6 x10^3$ CFU/ g) and Th-14 ($17x10^3$ CFU/g) as compared to control ($1x10^3$ CFU/g) (**Table 11**). Final mortality of the plants will be recorded one week before harvesting and yield data will be recorded after harvesting the crop i.e. during 1st week of May.

Table 10: Efficacy of promising *Trichoderma/Pseudomonas* isolates against seed and seedling mortality of chickpea in field

Treatment	Plant Stand (30 DAS)	Germination (30 DAS)	Seed mortality	Plant stand (45 DAS)	Plant stand (90 DAS)	Plant mortality (30-90DAS)
	No.	(%)	(%)	No.	No.	(%)
TCMS-2	165.6	69.0 (56.4)	30.9	161.6	148.3	10.4
TCMS-4	175.0	72.9 (58.6)	27.0	170.0	161.6	7.6
TCMS-5	189.6	79.0 (62.8)	20.9	184.3	174.0	7.9
TCMS 14a	192.0	80.0 (63.4)	20.0	185.3	175.3	8.6
TCMS-14b	190.3	79.3 (62.9)	20.6	185.6	178.0	6.4
TCMS-15	188.6	78.6 (62.5)	21.4	186.6	178.3	5.4
TCMS-16	177.3	73.2 (58.8)	26.1	173.6	164.3	7.3
TCMS-36	195.3	81.3 (64.5)	18.6	191.6	180.0	7.8
TCMS-43	178.6	74.4 (59.6)	25.5	174.0	165.0	7.6
TCMS-9	162.0	67.5 (55.6)	32.5	159.6	156.6	3.3
TCMS-65	198.0	82.5 (65.2)	17.5	193.0	183.0	7.5
Th-56	185.3	77.2 (61.9)	22.7	181.0	175.0	5.5
Th-69	185.6	77.3 (61.6)	22.6	178.6	176.0	5.1
Th-75	206.3	85.9 (68.2)	14.0	200.3	197.6	4.2
Th-82	176.0	73.3 (58.9)	26.6	170.0	160.0	9.0

Th-89	177.3	73.8 (59.2)	26.1	173.3	165.0	6.9
Th-14	190.3	79.3 (62.9)	20.6	186.3	176.6	7.1
Th-3	168.3	70.1 (56.9)	29.8	165.0	159.3	5.3
Th-17	197.0	82.0 (65.0)	17.9	192.3	185.0	6.0
TRPCh-3	196.3	81.8 (64.7)	18.1	192.3	182.3	7.1
TRPCh-4	208.3	86.8 (70.0)	13.1	205.3	196.6	5.6
Psf-3	205.3	85.5 (67.7)	14.4	200.3	191.6	6.6
Psf-28	186.6	77.7 (61.9)	22.2	182.3	168.3	9.8
Psf-173	192.3	80.1 (63.5)	19.8	187.6	172.6	10.5
Carbendazim	168.6	70.2 (56.9)	29.7	165.0	157.0	6.8
Control	162.0	61.9 (51.9)	32.5	157.6	149.0	8.0
CD(0.05)	13.4	10.0 (7.0)		12.4	10.8	
CV (%)	4.4	7.9 (6.9)		4.2	3.8	

240 counted seeds were sown per plot

Table 11: Population of promising *Trichoderma* isolates in rhizosphere and rhizoplane of chickpea (PG-186)

***Trichoderma* isolate**	**Rhizosphere (x10^3 CFU/g) 45 DAS**	**Rhizoplane (x10^3 CFU/g) 45 DAS**
TCMS-2	2.33	18.33
TCMS-4	6.00	2.0
TCMS-5	2.33	2.00
TCMS-14a	1.0	2.33
TCMS-14b	1.6	1.33
TCMS-15	2.33	5.67
TCMS-16	1.00	13.00
TCMS-36	3.33	4.67
TCMS-43	7.67	12.67
TCMS-9	3.33	19.67
TCMS-65	2.33	20.67
Th-56	6.33	4.33
Th-69	3.33	5.67
Th-75	10.33	17.67
Th-82	1.33	11.00
Th-89	3.33	5.67
Th-14	10.33	17.00
Th-3	4.00	4.67
Th-17	2.33	5.67
TRPCh-3	7.67	4.67
TRPCh-4	1.33	9.00
Control	1	1.00
CD (0.05)	0.9	1.0
CV (%)	14.3	7.0

2. Efficacy of promising copper tolerant *Trichoderma/Pseudomonas* isolates against seed and seedling mortality of chickpea in Glasshouse (GBPUAT)

A pot experiment was conducted in glasshouse at Department of Plant Pathology during Dec. 2014 to Feb. 2015 to evaluate the efficacy of bio-agents against seed and seedling mortality of chickpea caused by *Fusarium oxysporum* f.sp. *ciceri*. Bioagents were applied as soil inoculation in pots having 2 kg sterilized soil @ 5g/ kg soil one week prior to sowing, as seed treatment @ 10 g/kg seeds whereas fungicide was applied as seed treatment @ 1g/ kg seed. The sorghum grains colonized with *F. oxysporum* (5g/kg soil) was inoculated in each pot (2kg capacity) along with bioagents i.e. one week prior to sowing.

Occurrence of seed and seedling mortality: Maximum seed germination was recorded in Th-89,Th-14,TCMS-43& TRPCh-3 (95.2%) followed by TCMS-75 and Th-17(90.4%) as compared to control (47.6%). At 7DAS, significantly, minimum seedling mortality was observed with Th-14, Th- 89, TCMS-43 and TRPCh- 3 (4.47%) followed by Th-17 & TCMS-75 (9.5%) and TCMS 4 & TRPCh- 4 (14.2%) and were at par with each other but significantly different from other isolates and control (42.8%). Minimum seedling mortality at 30 DAS was observed with Th-75 (5.21%) followed by TRPCh-4 & carbendazim (12.3%), Th-3 &TCMS 69 (13.4%) as compared to control (50.0%) (**Table 12**).

Table 12: Efficacy of promising *Trichoderma/Pseudomonas* isolates against seed and seedling mortality of chickpea in glasshouse

Treatment	Plant Stand (7 DAS)	Germination (%)	Seed mortality (%)	Plant stand (30 DAS)	Seedling mortality (%)
TCMS-2	5.3	76.1 (60.9)	23.8	2.00	62.4
TCMS-4	6.0	85.7 (68.1)	14.2	2.67	55.5
TCMS-5	6.00	85.7 (67.9)	14.2	4.00	33.3
TCMS-14a	4.0	57.1 (49.1)	42.8	2.00	50.0
TCMS-14b	5.6	80.9 (64.2)	19.0	2.67	52.9
TCMS-15	4.0	57.1 (49.1)	42.8	1.33	66.7
TCMS-16	5.0	85.7 (67.8)	28.5	4.00	20.0
TCMS-36	5.3	76.1 (60.8)	23.8	3.00	43.7
TCMS-43	6.67	95.2 (79.7)	4.7	3.33	50.0
TCMS-9	6.0	80.9 (64.2)	14.2	5.00	16.6
TCMS-65	4.0	57.1 (49.1)	42.8	1.67	58.2
Th-56	4.0	57.1 (49.1)	42.8	2.33	41.7
Th-69	5.0	80.9 (64..4)	28.5	4.33	13.4
Th-75	6.3	90.4 (72.0)	9.5	6.00	5.21
Th-82	5.0	71.4 (57.6)	28.5	3.67	26.6
Th-89	6.6	95.2 (79.7)	4.7	4.33	35.0
Th-14	6.6	95.2 (77.7)	4.7	4.67	29.9
Th-3	5.0	71.4 (57.7)	28.5	4.33	13.4
Th-17	6.33	90.4 (72.4)	9.5	4.67	26.2
TRPCh-3	6.67	95.2 (77.7)	4.7	4.33	35.0
TRPCh-4	5.3	76.1 (60.7)	23.8	4.67	12.3
Psf-3	4.67	66.6 (54.7)	33.2	2.33	50.1
Psf-28	5.00	71.4 (57.7)	28.5	3.67	26.6
Psf-173	4.67	66.6 (54.7)	33.2	3.00	35.7

Carbendazim	5.33	71.4 (57.7)	23.8	4.67	12.3
Control	4.00	47.6 (43.6)	42.8	2.00	50.0
CD (0.05)	1.12	7.4 (6.67)	-	1.3	-
CV (%)	12.9	5.9 (6.54)	-	24.29	-

7 seeds were sown in each pot

3. Biological control of chilli anthracnose disease (GBPUAT, PAU & AAU-A)

AAU-A

Location: Agronomy farm, BACA, Anand Agricultural University, Anand.
Year of commencement: 2014-15
Season and year : *Kharif* 2014
Experimental details :

Treatments : 5
Replication : 03
Design : Randomized Block Design (RBD)
variety : GVC-111
Spacing : 60X60 cm
Plot size : Gross : 5.4 X 4.2 cm
Net : 2.7 X 3.4 cm

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^{-})
T3:*Trichoderma harzianum*(Th-3) Seed treatment, Seedling dip & Foliar spray($2x10^8$cfu g-1)
T-4: Recommended fungicidal control Seed treatment, Seedling dip & Foliar spray
T-5: Untreated control

Method of application

a) Seed treatment: The seeds were treated with formulations before sowing into nursery. Mix 10ml or grams of concentrated formulation with 100ml with water. This can be 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 raised in plastic trays or nursery beds was 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 10g or 10ml per litre of water using a high volume sprayer with a spray fluid volume of 500L 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.

Observations recorded

a) Disease intensity –Total numbers of healthy and diseased fruits in each plant was counted and percent fruit rot incidence in each replication will be calculated using the formula.

$$\text{Fruit rot incidence (\%)} = \frac{\text{Number of infected fruits per replication}}{\text{Total number of fruits per replication}} x\ 100$$

b) Yield (q/ha)
c) Weather parameters like, Temp., RH, Rain fall
d) Data statistically analyzed (ANOVA, CD)

Results: During 2014-15, the minimum disease intensity (10.27 %) was observed in fungicide treated plot (Carbendazim 50% WP @ 0.05%) with 85.72 per cent disease control over untreated control **(Table 13).** The next best treatment in order of merit was with *Pichia guilliermondii* (Y12) with 14.25 per cent DI and 72.78 per cent disease control over untreated check. *Hanseniaspora uvarum* (Y73) showed 18.62 % DI with 59.81% disease control. *Trichoderma harzianum* (Th-3) gave 54.24 per cent disease control and was on par with *Hanseniaspora uvarum* (Y73). Untreated control showed 28.16 % DI. Significantly higher green chilli fruit yield was recorded in fungicide treated plots (105 q/ha) as compared to untreated check (70.0 q/ha). The other best treatment with respect of yield was *Pichia guilliermondii* (Y12) (95.00 q/ha). However, T_2 and T_3 recorded 85.0 and 80.00 q/ha and were superior to untreated control yield (70.0 q/ha).

Table 13. Biological control of chilli anthracnose disease

Sr. No.	Treatment	Per cent Disease incidence (%)					Disease control over untreated (%)	Yield (q/ha)
		At 1st spray	At 2nd spray	At 3rd spray	At 4th spray	Pooled		
T_1	*Pichia guilliermondii* (Y12) Seed treatment, Seedling dip & Foliar spray ($2x10^8$cfu ml-1)	16.91 (8.46)	14.74 (6.47)	13.29 (5.28)	12.05 (4.36)	14.25 (6.06)	72.78	95.00
T_2	*Hanseniaspora uvarum* (Y73) Seed treatment, Seedling dip & Foliar spray ($2x10^8$cfuml-1)	20.07 (11.78)	18.79 (10.37)	16.94 (8.49)	15.84 (7.45)	17.91 (9.46)	59.81	85.00
T_3	*Trichoderma harzianum* (Th-3) Seed treatment, Seedling dip & Foliar spray ($2x10^8$cfu g-1)	21.14 (13.01)	19.26 (10.88)	17.58 (9.12)	16.47 (8.04)	18.62 (10.19)	54.24	80.00
T_4	Recommended fungicide	12.74 (4.86)	11.01 (3.65)	9.26 (2.59)	8.08 (1.98)	10.27 (3.18)	85.72	105.00

	(Carbendazim) control Seed treatment, Seedling dip & Foliar spray							
T_5	Untreated control	24.37 (17.03)	27.69 (21.59)	29.43 (24.14)	31.11 (26.70)	28.16 (22.27)	-	70.00
S.Em.		1.31	1.10	1.11	0.84	1.09	-	2.59
C. D. (5 %).		4.28	3.58	3.60	2.75	3.36	-	8.43
C.V. %		11.94	10.39	11.00	8.73	10.70	-	5.14

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

GBPUAT

A field experiment was conducted at Vegetable Research Centre, GBPUA&T, Pantnagar during Rabi 2015 to evaluate the efficacy of different biological control agents viz. *Trichoderma harzianum* (Th-3). *Pichia guilliermondii* (Y-12) and *Hanseniaspora uvarum* (Y-73) received from NBAII, Bangalore and Th-14, SBTT-2 (*Trichoderma harzianum* from Pantnagar and Hyderabad), Carbendazim (standard check) against Chilli anthracnose. The experiment was laid in a randomized block design in three replications with a plot size of 3x2m.

Date of nursery: Jan. 21, 2015

Transplanting: March, 20, 2015 (delayed as germination and growth was delayed due to low temp. and continuous rainfall).

Method of application

i. Seed treatment: Soaked the seeds in suspension for 5 min. then dried under shade before sowing in nursery beds
a**.** Bioagents @ 10g or 10 ml formulation in 100 ml water/kg seed
b. carbendazim @ 1g/kg seed

ii. Seedling dip treatment: Dipped the seedlings in bioagent suspension as above for 5 min.

iii. Foliar sprays: 10g or 10 ml formulation per litre of water. 1st spray at initiation of fruiting, then 3-4 sprays at one month intervals or until the last harvest.

Observations: In nursery, seedling growth was very good in Y 12 and Y 73 as compared to other treatments. The observations on occurrence of anthracnose disease on leaves and green and mature fruits shall be recorded as per technical programme.

PAU

The experiment was conducted on chilli 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 @ 750g) and untreated control with four replications

each. The chilli seedlings were transplanted as per recommended agronomic practice. The chilly seedlings were transplanted with spacing of 2x3 feet (between P-P = 2 feet and between R-R = 3 feet). Three foliar sprays of antagonist were given at the rate of 10 g or ml per litre water using a high volume sprayer with spray fluid volume of 500 L /ha .The first spray was given at initiation of fruit ripening and the later three sprays were given at monthly interval until the last harvest. The percent fruit rot incidence was recorded. Yield and weather parameters like temperature, RH and rainfall was also recorded. There was no disease incidence recorded during months of May and June. During July, the disease incidence was low and varied from 6.19 to 8.75 percent and was non-significant in different treatments. During August lowest per cent fruit rot (6.39%) was recorded in chilly plot treated with chemical control (Indofil M 45@ 750g in 250 ml water/acre) which was at par with plots treated with *T. harzianum* and *P. guilliermondii* which recorded 7.34 and 8.46 per cent respectively **(Table 14).** During September again lowest fruit rot incidence (6.78%) was observed in Indofil M-45 treated plot and was at par with *T. harzianum* treated plot (9.30%). *P. guilliermondii* and *H. uvarum* treated plots showed 12.31 & 13.47% incidence respectively. However, all the treatments were significantly better than untreated control (19.87%). Statistically significant differences in the yield were not observed in the different treatments including control. The weather parameters during 2014-2015 are given in (**Table 15).** So, it was concluded that lowest per cent fruit rot (6.78%) was recorded in chemical control and was at par with *Trichoderma harzanium* treatment. The experiment is again being conducted at Entomological Research Farm, Punjab Agricultural University Ludhiana on Chilli. The chilli seedlings have been transplanted in March 2015.

Table 14. Evaluation of fungal antagonist against chilli anthracnose disease

Treatments	**Per cent fruit rot incidence**				**Yield (q/acre)**
	1/7/14	**19/7/14**	**22/8/14**	**2/9/14**	
Pichia guilliermondii	5.78	8.28	8.46[a]	12.31[cb]	67.35
Hanseniaspora uvarum	6.27	6.19	11.88[b]	13.47[cd]	68.75
Trichoderma harzianum	5.33	7.13	7.34[a]	9.30[ba]	71.50
Indofil M 45@ 750g in 250 ml water/acre	4.98	5.96	6.39[a]	6.78[a]	72.25
Untreated control	5.58	8.75	13.10[b]	19.87[d]	67.45
CV (%)	32.56	29.35	10.87	11.65	20.75

Table 15. Record of weather parameters

Month	**Temperature (^{0} C)**	**Relative humidity (%)**	**Rainfall (mm)**
May	37.5	44.5	34
June	40.6	43.5	28.6
July	35.5	66.5	30.2
August	34.4	71.5	104.6
September	32.2	78.5	74

4. Management of bacterial wilt a local 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 (12.6X 6.6 m) and crop was transplanted at (60x60 cm) spacing. A total of eight treatments including an untreated control *viz*., intercropping with marigold (one row after every nine rows of brinjal and border), mustard oil cakes @ 5q per ha as soil amendments, seedlings root dip with CHF*Pf*-1 (a formulation prepared with a local strain of *Pseudomonas fluorescens* $2x10^8$ cfu per gm) @25g / liter of water dipping for 30 minutes before transplanting, soil drenching with CHF*Pf*-1 @ 2.5g / 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 M/S Hindustan Antibiotics Ltd, Pune, India @ 400ppm at 20 DAT, soil drenching of bleaching powder of M/S 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 was calculated based on the survived plants, average number and weight of fruit/plant. All the treatments showed a significantly lower wilt incidence than the untreated control **(Table 16).** The lowest incidence of bacterial wilt with 16.00% wilted plant was recorded in the plot treated with seedling root dip + soil drenching with CHF*Pf*-1 and it was on par with soil drenching with CHF*Pf*-1 (20.00% wilted plants). Soil drenching with CHF*Pf*-1 was comparable with soil drenching with streptocycline (19.66% wilted plants), soil application with mustard oil cake (20.80% wilted plants), soil drenching with bleaching powder (20.92% wilted plants) and seedling root dip with CHF*Pf*-1 (22.98% wilted plants). Intercropping with marigold recorded a 41.80% wilted plants. The highest average plant height (68.00cm), highest average number of fruit per plant (9.20 fruits) and average fruit weight (113.46g/fruit) was recorded in seedling root dip + soil drenching with CHF*Pf*-1 and it was closely followed by soil drenching with CHF*Pf*-1 with 66.46cm plant height, 8.66 fruits and 110.30g/fruit, in terms of average plant height, average number of fruits/ plant and average weight of fruit, respectively. The highest yield per ha was recorded in treatment with seedling root dip + soil drenching with CHF*Pf*-1 (242.60q/ha) and it was comparable with soil drenching with CHF*Pf*-1 (221.80q/ha). The yield of soil application with mustard oil cake (190.00q/ha), soil drenching with CHF*Pf*-1 (184.70q/ha), soil drenching with bleaching powder (180.70q/ha) and soil drenching with streptocycline (177.67q/ha) were on par with each other. The intercropping with marigold recorded only 95.90q/ha.

Table 16. 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)	41.80 (40.28)^{c}	62.90^{e}	6.86^{d}	107.00^{de}	95.90^{e}
Mustard oil cakes @5q/ha as soil amendment	20.80 (27.13)^{b}	67.00^{abc}	8.02^{b}	109.62^{bcd}	190.00^{b}
Soil drenching with *P. fluorescens* @2.5g/litre of water	20.00 (26.57)^{ab}	67.64^{ab}	8.76^{a}	112.30^{ab}	221.8^{a}
Seedlings root dip with *P. fluorescens* @25g/ litre of water	22.98 (28.64)^{b}	66.46^{bc}	8.06^{b}	110.30^{bc}	184.70^{b}
Seedlings root dip with *P. fluorescens* @25g/ litre of water + soil drenching with *P. fluorescens* @2.5g/litre of water at 20 DAT	16.00 (23.58)^{a}	68.00^{a}	9.20^{a}	113.46^{a}	242.60^{a}
Streptomycin (streptomycin sulphate 90 % + tetracycline hydrochloride 10%) @200ppm soil drenching at 20 DAT	19.66 (26.32)^{b}	65.40^{cde}	7.52^{bcd}	108.41^{cde}	177.5^{b}
Bleaching powder @ 5g/litre of water soil drenching at 20 DAT	20.92 (27.22)^{b}	66.08^{cd}	7.82^{bc}	108.20^{cde}	180.70^{b}
Untreated control	59.88 (50.70)^{d}	64.80^{de}	7.29^{cd}	109.5^{e}	84.90^{c}
SE(m)±	0.17	0.1	0.36	1.24	9.96
CD at (P=0.05%)	0.51	0.49	1.09	2.93	23.03
CV (%)	0.95	0.52	3.83	1.32	7.83

*Figures in parentheses are angular transformed values.

2.3. Biological Suppression of Sugarcane Pests

1. Monitoring of sugarcane woolly aphid incidence and impact assessment of natural enemies on its bio suppression (MPKV, PJTSAU, TNAU)

MPKV -Pune

The incidence of sugarcane woolly aphid (SWA) and occurrence of its natural enemies (*Encarsia flavoscutellum, Dipha aphidivora, Micromus igorotus*, syrphid and 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 2014 to February, 2015. The pest incidence was recorded in shade along riverside and canal areas. The SWA incidence was recorded along with natural enemies of SWA in fields. The villages *viz.*, Kasarsai, Tathwade, Punawale, Ravet, Jambh, Talegaon, Nerhe, Dattawadi and Marunji in Mulshi Tahsil, and Babulgaon, Padasthal, Bhavaninagar, Shelgaon in Inadapur Tahsil, Pandare, Malegaon and Nirawagaj in Baramati Tahsil in Pune district, Padegaon in Phaltan Tahsil, Umbraj and Bhavaninagar in Karad Tahsil, Nele, Kidgaon, Dhavadashi and Kalambe, Tahsil in Satara district, Akluj, Malinagar, Teburni, Pandharpur in Solapur district were surveyed. The predators were recorded. *Micromus igorotus* was recorded in July to November and *Dipha aphidivora* recorded from October to February. Low incidence of SWA is also noticed on research farm, College of Agriculture, Pune along with predator *Micromus igorotus* and *Dipha aphidivora*. *Encarsia flavoscutellum* was observed in Solapur, Pune and Satara district of western Maharashtra.

In this year, the incidence of SWA has slightly decreased in Pune and Solapur district as compared to last year. The natural enemies occurred immediately after the incidence of SWA. The average pest incidence and intensity were 1.27 per cent and 1.35, respectively. The natural enemies recorded in the SWA infested fields were mainly predators like, *Dipha aphidivora* (0.8-2.7 larvae/leaf), *Micromus igorotus* (1.1-5.8 grubs/leaf), syrphid, *Eupeodes confrator* (0.4-0.8 larvae/leaf) and spider (0.1-0.3 /leaf) during July to December, 2014. (**Table 17**). The parasitoid, *Encarsia flavoscutellum* distributed and established well in sugarcane fields and suppressed the SWA incidence in Solapur, Pune and Satara districts.

Table 17: Effect of natural enemies on incidence of sugarcane woolly aphids in Maharashtra

Districts surveyed	SWA incidence (%)	Pest intensity rating (1-6)	Natural enemies/leaf				Spiders
			D. aphidivora	*M. igorotus*	*E. flavosc-utellum*	*E. confrator*	
Pune	1.8	1.6	1.2	4.7	8.5	0.8	0.2
Satara	2.0	1.8	1.8	4.2	14.0	0.6	0.3
Sangli	1.1	1.2	1.3	2.4	11.0	0.4	0.2
Kolhapur	1.0	1.1	2.7	3.0	4.1	0.1	0.2
Ahmednagar	0.8	1.1	0.8	1.4	2.6	0.3	0.1
Solapur	3.2	2.7	1.9	5.8	33.6	1.0	0.3
Jalgaon	0.8	1.1	1.0	1.2	1.4	0.4	0.2
Dhule	0.6	1.1	0.9	1.1	1.2	0.6	0.1
Nandurbar	0.9	1.1	1.0	1.8	2.4	0.5	0.2
Nashik	0.5	1.1	1.3	1.8	0.8	0.4	0.1
Average Range	1.27 0.5 - 3.2	1.35 1.1-2.7	1.29 0.8-2.7	2.74 1.1–5.8	7.14 1.2-33.6	1.02 0.4- 0.8	0.2 0.1-0.3

PJTSAU- Hyderabad

District Agriculture Advisory and Transfer of Technology Centres (DAATTCs) were involved. Regular surveys in sugarcane growing areas of the state in collaboration with DAATTC have indicated only scanty presence of Sugarcane woolly aphid (SWA) in 2014-15. As per the reports, SWA populations are rarely noticed in very few patches of sugarcane belt of A.P. Sporadic Incidence was noticed in Chittoor and adjoining areas of southern Andhra Pradesh.

TNAU- Coimbatore

The sugarcane woolly aphid incidence and occurrence of natural enemies (*Dipha aphidivora*, *Micromus igorotus*, and *Encarsia flavoscutellum*.) were recorded from seven districts of Tamil Nadu.

Monitoring of sugarcane woolly aphid incidence was carried out from July 2014 to February 2015 from seven major sugarcane growing districts of Tamil Nadu *viz.*, Coimbatore, Erode, Tiruppur Karur, Cuddalore, Villupuram and Vellore.The incidence of SWA, pest intensity rating and natural enemies population on leaf at five spots and five clumps/ spot were recorded at monthly intervals during crop growth period.

In all the seven districts surveyed, the incidence of sugarcane woolly aphid was noted from November 2014 at low intensity which recorded a grade of 0-2 (**Table 18 and 19**). The SWA was noted in patches and the occurrence of *Dipha aphidivora*, *Micromus igorotus* and *Encarsia flavoscutellum* were also observed (**Table 18**) along with the population of SWA. In general, incidence of SWA was noted from November 2014 (0.0 -10.2 SWA /2.5sq.cm). The population escalated from January 2015 and the maximum population was recorded up to 14.2 SWA/2.5 sq.cm leaf area during February 2015 in Tiruppur district followed by Erode district (12.6 SWA/2.5 sq. cm).

Table 18: Mean incidence of Sugarcane Woolly Aphid and its natural enemies in different zones of Tamil Nadu

Districts surveyed	November 2014				December 2014				January 2015				February 2015			
	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	3.8	0.0	1.6	0.8	0.0	0.0	0.0	0.0	10.4	0.3	0.0	1.3	12.6	1.0	3.0	2.6
Tiruppur	10.2	1.0	1.3	2.5	0.0	0.0	0.0	0.0	6.3	0.0	0.0	1.7	14.2	0.5	4.0	3.5
Coimbatore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.2	1.8	0.0	0.0	0.2
Karur	4.2	0.0	2.3	2.1	0.0	0.0	0.0	0.0	5.2	0.2	0.0	0.7	9.8	1.2	2.4	3.2
Cudalore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6	0.0	0.0	1.2	8.3	1.0	2.0	1.8
Villupuram	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	0.6	4.7	0.6	1.5	1.2
Vellore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.3	0.0	1.3	6.4	0.8	1.8	2.0

Table 19: Mean incidence of Sugarcane Woolly Aphid (Intensity rating) in different zones of Tamil Nadu

Districts surveyed	July 2014		August 2014		September 2014		October 2014		November 2014		December 2014		January 2015		February 2015	
	% 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	4.2	1.0	0.0	0.0	6.4	1.0	10.8	2.0
Tiruppur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	1.0	0.0	0.0	9.2	1.0	12.5	2.0
Coimbatore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7	1.0	0.0	0.0	4.5	1.0	2.4	1.0
Karur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	1.0	0.0	0.0	6.0	1.0	7.8	1.0
Cuddalore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	1.0	0.0	0.0	3.4	1.0	6.2	1.0
Villupuram	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	1.0	0.0	0.0	2.6	1.0	4.8	1.0
Vellore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7	1.0	0.0	0.0	3.1	1.0	5.7	1.0

2.4. Cotton

1. Monitoring biodiversity and out breaks for invasive mealybugs on cotton (MPKV, PAU, PJTSAU, TNAU, UAS-R)

MPKV-Pune

Cotton seeds (var. Jai, Bollgard II) were sown on 25th July 2014 at 90 x 60 cm spacing in 40 x 40 m plot on the research farm of Agril. Entomology Section, College of Agriculture, Pune. All the recommended crop management practices except pesticide application were followed to maintain healthy crop growth. The incidence of cotton mealybug, *Phenacoccus solenopsis* Tinsley and occurrence of natural enemies were monitored at fortnightly interval from the day of germination.

The recording of mealybug incidence was carried out in cotton from 1st fortnight of August 2014 till January, 2015 in the experimental plot. However, the mealybug was not observed on cotton till January, 2015. The natural enemies generally present in cotton ecosystem were predatory coccinellids, *Coccinella*, *Menochilus* and *Scymnus*, chrysalides, *Brumoides* and spiders.

During the survey in farmers fields very less infestation of mealybug was noticed in the months of November, December, 2014. The parasitism of *A. bambawalei* was found on cotton, parthenium, marigold and *Hibiscus*. The cotton mealybug on *Hibiscus* was effectively controlled by *A. bambawalei.*

PAU-Ludhiana

Regular surveys were conducted to collect mealybugs and its natural enemies from different hosts from Ludhiana and major cotton growing areas (Bathinda and Abohar) of Punjab. During the survey, only one mealybug species, *Phenacoccus solenopsis* was recorded on cotton and other hosts. The incidence of mealybug was observed at isolated places on cotton, sponge gourd, okra, *Hibiscus* and other weed host and there was no major outbreak of the pest. However, coccinellid predators such as *Coccinella. sexmaculata, C. septempunctata* and *Brumus. suturalis,* and green lace wing, *Chrysoperla zastrowi sillemi* were noticed feeding on mealybug and their population varied from 0.2 to 3.4 predators per plant. The overall parasitization by parasitoids under field conditions varied from 42-73 per cent. 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 bambawalei* and hyperparasitoid *Promuscidea unfasciativentris* emerged from the infested samples (**Table 20**). The samples of parasitoids have been sent to NBAIR, Bangalore for identification.

Out of these, *A. bambawalei* was predominant species (75.7 %) followed by *P. unfasciativentris* (24.3%). The emergence of females of *Aenasius* was more (61.7 %) as compared to males (38.3 %) and the ratio of male to female was 1: 1.61.

Table 20: Relative abundance of parasitoid and hyperparasitoid emerged from mealybug during 2014

Date	Location	Host	*Aenasius bambawalei*		*Promuscidea unfasciativentris*
			♂	♀	
24.6.14	Abohar	Sponge gourd	0	1	-
9.7.14	Ludhiana	Hibiscus	2	4	2
23.7.14	Abohar	Cotton	8	8	1
8.8.14	Bathinda	Cotton	15	24	13
13.8.14	Abohar	Cotton & carrot grass	30	57	30
21.8.14	Ludhiana	Okra	3	4	1
28.8.14	Bathinda	Cotton & carrot grass	13	18	12
13.9.14	Ludhiana	Hibiscus	3	3	2
28.9.14	Ludhiana	Okra	1	2	2
Total (%)			**75 (38.3%)**	**121 (61.3%)**	**-**
			196 (75.7%)		**63 (24.3%)**

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PJTSAU-Hyderabad

Survey for incidence of mealybugs on cotton and collection of their natural enemies:

Fortnightly surveys were conducted in orchards/fields for mealybug incidence. Infested plant parts were brought back to the laboratory and held under caged conditions for emergence of natural enemies. Alternate host plants, if any, were also recorded. Specimens of mealybugs and natural enemies collected were preserved for identification. Crop wise records were maintained for extent of damage by the mealybug, level of natural enemies present, etc. were also maintained (**Table 21**).

Table 21: Incidence of mealybugs in cotton growing areas of *Telangana*

Date of sampling	No. of plants with mealybugs (top 5 cm of shoot from 50 plants)		
	Maconellicoccus hirsutus	***Phenococcus solenopsis***	***Paracoccus marginatus***
9.10 2014	3	43	7
12.11 2014	3	39	3
4.12.2014	1	46	4
Mean	**4.67**	**42.67**	**2.33**

Three types of mealybugs, *viz*., cotton mealybug, papaya mealybug and grape mealybug were noticed on *Bt* cotton. Among them, cotton mealybug, *Phenacoccus solenopsis* was found to be predominant with nearly 85.33 per cent incidence. There was only marginal presence of 9.33 per cent papaya mealybug, *Paracoccus marginatus* and meager presence of 4.67 per cent of grape mealybug, *Maconellicoccus hirsutus*. Mirid bugs were noticed, however, indicating least level of incidence.

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 22**) on cotton and other alternate host plants observed. *Phenacoccus solenapsis* and *Ferrisia virgata* were the predominant species recorded at high level 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 22: Cotton mealybug and other sucking pests and their natural enemies

Sl. No.	Species of sucking pests	Host Plants	Natural enemies recorded
1	*Maconellicoccus hirsutus*	Cotton, bhendi, grapevine, guava, hibiscus, mulberry	*Scymnus coccivora* (Coleoptera: Coccinellidae) *Cryptolaemus montrouzieri* (Coleoptera: Coccinellidae) *Mallada* sp (Neuroptera: Chrysopidae) *Spalgis epius* (Lycaenidae: Lepidoptera)
2	*Phenacoccus solenapsis*	cotton, sunflower, bhendi, and parthenium, *Hibiscus*	*Cryptolaemus montrouzieri* (Mulsant) (Coleoptera: Coccinellidae) *Coccinella septumpunctata* (Coleoptera: Coccinellidae) *Chrysoperla zastrowi sillemi* Esben- Peterson (Neuroptera: Chrysopidae) *Spalgis epius* (Lycaenidae: Lepidoptera)
3	*Ferrisia virgata*	Cotton, tapioca, custard apple, guava, papaya	*Scymnus coccivora* Ayyar (Coleoptera: Coccinellidae) *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae) *Menochilus sexmaculatus* (Fabricius) (Coleoptera: Coccinellidae) *Mallada* sp (Neuroptera: Chrysopidae)
4	*Nipaecoccus viridis*	Cotton, mango, gooseberry, tamarind, jack,	*Scymnus coccivora* Ayyar (Coleoptera: Coccinellidae), *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae) *Menochilus sexmaculatus* (Fabricius) (Coleoptera: Coccinellidae) *Coccinella transversalis* (Coleoptera: Coccinellidae)**5**
5	*Paracoccus marginatus*	Cotton, papaya, tapioca, *Jatropha curcas*, mulberry, bhendi, sunflower, *Hibiscus*, marigold, teak and *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)

6.	*Amrasca devastans*	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
10	*Mirid*	Cotton, bhendi	-

UAS, Raichur

To monitor the activity of cotton mealybug, a cotton hybrid, RCH-668 BG-II was grown in an area of 500 m^2 under unprotected situation. 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 results indicated that the activity of mealybug appeared during second fortnight of August and continued till the harvest of the crop. The peak activity was noticed during January month with an average population of 191.69 crawlers per 10 cm shoot length. The peak activity of coccinellids (0.31/plant) was noticed during December month while the spiders and *Chrysoperla* activity was high during September month (**Table 23**).

The predominant parasitoid associated with mealybug was *Aenasius bambawalei* (12.30%) followed by *Anagyrus dactylopii* (3.01%), *Promuscidea unfasciativentris* (2.66%), *Hamalotylus eytelweinii* (2.43%) and *Prochiloneurus pulchellus* (1.68%)

Table 23: Population dynamics of mealybugs, predators and parasitoids on cotton (RCH-668 BG-II) under irrigated ecosystem

Months	ISW Week	Number of mealybugs per 10 cm apical shoot length	Predators per plant			Parasitoids (% Emergence)				
			Coccinellids	*Chrysoperla*	Spiders	*Aenasius bambawalei*	*Promuscidea unfasciativentris*	*Hamalotylus eytelweinii*	*Prochiloneurus pulchellus*	*Anagyrus dactylopii*
Aug 20-26	34	0.54	0.04	0.06	0.26	2.77	1.04	1.04	0.00	1.04
Sep 10-16	37	0.23	0.03	0.15	0.33	3.46	1.35	1.25	0.00	2.08
Sep 24-30	39	0.64	0.01	0.12	0.26	3.46	0.00	1.46	1.04	1.35
Oct 8-14	41	1.27	0.12	0.04	0.17	3.46	2.77	1.38	0.69	1.73
Oct 22-28	43	3.40	0.05	0.26	0.12	4.50	3.46	0.69	1.38	2.77
Nov 5-11	45	12.81	0.02	0.02	0.25	5.20	2.08	1.04	1.04	3.12
Nov 19-25	47	29.38	0.15	0.07	0.16	6.93	2.77	1.73	1.04	3.12
Dec 3-9	49	47.24	0.16	0.05	0.26	9.36	3.46	2.77	1.73	3.12
Dec 17-23	51	85.42	0.31	0.12	0.23	10.05	3.81	4.16	3.12	5.54
Jan1-7	1	112.46	0.02	0.00	0.04	10.40	4.85	4.16	3.81	4.85
Jan 15-21	3	191.69	0.05	0.00	0.02	25.65	6.58	5.89	4.16	6.58
Jan 29-4	5	127.55	0.02	0.00	0.00	36.05	3.81	4.16	3.81	5.42
Feb 12-18	7	113.24	0.06	0.00	0.00	31.18	2.44	3.12	1.78	3.24
Feb 26-4	9	72.38	0.04	0.00	0.00	23.14	2.05	2.96	1.24	2.14
Mar 12-18	11	43.12	0.02	0.00	0.00	18.38	1.46	2.02	1.12	1.22
Mar 26- 1April	13	12.08	0.00	0.00	0.00	3.14	0.56	1.02	0.84	0.82
Mean		**53.34**	**0.07**	**0.06**	**0.13**	**12.32**	**2.66**	**2.43**	**1.68**	**3.01**

* Mean of 20 plants.

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

MPKV-Pune

Bt cotton var. Jai, Bollgard II was raised separately on the Research Farm, Agril. Entomology Section, College of Agriculture, Pune. Seeds were sown on 25th July 2014 on ridges and furrows at 90 x 60 cm spacing in 40 x 40 m 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 24** that the incidence of aphids, jassids and thrips was recorded from 2nd week of August 2014 (32nd MW), where as white flies was observed during 4th week of August 2014 (34th MW). Mites were noticed from 3rd week of October 2014 (42nd MW). Initially, the pest population was low but it was increased gradually from 35th MW. The peak incidence of jassids was recorded during 3rd week of November 2014 (46th MW) whereas that of thrips and whitefly was recorded during 5th week of October 2014 (44th MW). The aphid population was noticed maximum during 5th week of October 2014 (44th MW). The infestation of mealybug was not observed during August to January 2015. The natural enemies, coccinellids *Menochilus sexmaculata* Fab., *Coccinella septempunctata* Linn. and spiders were recorded from 3rd week of August to 4th week of December 2014 and their population recorded maximum during 5th week of November 2014 (48th MW). The chrysopid, *Chrysoperla zastrowi sillemi* Esb. was observed from the 3rd week of August 2014 (34th MW).

Besides, the farmers' plots were also surveyed from September to December 2013 but the incidence of all these sucking pests was comparatively low in *Bt* cotton plots.

Table 24: Incidence of sucking pests and their natural enemies in *Bt* cotton

Date of record	Av. population / 3 leaves / plant								
	Aphids	Jassids	Thrips	White flies	Mealybugs	Mites	Chrysopids	Cocci-nellids	Spiders
11/8/2014	1.40	0.48	0.08	0.00	0.0	0.0	0.00	0.04	0.32
25/8/2014	1.88	0.88	0.08	0.16	0.0	0.0	0.12	0.04	0.24
10/9/2014	4.20	1.68	0.44	0.25	0.0	0.0	0.10	0.08	0.44
29/9/2014	2.64	1.72	0.32	0.44	0.0	0.0	0.16	0.12	0.28
16/10/2014	13.40	13.52	6.28	5.0	0.0	4.12	0.56	0.72	0.64
30/10/2014	14.04	10.16	8.28	6.64	0.0	4.92	0.88	1.48	1.32
15/11/2014	12.24	14.40	6.64	3.24	0.0	1.48	0.48	1.60	1.12
28/11/2014	7.28	7.32	5.08	3.20	0.0	1.00	0.88	2.36	1.12
15/12/2014	7.40	5.60	4.04	2.28	0.0	0.64	0.64	1.80	1.36
30/12/2014	4.5	1.23	0.90	0.41	0.0	0.54	0.35	0.25	0.30
15/01/2015	6.30	1.15	1.35	0.60	0.0	0.90	0.25	0.45	0.55
24/01/2015	5.25	1.00	1.90	0.35	0.0	1.30	0.20	0.60	0.55

PAU -Ludhiana

Location I – Ludhiana

The seasonal incidence of sucking insect pests was recorded on *Bt* cotton hybrid (Ankur 3028 BG II) at the Entomological Research Farm, Punjab Agricultural University (PAU), Ludhiana. The crop was sown in first week of May, 2014 with plant to plant and row to row spacing of 67.5 and 75 cm, respectively. The crop was kept unsprayed throughout the cropping season. All agronomic practices recommended by PAU, Ludhiana were followed to raise the crop except for crop protection measures. The population of sucking insect pests was recorded from 20 plants selected randomly from 3 fully formed leaves of the upper canopy at weekly interval, i.e. Standard Meteorological Weeks (SMW) throughout the cropping season. 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.

Among sucking insect pests, leafhopper, *Amrasca biguttula biguttula* and whitefly *Bemisia tabaci* were key pests and remained active through the cropping season. *Thrips tabaci* population was only observed in early stages of the crop growth, whereas, aphid, *Aphis gossypii* population was negligible throughout the cropping season. The population of leafhopper, whitefly, thrips and aphid varied from 0.0 to 9.2, 0.2 to 55.6, 0.0 to 33.0 and 0.0 to 0.4 per three leaves, respectively (**Table 14**). The peak population of leafhopper nymphs (9.2/ 3 leaves) was recorded in 30th SMW (fourth week of July). The population of whitefly adults remained above ETH level (6 adults/ leaf) from 28th to 31st SMW and was maximum (55.60/ 3 leaves) during 29th SMW (third week of July). Thrips population showed its peak (33.0/ 3 leaves) during 29th SMW (third week of July). Among predators, coccinellids (*Coccinella septempuntata*, *Cheilomenus sexmaculata* and *Brumus suturalis*), green lacewing (*Chrysoperla* spp.) and spiders were recorded. The population of coccinellids, *Chrysoperla* and spiders varied from 0.0 to 9.5, 0.0 to 2.5 and 0.0 to 4.0 per 10 plants, respectively (**Table 25**). The population of coccinellids and *Chrysoperla* was maximum during 31st, SMW (end-July) while spiders were maximum during 32nd SMW (first week of August). Apart from these, an unidentified bug was also observed which varied from 0.0 to 33.0 per 10 plants with peak during 32nd, 35th and 36th SMW. The samples of spiders and bugs have been sent to NBAIR, Bangalore for exact identification. No parasitoid emerged from immature stages (nymphs and pupae) of whitefly collected from field.

Table 25: Seasonal abundance of sucking insect pests and their natural enemies in Bt cotton under unsprayed conditions at Ludhiana during 2014.

Standard weeks	Sucking insect pests / 3 leaves / plant				Predators/ 10 plants			Bug / 10 plants*
	Leafhopper	Whitefly	Thrips	Aphid	Coccinellids	*Chrysoperla*	Spiders*	
25	0.0	0.2	4.7	0.0	0.0	0.0	1.0	0.0
26	0.3	5.0	7.1	0.0	0.0	0.0	2.0	1.5
27	0.8	8.2	11.4	0.0	0.0	0.5	2.0	1.5
28	3.1	21.7	18.1	0.0	0.5	2.0	1.0	2.5
29	6.0	55.6	33.0	0.0	1.0	2.5	1.0	4.0
30	9.2	50.4	6.7	0.0	1.5	1.0	1.5	5.0
31	3.7	40.5	4.7	0.0	9.5	5.0	1.5	9.5
32	2.9	17.5	1.1	0.0	2.5	2.0	4.0	31.5
33	1.6	1.6	0.5	0.0	0.0	1.0	3.5	23.5
34	2.3	4.8	0.1	0.0	0.5	1.0	3.0	17.5
35	4.9	5.3	0.1	0.0	0.0	0.0	2.5	30.0
36	2.7	6.4	0.1	0.0	0.0	0.0	0.5	33.0
37	0.6	8.5	0.0	0.0	0.5	0.0	1.0	25.5
38	1.6	2.3	0.0	0.0	0.0	0.0	1.0	1.0
39	2.2	2.9	0.0	0.0	0.5	0.0	2.5	12.5
40	1.0	4.0	0.0	0.0	0.0	0.0	0.5	8.0
41	1.0	1.5	0.0	0.2	0.0	0.0	1.0	6.5
42	0.4	0.6	0.0	0.4	0.0	0.0	0.0	4.0

Coccinellids include *Coccinella septempuntata*, *Cheilomenus sexmaculata* and *Brumus suturalis*

* Samples of spiders and bug sent to NBAIR, Bangalore for identification

Location II - Bathinda

The seasonal incidence of sucking pests was recorded on Bt cotton hybrid (RCH 134 Bt) at the PAU Regional Station, Bathinda. The crop was sown on 15.5.2014 with plant to plant and row to row spacing of 67.5 and 90 cm, respectively. The crop was kept unsprayed throughout the cropping season. The population of sucking insect pests was recorded from 10 plants selected randomly from three fully formed leaves of the upper canopy at weekly interval throughout the cropping season. The population of predators was recorded on whole plant basis.

The population of leafhopper, whitefly and thrips varied from 0.00 to 14.8, 0.00 to 98.0, and 0.0 to 15.2 per 3 leaves, respectively (**Table 26**). The peak population of leafhopper nymphs (14.8/ 3 leaves) was recorded in 33rd SMW (second week of August). The population of whitefly adults remained above ETH level (6 adults/ leaf) from 37th to 41st SMW and was maximum (98.0/ 3 leaves) during 39th SMW (fourth week of September). Thrips population showed its peak (15.2/ 3 leaves) during 30th SMW (end July). The population of coccinellids, *Chrysoperla* and spiders varied from 0.0 to 2.0, 0.0 to 0.5 and 0.0 to 2.5 per 10 plants, respectively. The population of coccinellids and spiders was maximum during 31st SMW while *Chrysoperla* was maximum during 30th SMW. The population of bugs varied from 0.0 to 1.6 per 10 plants with peak during 30th SMW.

Table 26: Seasonal abundance of sucking insect pests and their natural enemies in Bt cotton under unsprayed conditions at Bathinda during 2014

Standard weeks	Sucking pests / 3 leaves / plant				Predators/ 10 plants			Bug / 10 plants*
	Leafhopper	Whitefly	Thrips	Aphid	Coccinellids	*Chrysoperla*	Spiders	
25	0.0	0.0	0.6	0.0	0.0	0.0	0.4	0.4
26	0.6	0.0	0.8	0.0	0.0	0.0	0.5	1.2
27	0.6	0.0	1.0	0.0	0.1	0.2	0.5	1.0
28	1.6	2.0	3.6	0.0	0.1	0.2	0.8	1.0
29	2.7	2.6	4.2	0.0	0.4	0.2	1.2	0.9
30	6.0	5.1	15.2	0.0	0.5	0.5	1.7	1.4
31	8.9	6.4	8.0	0.0	2.0	0.2	2.5	1.2
32	5.5	9.0	4.0	0.0	0.8	0.0	1.7	0.7
33	4.2	7.2	6.3	0.0	0.4	0.2	2.1	0.7
34	4.0	6.4	10.0	0.0	0.8	0.3	1.8	0.7
35	14.8	11.5	0.0	0.0	1.8	0.0	0.9	0.5
36	7.0	12.6	0.0	0.0	1.6	0.0	0.7	0.5
37	3.2	24.4	0.0	0.0	1.4	0.3	0.7	0.3
38	2.0	44.2	0.0	0.0	0.6	0.0	0.4	0.0
39	1.2	98.0	0.0	0.0	0.5	0.1	0.4	0.0
40	3.0	54.0	0.0	0.0	0.0	0.0	0.4	0.0
41	2.5	20.0	0.0	0.0	0.2	0.0	0.2	0.0
42	2.0	16.4	0.0	0.0	0.1	0.0	0.4	0.0
43	1.1	9.9	0.0	0.0	0.0	0.3	0.0	0.0
44	0.9	7.0	0.0	0.0	0.0	0.0	0.0	0.0

Coccinellids include *Coccinella septempuntata*, *Cheilomenus sexmaculata* and *Brumus suturalis*

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

AAU-A

Bioefficacy of microbial insecticides against sucking pests on *Bt* cotton was undertaken at Agronomy farm, BACA, Anand Agricultural University, Anand during Kharif 2014. The trial included 10 treatments as given below.

Details of treatments

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

The bioefficacy of microbial insecticides was evaluated against aphid, *A. gossypii*, jassid, *A. biguttula biguttula*, whitefly, *B. tabaci* and thrips, *T. tabaci* based on pest population. 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 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, seed 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.

The data are presented in **Tables 27 to 31**. Significantly minimum number of jassids (1.24 /leaf), whiteflies (1.04 /leaf), aphids (2.49 /leaf) and thrips (0.71 /leaf) were registered in insecticide treated plots. *Beauveria bassiana* or *Verticilium lecanii* @ 40 g/ 10 liter of water also proved better treatments by recording lower number of jassids, whiteflies, aphids as well as thrips per leaf and next to the treatment of chemical insecticide. Similarly, the highest seed cotton yield was noted in plot treated with chemical insecticide and it was at par with the treatments of *Beauveria bassiana* or *Verticillium lecanii* @ 4g/liter.

Table 27: Bio-efficacy of microbial insecticides against jassids in *Bt* cotton

Treatments		No. of jassids/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:	*Beauveria bassiana* @ 30 g /10 litres water	2.85 (7.62)	2.57 (6.10)	2.18 (4.25)	2.19 (4.30)	2.31 (4.84)	2.32 (4.88)	2.04 (3.66)	3.05 (8.80)	2.14 (4.08)	2.22[c] (4.43)
T2:	*Beauveria bassiana* @ 40 g /10 litres water	2.94 (8.14)	2.27 (4.65)	1.95 (3.30)	1.72 (2.46)	1.98 (3.42)	1.76 (2.60)	1.61 (2.09)	1.48 (1.69)	1.62 (2.12)	1.80[b] (2.74)
T3:	*Verticillium lecanii* @ 30 g /10 litres water	2.94 (8.14)	2.63 (6.42)	2.32 (4.88)	2.36 (5.07)	2.44 (5.45)	2.42 (5.36)	2.12 (3.99)	2.17 (4.21)	2.24 (4.52)	2.34[cd] (4.98)
T4:	*Verticillium lecanii* @ 40 g /10 litres water	3.03 (8.68)	2.32 (4.88)	2.05 (3.70)	1.75 (2.56)	2.04 (3.66)	1.90 (3.11)	1.75 (2.56)	1.57 (1.96)	1.74 (2.53)	1.89[b] (3.07)
T5:	*Metarhizium anisopliae* @ 30 g /10 litres water	2.78 (7.23)	2.58 (6.16)	2.35 (5.02)	2.38 (5.16)	2.44 (5.45)	2.46 (5.55)	2.23 (4.47)	2.33 (4.93)	2.34 (4.98)	2.39[d] (5.21)
T6:	*Metarhizium anisopliae* @ 40 g /10 litres water	2.91 (7.97)	2.31 (4.84)	2.07 (3.78)	1.86 (2.96)	2.08 (3.83)	1.81 (2.78)	1.83 (2.85)	1.74 (2.53)	1.79 (2.70)	1.94[b] (3.26)
T7:	*Nomurea rileyi* @ 30 g /10 litres water	2.83 (7.51)	2.75 (7.06)	2.59 (6.21)	2.64 (6.47)	2.66 (6.58)	2.57 (6.10)	2.53 (5.90)	2.47 (5.60)	2.52 (5.85)	2.59[e] (6.21)
T8:	*Nomurea rileyi* @ 40 g /10 litres water	2.74 (7.01)	2.62 (6.36)	2.40 (5.26)	2.48 (5.65)	2.50 (5.75)	2.39 (5.21)	2.31 (4.84)	2.42 (5.36)	2.37 (5.12)	2.44[de] (5.45)
T9:	Recommended insecticide	2.76 (7.12)	1.76 (2.60)	1.37 (1.38)	1.20 (0.94)	1.44 (1.57)	1.31 (1.22)	1.17 (0.87)	1.09 (0.69)	1.19 (0.92)	1.32[a] (1.24)
T10:	Control (water spray)	2.89 (7.85)	3.01 (8.56)	2.89 (7.85)	2.73 (6.95)	2.88 (7.79)	3.13 (9.30)	3.02 (8.62)	2.90 (7.91)	3.01 (8.56)	2.95[f] (8.20)
S. Em. +	**Treatment (T)**	0.18	0.15	0.12	0.14	0.07	0.15	0.14	0.11	0.07	0.05
	Spray (S)	-	-	-	-	0.04	-	-	-	0.04	0.02
	Period (P)	-	-	-	-	-	-	-	-	-	0.02
	T x S	-	-	-	-	0.14	-	-	-	0.13	0.04
	T x P	-	-	-	-	-	-	-	-	-	0.08
	S x P	-	-	-	-	-	-	-	-	-	0.06
	T x S x P	-	-	-	-	-	-	-	-	-	0.11
C. D. at 5%	**T**	NS	0.45	0.36	0.40	0.21	0.45	0.40	0.34	0.20	0.15
	S	-	-	-	-	-	-	-	-	-	0.07
	P	-	-	-	-	-	-	-	-	-	0.06
	T x S	-	-	-	-	NS	-	-	-	NS	NS
	T x P	-	-	-	-	-	-	-	-	-	0.22
	S x P	-	-	-	-	-	-	-	-	-	NS
	T x S x P	-	-	-	-	-	-	-	-	-	NS
C. V. (%)		10.76	10.57	9.58	11.02	10.43	11.76	11.43	9.83	11.10	10.75

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 28: Bio-efficacy of microbial insecticides against whitefly in *Bt* cotton

Treatments		No. of whiteflies/ 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:	*Beauveria bassiana* @ 30 g /10 litres water	2.62 (6.36)	2.20 (4.34)	2.22 (4.43)	2.11 (3.95)	2.18 (4.25)	2.05 (3.70)	2.11 (3.95)	1.91 (3.15)	2.02 (3.58)	2.10^{cd} (3.91)
T2:	*Beauveria bassiana* @ 40 g /10 litres water	2.45 (5.50)	1.93 (3.22)	1.92 (3.19)	1.63 (2.16)	1.83 (2.85)	1.55 (1.90)	1.54 (1.87)	1.42 (1.52)	1.50 (1.75)	1.67^{b} (2.29)
T3:	*Verticillium lecanii* @ 30 g /10 litres water	2.55 (6.00)	2.31 (4.84)	2.30 (4.79)	2.21 (4.38)	2.27 (4.65)	2.07 (3.78)	2.21 (4.38)	2.16 (4.17)	2.14 (4.08)	2.21^{de} (4.38)
T4:	*Verticillium lecanii* @ 40 g /10 litres water	2.49 (5.70)	2.02 (3.58)	2.03 (3.62)	1.69 (2.36)	1.91 (3.15)	1.66 (2.26)	1.60 (2.06)	1.45 (1.60)	1.57 (1.96)	1.74b (2.53)
T5:	*Metarhizium anisopliae* @ 30 g /10 litres water	2.53 (5.90)	2.31 (4.84)	2.39 (5.21)	2.34 (4.98)	2.35 (5.02)	2.12 (3.99)	2.31 (4.84)	2.31 (4.84)	2.25 (4.56)	2.30^{ef} (4.79)
T6:	*Metarhizium anisopliae* @ 40 g /10 litres water	2.53 (5.90)	1.97 (3.38)	2.16 (4.17)	2.11 (3.95)	2.08 (3.83)	1.70 (2.39)	2.08 (3.83)	1.95 (3.30)	1.91 (3.15)	1.99^{c} (3.46)
T7:	*Nomurea rileyi* @ 30 g /10 litres water	2.56 (6.05)	2.47 (5.60)	2.78 (7.23)	2.52 (5.85)	2.59 (6.21)	2.40 (5.26)	2.65 (6.52)	2.45 (5.50)	2.50 (5.75)	2.55^{g} (6.00)
T8:	*Nomurea rileyi* @ 40 g /10 litres water	2.39 (5.21)	2.33 (4.93)	2.60 (6.26)	2.33 (4.93)	2.42 (5.36)	2.20 (4.34)	2.52 (5.85)	2.29 (4.74)	2.34 (4.98)	2.38^{f} (5.16)
T9:	Recommended insecticide	2.44 (5.45)	1.52 (1.81)	1.38 (1.40)	1.17 (0.87)	1.35 (1.32)	1.19 (0.92)	1.09 (0.69)	1.07 (0.64)	1.12 (0.75)	1.24^{a} (1.04)
T10:	Control (water spray)	2.51 (5.80)	2.58 (6.16)	2.94 (8.14)	2.88 (7.79)	2.80 (7.34)	2.73 (6.95)	3.03 (8.68)	3.10 (9.11)	2.95 (8.20)	2.88^{h} (7.79)
S. Em. +	**Treatment (T)**	0.13	0.13	0.13	0.13	0.07	0.12	0.15	0.14	0.08	0.05
	Spray (S)	-	-	-	-	0.04	-	-	-	0.04	0.02
	Period (P)	-	-	-	-	-	-	-	-	-	0.01
	T x S	-	-	-	-	0.13	-	-	-	0.14	0.02
	T x P	-	-	-	-	-	-	-	-	-	0.05
	S x P	-	-	-	-	-	-	-	-	-	0.04
	T x S x P	-	-	-	-	-	-	-	-	-	0.08
C. D. at 5%	**T**	NS	0.38	0.38	0.39	0.21	0.36	0.44	0.41	0.21	0.15
	S	-	-	-	-	-	-	-	-	-	0.05
	P	-	-	-	-	-	-	-	-	-	0.04
	T x S	-	-	-	-	NS	-	-	-	NS	0.07
	T x P	-	-	-	-	-	-	-	-	-	0.15
	S x P	-	-	-	-	-	-	-	-	-	NS
	T x S x P	-	-	-	-	-	-	-	-	-	NS
C. V. (%)		9.04	10.18	9.62	10.73	10.16	10.66	12.22	11.85	11.64	10.88

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 29: Bio-efficacy of microbial insecticides against aphid in *Bt* cotton

Treatments		No. of aphids/ 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:	*Beauveria bassiana* @ 30 g /10 litres water	3.59 (12.39)	3.37 (10.86)	3.02 (8.62)	2.56 (6.05)	2.98 (8.38)	2.97 (8.32)	2.81 (7.40)	2.32 (4.88)	2.70 (6.79)	2.84[d] (7.57)
T2:	*Beauveria bassiana* @ 40 g /10 litres water	3.37 (10.86)	2.69 (6.74)	2.47 (5.60)	1.96 (3.34)	2.37 (5.12)	2.10 (3.91)	2.07 (3.78)	1.71 (2.42)	1.96 (3.34)	2.17[b] (4.21)
T3:	*Verticillium lecanii* @ 30 g /10 litres water	3.58 (12.32)	3.44 (11.33)	3.14 (9.36)	2.85 (7.62)	3.14 (9.36)	3.14 (9.36)	2.99 (8.44)	2.63 (6.42)	2.92 (8.03)	3.03[de] (8.68)
T4:	*Verticillium lecanii* @ 40 g /10 litres water	3.58 (12.32)	2.85 (7.62)	2.68 (6.68)	1.97 (3.38)	2.50 (5.75)	2.37 (5.12)	2.20 (4.34)	1.82 (2.81)	2.13 (4.04)	2.31[bc] (4.84)
T5:	*Metarhizium anisopliae* @ 30 g /10 litres water	3.55 (12.10)	3.45 (11.40)	3.25 (10.06)	2.95 (8.20)	3.22 (9.87)	3.23 (9.93)	3.12 (9.23)	2.79 (7.28)	3.05 (8.80)	3.13[ef] (9.30)
T6:	*Metarhizium anisopliae* @ 40 g /10 litres water	3.45 (11.40)	3.07 (8.92)	2.72 (6.90)	2.18 (4.25)	2.66 (6.58)	2.34 (4.98)	2.44 (5.45)	2.17 (4.21)	2.32 (4.88)	2.49[c] (5.70)
T7:	*Nomurea rileyi* @ 30 g /10 litres water	3.72 (13.34)	3.53 (11.96)	3.56 (12.17)	3.14 (9.36)	3.41 (11.13)	3.39 (10.99)	3.42 (11.20)	3.04 (8.74)	3.28 (10.26)	3.35[f] (10.72)
T8:	*Nomurea rileyi* @ 40 g /10 litres water	3.73 (13.41)	3.51 (11.82)	3.55 (12.10)	3.00 (8.50)	3.35 (10.72)	3.41 (11.13)	3.33 (10.59)	2.85 (7.62)	3.20 (9.74)	3.27[f] (10.19)
T9:	Recommended insecticide	3.79 (13.86)	2.15 (4.12)	1.98 (3.42)	1.57 (1.96)	1.90 (3.11)	1.80 (2.74)	1.57 (1.96)	1.33 (1.27)	1.57 (1.96)	1.73[a] (2.49)
T10:	Control (water spray)	3.54 (12.03)	4.06 (15.98)	4.35 (18.42)	4.48 (19.57)	4.30 (17.99)	3.96 (15.18)	4.35 (18.42)	4.65 (21.12)	4.32 (18.16)	4.31[g] (18.08)
S. Em. +	**Treatment (T)**	0.25	0.17	0.17	0.15	0.10	0.18	0.19	0.16	0.11	0.07
	Spray (S)	-	-	-	-	0.05	-	-	-	0.06	0.03
	Period (P)	-	-	-	-	-	-	-	-	-	0.02
	T x S	-	-	-	-	0.16	-	-	-	0.18	0.04
	T x P	-	-	-	-	-	-	-	-	-	0.10
	S x P	-	-	-	-	-	-	-	-	-	0.08
	T x S x P	-	-	-	-	-	-	-	-	-	0.13
C. D. at 5%	**T**	NS	0.50	0.52	0.44	0.28	0.53	0.55	0.49	0.30	0.20
	S	-	-	-	-	-	-	-	-	-	0.08
	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. (%)		12.27	9.06	9.79	9.65	9.50	10.76	11.38	11.27	11.14	10.30

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 30: Bio-efficacy of microbial insecticides against thrips in *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:	*Beauveria bassiana* @ 30 g /10 litres water	2.44 (5.45)	2.34 (4.98)	2.06 (3.74)	2.13 (4.04)	2.17 (4.21)	2.24 (4.52)	2.06 (3.74)	2.13 (4.04)	2.14 (4.08)	2.16[d] (4.17)
T2:	*Beauveria bassiana* @ 40 g /10 litres water	2.56 (6.05)	2.19 (4.30)	1.89 (3.07)	1.79 (2.70)	1.96 (3.34)	2.10 (3.91)	1.74 (2.53)	1.68 (2.32)	1.84 (2.89)	1.90[c] (3.11)
T3:	*Verticillium lecanii* @ 30 g /10 litres water	2.38 (5.16)	2.27 (4.65)	1.96 (3.34)	2.03 (3.62)	2.08 (3.83)	2.12 (3.99)	1.96 (3.34)	1.96 (3.34)	2.01 (3.54)	2.05[cd] (3.70)
T4:	*Verticillium lecanii* @ 40 g /10 litres water	2.49 (5.70)	1.87 (3.00)	1.55 (1.90)	1.38 (1.40)	1.60 (2.06)	1.68 (2.32)	1.23 (1.01)	1.25 (1.06)	1.39 (1.43)	1.49[b] (1.72)
T5:	*Metarhizium anisopliae* @ 30 g /10 litres water	2.54 (5.95)	2.54 (5.95)	2.26 (4.61)	2.30 (4.79)	2.37 (5.12)	2.43 (5.40)	2.21 (4.38)	2.26 (4.61)	2.30 (4.79)	2.33[e] (4.93)
T6:	*Metarhizium anisopliae* @ 40 g /10 litres water	2.59 (6.21)	2.29 (4.74)	2.07 (3.78)	2.15 (4.12)	2.17 (4.21)	2.21 (4.38)	2.03 (3.62)	2.08 (3.83)	2.11 (3.95)	2.14[d] (4.08)
T7:	*Nomurea rileyi* @ 30 g /10 litres water	2.52 (5.85)	2.49 (5.70)	2.36 (5.07)	2.58 (6.16)	2.48 (5.65)	2.49 (5.70)	2.51 (5.80)	2.51 (5.80)	2.50 (5.75)	2.49[e] (5.70)
T8:	*Nomurea rileyi* @ 40 g /10 litres water	2.61 (6.31)	2.47 (5.60)	2.30 (4.79)	2.49 (5.70)	2.42 (5.36)	2.47 (5.60)	2.42 (5.36)	2.43 (5.40)	2.44 (5.45)	2.43[e] (5.40)
T9:	Recommended insecticide	2.59 (6.21)	1.42 (1.52)	1.21 (0.96)	1.14 (0.80)	1.26 (1.09)	1.04 (0.58)	0.87 (0.26)	0.89 (0.29)	0.93 (0.36)	1.10[a] (0.71)
T10:	Control (water spray)	2.70 (6.79)	2.81 (7.40)	2.78 (7.23)	2.94 (8.14)	2.84 (7.57)	2.93 (8.08)	2.89 (7.85)	2.96 (8.26)	2.93 (8.08)	2.89[f] (7.85)
S. Em. +	**Treatment (T)**	0.12	0.12	0.12	0.12	0.07	0.13	0.10	0.11	0.06	0.05
	Spray (S)	-	-	-	-	0.04	-	-	-	0.04	0.02
	Period (P)	-	-	-	-	-	-	-	-	-	0.02
	T x S	-	-	-	-	0.12	-	-	-	0.11	0.03
	T x P	-	-	-	-	-	-	-	-	-	0.06
	S x P	-	-	-	-	-	-	-	-	-	0.05
	T x S x P	-	-	-	-	-	-	-	-	-	0.08
C. D. at 5%	**T**	NS	0.35	0.37	0.36	0.19	0.38	0.28	0.34	0.18	0.13
	S	-	-	-	-	-	-	-	-	-	0.05
	P	-	-	-	-	-	-	-	-	-	0.04
	T x S	-	-	-	-	NS	-	-	-	NS	0.08
	T x P	-	-	-	-	-	-	-	-	-	0.17
	S x P	-	-	-	-	-	-	-	-	-	NS
	T x S x P	-	-	-	-	-	-	-	-	-	NS
C. V. (%)		8.51	8.92	10.49	9.93	9.76	10.21	8.33	9.75	9.52	9.65

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 31: Impact of microbial insecticides on yield of *Bt* cotton

Treatments		Seed cotton yield (q/ha)
T1:	*Beauveria bassiana* @ 30 g /10 litres water	23.91^{cde}
T2:	*Beauveria bassiana* @ 40 g /10 litres water	28.35^{ab}
T3:	*Verticillium lecanii* @ 30 g /10 litres water	22.44^{def}
T4:	*Verticillium lecanii* @ 40 g /10 litres water	26.93^{abc}
T5:	*Metarhizium anisopliae* @ 30 g /10 litres water	22.13^{def}
T6:	*Metarhizium anisopliae* @ 40 g /10 litres water	25.67^{bcd}
T7:	*Nomurea rileyi* @ 30 g /10 litres water	21.85^{ef}
T8:	*Nomurea rileyi* @ 40 g /10 litres water	19.07^{fg}
T9:	Recommended insecticide	29.70^{a}
T10:	Control (water spray)	16.71^{g}
S. Em. +	**Treatment (T)**	1.11
C. D. at 5%	**T**	3.28
C.V. (%)		8.09

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

2.5. Rice

1. Seasonal abundance of predatory spiders in rice ecosystem (PAU)

PAU- Ludhiana

Regular surveys were conducted to collect spiders from rice growing areas (Ludhiana, Patiala, Bathinda, Fatehgarh Sahib) of Punjab. The spiders were collected from different rice fields. Collected specimens were brought back to the laboratory and were preserved in 70 % alcohol. The population of spiders was quite high (0.1 to 2.0 spiders/plant) during the season with maximum population (2.0 spiders/plant) during 38th SMW (3rd week of September). Eight species in the areas of Ludhiana and six species of spiders in the areas of Nabha were noticed. The detail of seasonal abundance spiders is mentioned in the **Table 17**. All the specimens of these spiders have been sent to NBAIR, Bangalore for identification. The species diversity and species evenness of the spiders will be calculated after getting the information of their identification.

2. Laboratory and field evaluation of fungal pathogens on Gandhi bug, *Leptocorisa acuta*. (KAU)

During 2014-15, *M. anisopliae* and *B. bassiana* (local isolate) were evaluated in the field at Vellanikkara with the following treatments. Spraying was done in the evening hours and observations were recorded on 3rd, 5th and 7th day by counting the rice bugs.

1. *Beauveria bassiana* (local isolate) @ 2x10^7 spores/ ml
2. *Beauveria bassiana* " @ 2x10^8 spores/ml
3. *Beauveria bassiana* " @ 2x10^9 spores/ml
4. *Metarhizium anisopliae* @ 2x10^7 spores/ ml
5. *Metarhizium anisopliae* @ 2x10^8 spores/ ml
6. *Metarhizium anisopliae* @2x10^9 spores/ml
7. Control

Precount of *Leptocorisa acuta* was 5-8 no./sq.m. There was reduction in rice bug count in all the treated plots. Samples of rice bugs were also collected and brought to the laboratory for observing the fungal infection.

2.6. Maize

1. Evaluation of *Trichogramma chilonis* against maize stem borer *Chilo partellus* (PJTSAU)

Evaluation of *Trichogramma chilonis* against maize stem borer *Chilo partellus* was done at ARS, Tandur during the *Rabi* season of 2014 with the following treatments.

T1 : *Trichogramma chilonis* @ 250000 parasitoids/ha. (Two times at weekly intervals, starting round 10 days after germination).
T2 : Farmers practice

Damage on 50 randomly selected plants per plot were recorded. Grain yield from plots were also recorded. Sole application of *Trichogramma chilonis* proven to be ineffective in managing stem borer. The colonization of *Trichogramma* can be achievable only after prolonged inundative releases but not in a single season **(Table 32)**.

Table 32: Evaluation of *Trichogramma chilonis* against Maize stem borer *Chilo partellus*

Replications	**No. of damaged plants (out of 50 randomly selected plants/plot)**		**p-value (t-Test)**
	***Trichogramma chilonis* @ 2,50,000 parasitoids/ha. Two times at weekly intervals, starting first round 10 days after germination.**	**Farmers' practice**	0.02203 Sig. at 5 % level
R1	6	0	
R2	10	4	
R3	6	0	
R4	7	0	
R5	4	6	

2.7. Sorghum

1. Field evaluation of NBAIR entomopathogenic strains against sugarcane stem borer, *Chilo partellus* (Swinhoe) in Kharif sorghum (IIMR)

An experiment was conducted at the Indian Institute of Millets Research (IIMR), Hyderabad, Telangana State, during Kharif 2014. The experimental material consisted of sorghum variety *viz*, C 43, sown 08.07.2014 for evaluation of entomofungal formulation against stem borer. The experimental plots received a basal dose of NPK (20:20:20) @ 80:40:40 kg/ha. Sorghum variety, C 43 was sown in eight row plots of 4 m row length, spaced 60 cm apart (19.2 m^2). The trial was laid in randomized block design with eight treatments and three replications. The seeds were hand sown at a depth of 5 cm below the soil surface. The field was irrigated immediately after sowing, and thereafter two irrigations at 30 and 50 days after seedling emergence (DAE) respectively were provided. Thinning was carried out to maintain a spacing of 10 cm between the plants one week after seedling emergence. No insecticide was applied in the experimental plots. Interculture and earthing up operations were carried out at 15 and 45 DAE. Hand weeding was carried out, field top dressed with urea @ 100 kg/ha prior to earthing up at 30 DAE. Entomofungal formulations received from NBAII, Bangalore were sprayed at 20, 30 DAE at the recommended dose. Three strains each of *Metarrhizium anisopliae* and *Beauveria bassiana* were evaluated against spotted stem borer *Chilo partellus* during Kharif 2014. The carbofuran 3G also applied as one of the treatments. The observations were recorded on plants with dead hearts at 45 DAE, number of exit holes/plant, stem tunneling and seed yield / plot.

Results:

Dead hearts (%)*:* The dead hearts caused by *C. partellus* at 45 DAE following application of entomofungal formulation indicated that the strain Ma 36, Ma 35 and Ma 52 caused significant reduction in deadhearts (9.1, 9.3 and 9.9 %) respectively as compared to control which recorded 16.1 % dead hearts. Whorl application of carbofuran @ 8 kg/ha was significantly the best (3.8 %) over the entomofungal formulations (**Table 33**). There was 76% reductions in deadhearts due to whorl applications of carbofuran @ 8 kg/ha.

Stem tunneling (%)*:* The data on stem tunneling caused by *C partellus* indicated that the strain Ma 35 and Ma 36 resulted in significantly low stem tunneling (3.3 and 3.5 %), respectively as compared to control which recorded 12.8 % dead hearts. Carbofuran whorl application @ 8 kg/ha was significantly the best with low stem tunneling (2.1 %) and was on par with the strain Ma 35 and Ma 36. There was 83% reductions in stem tunneling due to whorl applications of carbofuran @ 8 kg/ha.

Exit holes (No./stalk): The data on exit holes/ stalk revealed that formulation Ma 35, Ma 36 recorded significantly less damage (1.4, 1.5 exit holes/ stalk) respectively over the control (6.2 exit holes/ stalk) and the damage was on par with carbofuran application (0.2 exit holes/ stalk) indicating their effectiveness (**Table 33**).

Grain yield (kg/plot): The grains harvested from the experimental plot (19.2 m^2) indicated that the strain Ma 36 and Ma 35 realized significantly high grain yield (5.51 and 5.48 kg/ plot), respectively as compared to control which recorded 3.24 kg/plot. Carbofuran whorl application @ 8 kg/ha was significantly superior (5.62 kg/plot and was on par with the strain Ma 36 and Ma 35 (**Table 33**).

Table 33: Evaluation of entomofungal formulations of *B. bassiana* and *M. anisopliaea* against stem borer in sorghum-Kharif 2014, IIMR, Hyderabad

Treat-ment	Isolate	DH % 45 DAE	EHS (no.)	ST %	Grain yield Kg/ 19.2 m^2
T1	Bb 23 @5ml/ lt*	13.3	5.0	9.3	3.75
T2	Bb 45 @5ml/ lt	13.6	4.4	10.8	3.82
T3	Bb 14 @5ml/ lt	12.2	4.1	9.9	3.74
T4	Ma 35 @5ml/ lt	9.3	1.4	3.3	5.48
T5	Ma 36 @5ml/ lt	9.1	1.5	3.5	5.54
T6	Ma 52 @5ml/ lt	9.9	2.1	5.7	3.95
T7	Carbofuran 3 G whorl application @ 8 kg/ha at 20 DAE	3.8	0.2	2.1	5.62
T8	Control	16.1	6.2	12.8	3.24
	CD (0.05)	**2.9**	**1.6**	**1.7**	**0.89**
	CV %	**15.6**	**18.3**	**24.2**	**12.6**

*Entomofungal formulations were sprayed at 20, 30 DAE
DH% = dead hearts (%), EHS = exit holes (no/stalk), ST (%) = stem tunneling (%)

2.8. Pulses

1. Evaluation of *Bt* Formulations against pulse borer (*Helicoverpa armigera*) and legume pod borer (*Maruca testulalis*) (MPKV, PJTSAU, AAU-A, UAS-R)

MPKV-Pune

A field experiment was conducted on the Research farm, College of Agriculture, Pune. The pigeon pea var. ICPL-87 was sown at 30 x 10 cm spacing in 8 x 5 m plots during 2011 -2014. The trial was laid out in RBD with nine treatments and three replications. The treatments comprised spraying of liquid formulations of *Bt* strains PDBC-BT1 @ 1 and 2%, NBAII-BTG4 @ 1 and 2%, *Beauveria bassiana* @ 1.5 and 2.0 kg/ha, NSKE 5%, chlorpyriphos 0.04% as standard chemical check and untreated control. The three sprays of treatments were given. The larval population of *H. armigera* and *M. testulalis* were recorded a day before treatment application as pre-count and post counts at 3 and 7 days after each spray. The data on larval population were transformed into $\sqrt{x+0.5}$. values, per cent pod and seed damage transformed into arc sin values and yield data converted into quintal per ha. The data were then subjected to analysis of variance.

Pooled analysis of three years data (**Table 34, 35 and 36**) revealed that three sprays of chlorpyriphos 0.05% at fortnightly interval was significantly superior over other treatments in suppressing the larval population of *H. armigera* (av. 0.8 larvae/plant) and *M. vitrata* (av. 2.1 larvae/25 inflorescence) on pigeon pea and recorded minimum pod (9.0%) and seed 6.4 %) damage with maximum 16.4 q/ha yield (Tables 4, 5 and 6). It was however, at par with the *Bt* strain NBAII-BTG4 @ 2% in respect of pod damage (9.8%) and yield (15.0 q/ha). Moreover, the treatment PDBC-BT1 @ 2% was also found to be equally effective to superior ones. The *Bt* strain NBAII-BTG4 @ 2% ranked next best to the insecticidal spray in recording surviving larval population of *H. armigera* (av. 1.9 larvae/plant) and *M. vitrata* (4.6 larvae/25 inflorescence).

Table 34: Effect of *Bt* formulations against *Helicoverpa armigera* in pigeon pea (Pooled data for 2011-12, 2012-13 and 2013-14)

Treatments	Pre-count	No. of *H. armigera* larvae/plant on pigeon pea after				
		2nd Spray		3rd spray		Average of 2 sprays
		3DAS	7 DAS	3DAS	7 DAS	
PDBC-BT @ 1%	4.6[a]	4.5[b]	2.5[b]	1.6[b]	1.3[c]	2.5[a]
PDBC-BT1 @ 2%	4.7[a]	3.9[b]	1.9[b]	1.3[b]	0.7[b]	1.9[a]
BTG4 @ 1%	4.8[a]	3.7[a]	2.2[b]	1.4[b]	0.8[b]	2.0[a]
BTG4 @ 2%	4.8[a]	3.6[a]	1.8[a]	1.2[b]	0.5[b]	1.8[a]
B. bassiana@ 1. 5 kg/ha	4.9[a]	4.6[b]	3.5[c]	2.2[c]	1.8[c]	3.0[b]
B. bassiana @ 2.0 kg/ha	4.9[a]	3.9[b]	2.9[c]	1.8[c]	1.2[c]	2.4[a]
NSKE 5% susp.	4.6[a]	4.9[c]	3.9[d]	2.1[c]	1.7[c]	3.1[b]

Chlorpyriphos 0.05%	4.9 [a]	2.7 [a]	1.2 [a]	0.4 [a]	0.0 [a]	0.8 [a]
Control	4.7 [a]	5.9 [c]	7.2 [e]	8.6 [d]	10.5 [d]	8.0 [c]
CD (p = 0.05)	**NS**	**0.26**	**0.21**	**0.18**	**0.21**	**0.11**

Table 35: Evaluation of different liquid formulations of *Bt* against legume pod borer *Maruca vitrata* on pigeon pea (Pooled data for 2011-12, 2012-13 and 2013-14)

Treatments	Pre count	No. of *M. testulalis* larvae/25 inflorescence on pigeonpea after								
		I Spray		Pre count	II Spray		Pre-count	III Spray		Cumul. Average
		3 DAS	7 DAS		3 DAS	7 DAS		3 DAS	7 DAS	
PDBC-BT1 @ 1%	3.8 [a]	4.3 [c]	6.3 [c]	19.0 [a]	11.5 [c]	7.8 [b]	6.1 [a]	4.1 [b]	2.9 [c]	6.1 [d]
PDBC-BT1 @ 2%	4.1 [a]	3.2 [b]	3.9 [b]	18.2 [a]	9.6 [b]	6.1 [b]	4.6 [a]	3.0 [b]	1.6 [b]	4.6 [c]
BTG4 @ 1%	3.5 [a]	4.0 [c]	5.2 [c]	19.0 [a]	9.8 [b]	7.2 [b]	6.1 [a]	3.7 [b]	3.2 [c]	5.5 [d]
BTG4 @ 2%	4.0 [a]	3.0 [b]	2.3 [a]	18.2 [a]	7.9 [b]	4.0 [a]	4.3 [a]	2.1 [a]	1.3 [b]	3.4 [b]
B.bassiana @ 1.5 kg/ha	4.0 [a]	4.1 [c]	5.3 [c]	16.6 [a]	13.2 [c]	9.9 [c]	7.3 [a]	5.7 [c]	5.1 [d]	7.2 [e]
B.bassiana @ 2.0 kg/ha	3.9 [a]	3.3 [b]	3.6 [b]	17.6 [a]	11.3 [c]	8.7 [b]	7.0 [a]	4.5 [b]	4.2 [c]	6.0 [d]
NSKE 5% suspension	4.0 [a]	4.2 [c]	4.4 [b]	19.6 [a]	11.4 [c]	9.2 [c]	7.9 [a]	6.4 [c]	5.2 [d]	6.8 [e]
Chlorpyriphos, 0.05%	3.4 [a]	2.2 [a]	1.8 [a]	17.8 [a]	4.2 [a]	3.0 [a]	2.1 [a]	1.1 [a]	0.2 [a]	2.1 [a]
Control	3.9 [a]	6.4 [d]	10.6 [d]	18.6 [a]	27.7 [d]	30.2 [d]	23.9 [a]	22.0 [d]	19.4 [e]	19.4 [f]
CD (p = 0.05)	**NS**	**0.24**	**0.34**	**NS**	**0.54**	**0.51**	**NS**	**0.43**	**0.44**	**0.15**

Table 36: Effect of different *Bt* formulations on pod, grain damage and yield of pigeon pea (Pooled data for 2011-12, 2012-13 and 2013-14)

Treatments	Pod damage (%)	Grain damage (%)	Yield (q/ha)
PDBC-BT @ 1%	16.3 [d]	14.6 [d]	13.5 [c]
PDBC-BT1 @ 2%	12.0 [b]	9.7 [c]	14.8 [b]
BTG4 @ 1%	15.5 [c]	13.6 [d]	13.8 [b]
BTG4 @ 2%	9.8 [a]	8.3 [b]	15.0 [b]
B. bassiana @ 1.5 kg/ha	22.6 [g]	20.1 [g]	10.8 [e]
B. bassiana @ 2.0 kg/ha	19.7 [f]	17.7 [f]	10.9
NSKE 5% suspension	18.3 [e]	15.8 [e]	11.6 [d]
Chlorpyriphos 0.05%	9.0 [a]	6.4 [a]	16.4 [a]
Control	26.9 [h]	22.9 [h]	8.8 [f]
CD (p = 0.05)	**0.77**	**1.32**	**1.39**

PJSTAU-Hyderabad

Trial was laid out at Agricultural research Station, Tandur during Kharif 2014-15. Among Biological options tested for their efficacy in Bio suppression of pod borers, NBAII BTG 4 (2%) maintained its supremacy in *Helicoverpa* management by recording least no. of larvae (0.4 to 0.9/plant) followed by *Beauveria bassiana* (0.8 to 1.1/plant /plant) and are comparable with insecticidal check (04 to 1.3/plant). NSKE 5% was found to be least effective (1.2 to 1.6/plant) which was more or less comparable with un treated control (2.1 to 3.3/plant). NBAII BTG 4 (2%) by being *Bt* formulation reduced *Helicoverpa* population comparatively early (at 7 days after spray) while *Beauvera bassiana* was found more promising at 10 days after spray conforming the quick knock down effect of NBAII BTG 4 and sustainable nature of *Beauvera bassiana* in suppressing the target pest in pigeon pea ecosystem. Least pod damage was also noticed in NBAII BTG 4 (2%) followed by *Beauvera bassiana* confirming their supremacy in management of *Helicoverpa* in pigeon pea ecosystem.

AAU-Anand

Large scale demonstration was carried out at village Dhavat Ta. Karjan to control *Helicoverpa armigera* in pigeon pea. Two farmers were selected for large scale demonstration of NBAII liquid formulation against pod borer in pigeon pea. The crop is found to be effectively controlled by our liquid formulation and the experiment is in progress hence results will be communicated before workshop.

UAS-Raichur

Three years of experimentation on efficacy of *Bt* formulations showed that NBAII BTG 4 *Bt* @ 2g/lit was effective in reducing pod borer population with higher grain yield in pigeon pea ecosystem. Large scale demonstration of NBAII BTG 4 *Bt* was done in a Kallur (T) of Raichur taluka over an area of 5 ha. Totally five farmers were selected to demonstrate the effectiveness of NBAII BTG 4 *Bt* in comparison with farmers practice.

Minimum per cent pod damage of 9.46 which was statistically superior compared to NBAII BTG 4 *Bt* (13.46%). Similarly lowest grain damage (1.44) was noticed in farmers

practice compared to NBAII BTG 4 *Bt* (2.19%). Higher grain yield of 14.98 q/ha was noticed in farmers practice compared to NBAII BTG 4 *Bt* which recorded 12.14q/ha grain yield (**Table 37**).

Table 37. Performance of NBAII BTG 4 *Bt* in comparison with farmers practice at Kallur village, Raichur

Sl. No.	Particulars	% Pod damage	% Seed damage	Grain Yield (q/ha)
1.	NBAII BTG 4 *Bt*	13.46	2.19	12.14
2.	Farmers Practice	9.46	1.44	14.98
SEm ±		**0.12**	**0.03**	**0.23**
CD at 5 %		**0.38**	**0.10**	**0.71**

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

PAU-Ludhiana

The experiment was conducted on moong bean (variety PAU 911) sown at Entomological Research Farm, Punjab Agricultural University, Ludhiana. The experiment was conducted in plot size of 20sq m in randomized block design during 2014. There were ten treatments with three replications. These ten treatments were liquid formulation of *Bacillus thuringiensis* Bt1 (1%), Bt 1 (2%), NBAII BT G4 (1%), NBAII Bt G4 (2%), Delfin @1 Kg/ha, Delfin @ 2Kg/ha, *Beauveria bassiana* (Mycojal) 1.5Kg/ha, *Beauveria bassiana* (Mycojal) 2.0 Kg/ha, chlorpyriphos 20EC@1.5 l/acre and untreated control. There were three sprays of bioagents at ten days interval and two sprays of chemical control at fifteen days interval. Per cent pod damage and yield was recorded on whole plot basis. Per cent pod damage was recorded after fifteen days interval. During the first fortnight of September, lowest per cent pod damage (20.38%) was recorded in chemical control and was at par with PDBC Bt1 (2%), NBAII Bt G4 (1% and 2%) and Delfin (@1 and 2Kg/ha) which recorded 21.98, 23.85, 22.35, 22.51 and 22.28 per cent respectively. Highest per cent pod damage (25.03%) was recorded in untreated control (**Table 38**).

During second fortnight of September, lowest per cent pod damage (19.25%) was recorded in chemical control chlorpyriphos 20EC @ 1.5 l/acre and this was followed by PDBC Bt1 (2%) which was at par all *Bacillus thuringiensis* formulations at their both concentrations. However, highest pod damage (26.55%) was recorded in untreated control and was at par with *Beauveria bassiana* treatments. During October, lowest per cent pod damage (19.41%) was recorded in chemical control and this was at par with PDBC *Bt*1 (2%) and both concentrations of Delfin (@1 and 2 Kg /ha). This was followed by lower concentration of PDBC Bt1 (1%), NBAII *Bt* G4 (1% and 2%). The highest pod damage was recorded in untreated control (30.91%). However, all the treatments were significantly better than untreated control. Yield was highest in chemical control (3.87q/acre) and was followed by at par with both doses of Delfin and higher dose of PDBC *Bt*1 (2%).

So, it can be concluded that among all bioagents, higher dose of PDBC *Bt*1 (2%) and both doses of Delfin were at par with each other and recorded lowest pod damage followed by chemical control chlorpyriphos 20EC@1.5 l/acre.

Table 38: Evaluation of microbial agents for the management of lepidopteron pests on Moong bean (2014)

S. No	Treatment	Per cent pod damage			Yield(q/acre)
		13/9/14	27/9/14	14/10/14	
1	PDBC Bt1 (1%)	23.61[b]	23.30[bc]	21.95[b]	3.17[bc]
2	PDBC Bt 1(2%)	21.98[a]	21.45[b]	20.65[ab]	3.36[a]
3	NBAII BtG4 (1%)	23.85[ba]	24.11[cb]	22.65[b]	3.12[bc]
4	NBAII BtG4 (2%)	22.35[a]	23.77[b]	21.28[b]	3.17[bc]
5	Delfin WG (@ 1Kg/ha)	22.51[a]	22.28[bc]	20.41[ab]	3.26[abc]
6	Delfin WG (@ 2Kg/ha)	22.28[a]	22.21[b]	19.80[a]	3.41[ab]
7	*Beauveria bassiana* (1.5Kg/ha)	24.18[ba]	24.65[c]	24.65[c]	2.20[cd]
8	*Beauveria bassiana* (2.0Kg/ha)	24.25[ba]	23.61[c]	23.71[c]	2.63[cd]
9	Chlorpyriphos 20EC @1.5 lt/acre	20.38[a]	19.25[a]	19.41[a]	3.87[a]
10	Control	25.03[b]	26.55[dc]	30.91[d]	2.01[d]
	CV (%)	3.32	2.64	2.60	12.9

2.9. Oil seeds

1. Biological Suppression of safflower aphid, *Uroleucon compositae* on safflower (MPKV, PJTSAU)

MPKV-Pune

A field experiment was conducted on the research farm of Entomology Section, College of Agriculture, Pune during *Rabi* 2011-14. The seeds of safflower var. SSF 658 (non-spiny) were sown at the rate 10 kg/ha at 45 x 20 cm spacing in the plots of 8 x 5 m size. The trial was laid out in randomized block design with seven treatments and three replications. The treatments comprised release of *Chrysoperla zastrowi sillemi* @ 5,000 grubs/ha, spraying of *Verticillium lecanii, Beauveria bassiana, Metarhizium anisopliae* each @ 10^{13} conidia/ha, NSKE 5% suspension, insecticidal check dimethoate 30EC @ 0.05% and untreated control. Three releases of *Chrysoperla* and three sprays of remaining treatments were given at fortnightly interval starting from 14/01/2013. The aphid population was recorded on 5 cm apical shoot per plant from 10 randomly selected plants per plot a day before treatment application and post counts at 7 days after each spray. Data on aphid population transformed into $\sqrt{x+0.5}$ values for statistical analysis. The yield data was recorded on per plot basis and converted into quintal/ha for statistical analysis (**Table 39**)

Pooled analysis of three years data (**Table 39**) r**e**vealed that three sprays of dimethoate @ 0.05 % at fortnightly interval found significantly superior over other treatments in suppressing the aphid population (4.54 aphids/5 cm apical twig) on non-spiny variety of safflower and increased the yield (11.21 q/ha). However, similar sprays of *M. anisopliae* @ 10^{13} conidia/ha given at fortnightly interval was found to be the next best treatment in reducing the aphid population (7.45 aphids/5 cm apical twig and 10.79 q/ha).

Table 39: Evaluation of different biopesticides and predator against safflower aphid, *Uroleucon compositae* (Pooled data for 2011-12, 2012-13 and 2013-14)

Treatments	Pre-count	Aphid Population./ 5 cm topical twig after 7 DAS				Yield (q/ha)
		I Spray	II Spray	III Spray	Average	
Chrysoperla @ 5,000 grubs/ha	43.3[a]	37.4[d]	27.8[f]	19.3[d]	28.2[e]	7.5[b]
V. lecanii @ 10^{13} conidia/ha	44.1[a]	30.6[c]	18.5[d]	9.7[c]	19.6[d]	8.2[b]
B. bassiana @ 10^{13} conidia/ha	44.6[a]	40.6[d]	22.5[e]	15.6[d]	26.2[e]	7.9[b]
M. anisopliae @ 10^{13} conidia/ha	43.0[a]	15.0[b]	5.6[b]	1.8[a]	7.4[b]	10.8[a]
NSKE @ 5%	44.0[a]	17.8[b]	12.0[c]	5.3[b]	11.7[c]	10.3[a]
Dimethoate 0.05%	43.4[a]	9.5[a]	3.7[a]	0.4[a]	4.5[a]	11.2[a]
Control	43.1[a]	48.5[e]	56.4[g]	62.9[e]	55.9[f]	5.9[c]
CD (p = 0.05)	**NS**	**0.43**	**0.39**	**0.62**	**0.21**	**1.30**

PJTSAU-Hyderabad

An **e**xperiment was carried out with the following set of treatments.

T1 *Bt* 1kg/h
T2 *Beauveria bassiana* 5g/l
T3 *Metarrhizium anisopliae* 5g/l
T4 *Verticillium lecanii* 5g/l
T5 Neem oil (Azadirachtin 1500 ppm) 5ml/l
T6 Insecticidal check
T7 Untreated Control

The first spray was given on initial occurrence of the pest and rest based on abundance of pest. Cloth screen was used to avoid drift into neighbouring plots. Aphid population in 5 randomly selected plants (terminal shoots) from each plot was recorded before treatment and 10 days after each treatment. Yield per plot was recorded at harvest

Among the botanicals and bio pesticides tested, *Verticillium lecanii* recorded significantly lesser populations of aphids (62.40 and 4.89 aphids) followed by Neem oil (66.83 and 7.01) on top five cm of shoot of five randomly selected plants per plot. However, other biological options *viz.*, *Metarhizium anisopliae*, *Beauveria bassiana* and *Bt* were failed to show their impact by proving better only than untreated control (**Table 40**).

Table 40: Biological Suppression of *Uroleucon carthami* in non spiny safflower varieties.

S.No.	Treatment	Aphid population (top 5cm of shoots of 5 randomly selected plants; mean of 3 rep.)	
		After first application	After second application
1.	Bt @ 1kg/ha	84.37^{c}	17.10^{c}
2.	*Beauveria bassiana* @ 5g/L	84.67^{c}	21.30^{d}
3.	*Metarrhizium anisopliae* @ 5 g/L	86.50^{c}	21.03^{d}
4.	*Lecanicillium lecanii* @ 5 g/L	62.40^{b}	4.89^{b}
5.	Neem oil (Azadirachtin 1500 ppm) @ 5 ml/L	66.83^{b}	7.01^{b}
6.	Chemical check – Dimethoate @ 0.3 ml/L	56.60^{a}	2.73^{a}
7	Untreated control	99.53^{d}	24.33^{e}
	F-value	Sig.	Sig.
	CD	5.40	2.15

2. Biological control of Groundnut pest complex (PJTSAU-Hyderabad)

The trial was laid out at Agricultural Research Station, Tandur with the following treatments.

T1 Release of *T.chilonis* @ 1,00,000/ha, 3-4 times
T2 :Spray of *Bt*. @ 1 kg/ha twice at 15 day interval
T3 :Spray of NSKE 5% 3-4 times
T4 :Spray of *Beauveria bassiana* 2 kg/ha twice at 15 days
T6 :Insecticidal check
T7 :Control

Despite good crop growth, the populations of *Spodoptera litura* and aphids are continued to be below the ETL.

3. IPM in Groundut in Rajasthan and Haryana (NCIPM-New Delhi)

Preliminary evaluation of IPM module against white grub damage in groundnut was undertaken at ARS, Durgapura. Five treatments were compared with and without the involvement of bioagents. Two bioagents viz. *Metarhizium anisopliae* (obtained from NBAII, Bangalore) was used for seed treatment while the other bioagent i.e. entomopathogenic nematode (*Heterorhabditis sp.*) carrying cadavers of *Galleria melonella* were released @4000/acre. Other treatments included seed treatment with chlorothalonil alone; combination of chlorothalonil with Tebuconazole, besides the maintenance of crop hygiene for pest management as per details in (**Table 41**).

Results indicated that while the yields in seed treatment with chlorothalonil alone and in combination with Tebuconazone were at par at 24.16 and 24.58 q/ha, respectively as compared to 8.33 q/ha in untreated check. The plant population was significantly higher in T4. Followed by T3 as compared to other treatments except T-1 which was marginally better than control and T2 and T5 (**Table 41**).

Table 41: Data on preliminary evaluation of IPM module against white grub damage in groundnut

Treatments	Plant population/ plot	Cumulative plant mortality/plot	Pod yield (qt/ha)	Nodule count/g of root
Control (Untreated check)	639	197	8.33	406
T1: Seed treatment with *M. anisopliae* at 2 kg/ha	737	143	12.08	358
T2: Application EPN (*G. melonella* cadavers at 4000/acre)	623	144	12.50	474
T3: Seed treatment with Chlorothalonil at 2 gm/kg seed	1255	114	24.16	315
T4: Seed treatment with Tebuconazole + Chlorothalonil at 2 gm/kg seed each	1535	116	24.58	311
T5: Maintenance of crop hygiene for prevention of pest management	664	177	11.25	481

Trial Location 2: Village Phogat, Dist. Bhiwani via Jhajjar, Haryana (Farmer's Field)

Area: approx. 1 Acre
Date of sowing: 23.7.2014
Plant Spacing: R-R: 40 cm x P-P 20 cm

Variety sown: Groundnut var. G-10 (Anand Industries, Gujarat)

Metarrhizium anisopliae and *Galleria melonella* cadavers carrying Entomopathogenic nematodes *Heterorhabiditis* sp. IARI Strain (obtained from NGO FARMER, Ghaziabad UP)

The Experiment was carried out in one acre area of sandy loam soil. Thirteen different IPM treatments were carried out in groundnut field for the management of whitegrub (*Holotrichia consanguinea*). Average yield (kg/100 sqm), root nodulation, (no./g d wt of root) and per cent damage of whitegrub were recorded (**Table 42**).

Highest average yield (22.90 kg/100 sqm) was found in T_{12} (*Rhizobium* + T_3) treatment, followed by T_3, T_{11}, T_{14}, T_4, T_{10}, T_8, T_6 and T_2 treatments with an yield range of 18.0 to 20.0 kg/100 sqm area. Treatments of *Rhizobium* alone and in combination with other treatments indicated comparatively more pod yield. Similarly, more root nodulation were also recorded in *Rhizobium* treatments ranging from 352 to 428 root nodules in per g d wt roots. Whereas, it varied from 142 to 177 nodules/ g d wt roots in treatments without *Rhizobium*. Although, whitegrub infestation was found in all the plots, but as compared to untreated plot it was rather lower in different treatments. Lowest pest infestation was recorded in T_4 treatment with 18% plant mortalities, while it was 35% in untreated plot. Other treatments exhibited infestation of whitegrub between 19 to 32%, while *Galleria* cadavers carrying entomopathogenic nematodes failed to yield any infective juveniles at field level.

Table 42: Performance of different treatments for the management of pest infestation in groundnut

Treatments	Area (sq.m.)	Average no. of plants	Average yield /100 sqm	Average Nodulation/g root	Whitegrub damage (%)
Untreated Control:	500	5000	7.80	163	35
T-1: Bavistin 50% EC) @ 2g a.i. /kg seed	210	2100	7.30	152	32
T2: Seed Treatment with *M. anisopliae* 10 ml/kg seed	210	2100	18.00	155	21
T3: *M. anisopliae* 10 ml/kg seed + Bavistin	500	5000	20.00	161	19
T4: FYM+ *M. anisopliae* 500 ml/50 kg FYM	500	5000	19.10	166	18
T5: Application of *EPN* (IARI strain) alone	300	3000	8.10	177	33
T6: *Rhizobium* alone	300	3000	18.20	428	29
T7: EPN+ T1	100	1000	8.30	143	31
T8: *Rhizobium*+ T1	100	1000	18.40	401	27
T9: EPN+ T2	100	1000	8.10	142	31
T10: *Rhizobium* +T2	100	1000	18.70	365	24
T11: EPN + T3	300	3000	19.70	153	23
T12: *Rhizobium*+ T3	300	3000	22.90	396	21
T13: EPN+ T4	300	3000	11.20	144	29
T14: *Rhizobium*+T4	300	3000	19.30	352	22

4. Field Evaluation of entomopathogenic fungi against Soybean Defoliators (Dir.Soy.Res,Indore)

A field trial was conducted at the Research Farm of ICAR-Directorate of Soybean Research, Indore during kharif 2014 to evaluate the efficacy of native strains of *Beauveria bassiana* against major lepidopteron defoliators of soybean namely *Chrysodeixis acuta* (Walker), *Diachrysia orichalcea* (Fabricius), *Gesonia gemma* Swinhoe, and *Spodoptera litura* (Fabricius). There were four treatments consisting of three *B. bassiana* strains of DSR, Indore and an untreated control. One aqueous spray @ 10^8 spores/ml strength was applied at pod initiation stage. Observations were recorded ten days after spraying for number of larvae for meter crop row and yield at harvest.

Treatment effects on number of larvae per meter crop row and yield were not significant (**Table 43**) and *B. bassiana* infection was not observed in the field. However, in treatments DSRBB1 and DSRBB3 lower semiloopers population (7.7 and 10.0 respectively per mrl) was recorded as compared to the control (12.3 per mrl) which

accounted for 38 and 19 per cent reduction over control respectively. In the treatment DSRBB2 a higher number of larvae were observed (13.0 per mrl) as compared to control. Though treatment effects were not significant grain yield in treated plots was higher as compared to control (1412 Kg ha^{-1}). Highest yield was recorded in the treatment DSRBB3 (1701 Kg ha^{-1}) followed by DSRBB1 (1693 Kg ha^{-1}) that is nearly 20 per cent increase over control. Incidence of *S.litura* was below ETL hence data is not reported.

Table 43. Efficacy of native *Beauveria bassiana* isolates against semiloopers in soybean in year 2014 at Indore

Treatment	No. of larvae per meter crop row*		Yield Kg^{-1}	PCOC[§] Incidence	PCOC Yield
	1DBT[$]	10DAT[#]			
DSRBB1	5.0[a] (2.34)	7.7[a] (2.81)	1693[a]	-38	+19.9
DSRBB2	5.3[a] (2.41)	13.0[a] (3.41)	1604[a]	+5	+13.6
DSRBB3	5.3[a] (2.40)	10.0[a] (3.17)	1701[a]	-19	+20.5
Control	4.0[a] (2.11)	12.3[a] (3.54)	1412[a]	0	0.0
F (*df* = 3, 6)	1.65	0.47	0.29	-	-
P>F (ANOVA)	0.27	0.72	0.83	-	-

Figures in the parentheses are square root transformed values. Means within a column followed by the same alphabet are significantly not different (Tukey's test, P>0.05). **Chrysodeixis acuta+Diachrysia orichalcea+Gesonia gemma* [$] DBT: days before treatment [#]DAT: days after treatment [§]PCOC: Per cent change over control

5. Evaluation of entomopathogens and botanicals against soybean pest complex (MPKV-Pune)

The experiment was conducted on the research farm of Botany Section, College of Agriculture, Pune during *Kharif* for three years during 2011 to 2014. The seeds of soybean var. JS- 9305 were sown at 45 x 10 cm distance in 5 x 4 m plots. The trial was laid out in randomized block design with six treatments and four replications. The treatments comprised MPKV and NBAII strains of *Nomuraea rileyi* @ 10^8 conidia/ml, *Sl*NPV @ 250 LE/ha (1.5 x 10^{12} POBs/ha), EPN *Heterorhabditis indica* @ 1 billion IJs/ha, NSKE 5% suspension and untreated control. Three sprays were given at fortnightly interval starting from 12/9/2013. The larval population of *Spodoptera litura* was recorded in 1 m row at 5 spots per plot a day before treatment application as pre-count and post counts, a week after each spray. The data on larval population were transformed into $\sqrt{x+0.5}$ values for statistical analysis. About 30 larvae of *S. litura* per plot were collected 24 hr after third spray along with food and brought to the laboratory. The larvae were reared on the food collected from the respective plots till mortality / pupation to compute per cent mortality due to diseased conditions. At harvest, grain yield per plot were recorded and then converted into quintal per ha.

The experiment was conducted for three consecutive years during 2011-2012 to 2013-2014. Pooled analysis of three years data revealed that three sprays of *Sl*NPV @

250 LE/ha (1.5 x 10^{12} POBs/ ha) was significantly superior in suppressing the larval population of *S. litura* (2.0 larvae/m row) with 77.5 per cent mortality due to virus infection and gave maximum of 22 q/ha yield of soybean. It was, however, at par with *N. rileyi* strains of MPKV as well as NBAII. The MPKV strain of *N. rileyi* showed av. 2.5 surviving larval population of *S. litura* per m row with 63.8 per cent mortality due to fungal infection and 19.9 q/ha yield followed by NBAII strain (**Table 44**).

Table 44: Effect of entomopathogens on larval population of *S. litura* on soybean (Pooled Data 2011-12, 2012-13 and 2013-14).

Treatments	Pre-count	Larval population/m row @ 7 DAS				Mortality (%)	Yield (q/ha)
		I spray	II spray	III spray	Pooled mean		
MPKV *N. rileyi* @ 10^8 conidia/ml	6.0 [a]	4.1 [a]	2.1 [a]	1.2 [b]	2.5 [b]	63.8	19.9 [a]
NBAII *N. rileyi* @ 10^8 conidia/ml	6.3 [a]	4.1 [a]	2.3 [a]	1.2 [b]	2.5 [b]	55.3	19.3 [b]
*Sl*NPV @ 250 LE/ha	6.1 [a]	3.9 [a]	1.8 [a]	0. 4 [a]	2.0 [a]	77.5	22.0 [a]
EPN-*H. indica* @ 1 billion IJs/ha	6.6 [a]	5.7 [b]	3.9 [b]	2.5 [c]	4.0 [c]	37.9	16.6 [c]
NSKE 5% suspension	6.5 [a]	5.7 [b]	3.9 [b]	1.9 [b]	3.8 [c]	47.0	16.8 [c]
Control	6.1 [a]	8.9 [c]	11.7 [c]	14.5 [d]	11.7 [d]	5.5	12.6 [d]
CD (p = 0.05)	**NS**	**0.29**	**0.28**	**0.24**	**0.13**	**-**	**2.21**

6.Validation of IPM module in soybean (MPUAT-Udaipur)

The experiment was laid out at agronomy farm RCA, MPUAT, Udaipur and at farmer's field sarangpura kanod, panchayat samiti Bhinder, Udaipur in *Kharif*, 2014. Soybean variety JS-9305 was sown. Soil application of *Metarhizium anisopliae* and two sprays of NSKE 5% were found significantly effective in controlling major pests of soybean crop and produced higher grain yield of 16.05 q/ha (**Table 45).**

Table 45 : Validation of IPM modules in soybean (MPUAT) Two year pooled data.

S.No.	Treatments	Green Semilooper larval population mrl*	Per cent Plant mortality per plot due to soil pest	Sucking pests/3 trifoliate leaves	Tobacco caterpillar larval population mrl*	Yield (qt/ha)
1.	*Metarhizium anisopliae*	2.7 (9.46)	4.26 (11.91)	2.28 (8.68)	3.52 (10.81)	10.50
2.	*Trichogramma chilonis*	3.2 (10.30)	7.30 (15.67)	2.90 (9.80)	2.66 (9.38)	11.00
3.	Soil application of *Metarhizium anisopliae* and two sprays NSKE 5%	2.9 (9.80)	5.32 (13.33)	2.20 (8.53)	2.32 (8.76)	16.05
4.	Farmer Practices	4.6 (12.38)	8.89 (17.35)	5.19 (13.17)	6.17 (14.38)	8.75
	Sem±	0.217	0.852	0.589	0.626	0.915
	CD 5%	0.673	2.641	1.823	1.940	2.836

Large scale (10 ha) validation of IPM module at farmers field i.e. Soil application of *Metarhizium anisopliae* and two sprays of NSKE 5% were found significantly effective in controlling major pests of soybean crop with higher grain yield 14.6 q/ha and as compare to the yield of farmers practise (12.90 q/ha) (**Table 46).**

Table 46:- Validation of IPM modules in soybean at farmers field kharif 2014 (sarangpura kanod, Udaipur**)**

S. No	Treatment	yield
1	IPM modules	14.60
2	Farmer practices	12.90

7. Biological suppression of mustard aphid, *Lipaphis erysimi* (MPKV-Pune)

A field experiment is laid out on the Research farm of Entomology Section, College of Agriculture, Pune during *rabi* 2014-15. The seeds of mustard var. Sita are sown at the rate 5 kg/ha at 45 x 15 cm spacing in the plots of 8 x 5 m size on 28/12/2014. The trial was laid out in RBD with 7 treatments and 3 replications. The treatments comprised spraying of *Metarhizium anisopliae, Lecanicillium lecanii, Beauveria bassiana,* each @ 10^8 conidia/ha, NSKE 5% suspension, insecticidal check dimethoate 30EC @ 0.06% and untreated control. Three sprays of treatment applications were given at fortnightly interval starting from 30/01/2015. The aphid population was recorded on 5 cm apical shoot per plant from 10 randomly selected plants per plot a day before treatment application and post counts at 3, 5 and 7 days after each spray. Data on aphid population was transformed into $\sqrt{x+0.5}$ values for statistical analysis. The yield data was recorded on per plot basis and converted into quintal/ha for statistical analysis.

Data in **Table 47** indicated that, three sprays of dimethoate @ 0.5 % at fortnightly interval found significantly superior over rest of the treatments in suppressing the mustard aphid population (4.4 aphids/5 cm apical twig) and increased the yield (7.4 q/ha). However, it was at par with combination treatment of *L. lecanii* @ 10^8 conidia/ml + *M. anisopliae* @ 10^8 conidia/ml in reducing the mustard aphid population (6.0 aphids/5 cm apical twig) and increase in seed yield of mustard (7.2 q/ha).

Table 47: Effect of different bioagents on aphid population and yield of mustard

Treatments	Aphid population/5 cm shoot/plant					Yield (q/ha)
	Pre count	I spray	II spray	III spray	Average	
M. anisopliae @ 10^8 conidia/ml	23.3 [a]	13.1[b]	9.1[b]	4.5[b]	8.9[b]	6.7[b]
L. lecanii @10^8 conidia/ml	24.1[a]	14.5[b]	9.5[b]	5.3[b]	9.8[b]	6.4[b]
B. bessaina @ 10^8 conidia/ml	23.7[a]	16.0[c]	14.3[c]	9.6[c]	13.3[c]	5.9[c]
NSKE @ 5%	23.6[a]	16.3[c]	12.9[c]	9.4[c]	12.9[c]	6.0[c]
L. lecanii + *M. anisopliae* @ 10^8 conidia/ml	24.2[a]	10.2[a]	5.8 [a]	2.1[a]	6.0 [a]	7.2 [a]
Dimethoate 30 EC @0 .05%	24.8[a]	8.3[a]	3.9 [a]	1.1[a]	4.4 [a]	7.4 [a]
Untreated control	23.7[a]	30.9 [d]	32.6[d]	38.1[d]	33.8[d]	4.8[d]
CD (p = 0.05)	**NS**	**0.30**	**0.43**	**0.67**	**0.37**	**0.60**

2.10. Coconut

1. Survey and collection of natural enemies of coconut black headed caterpillar, eriophyid mite and red palm weevil (CPCRI)

CPCRI - Kayamkulam

Various stages of pests of coconut were collected from infested tracts for documenting natural enemies at Kayamkulam. The natural enemies recorded were given in **Table 48**.

Table 48: Natural enemies recorded on pests of coconut palm

Pest	Location	Natural enemies	Period of observation
Coconut black headed caterpillar (*Opisina arenosella*)	Kerala, Karnataka	*Brachymeria nosatoi*	April, June, August, February
		Goniozus nephantidis	April, June
		Apanteles taragamae	April, October, March
		Elasmus nephantidis,	June
		Bracon brevicornis	June
		Xanthopimpla sp	August
		Parena nigrolineata	June, March
Eriophyid mite (*Aceria guerreronis*)	Kerala	*Bdella sp*	January
		Neoseiulus baraki	Throughout the year
		Thrips	November
Red palm weevil (*Rhynchophorus ferrugineus*)	Kerala, Assam	*Nil*	--

2. Surveillance and need-based control of coconut leaf eating caterpillar, *Opisina arenosella* in Kerala (CPCRI)

An outbreak of *Opisina arenosella* (42.06% leaf damage) was noticed in Trivandrum during April 2014 in West Coast Tall variety of coconut palms aged above 30 years with a spread of about 3ha of area with pest population of 157/100 leaf lets. Awareness campaign was conducted with active participation of Parasite Breeding Station, Dept. of Agriculture, Trivandrum and Peoples' representatives of the locality on biological control of the pest. Pest incidence was noticed in Maniyanthuruthu area, Vechoor Panchayath of Kottayam District during April 2014 with a spread of about 10ha area. Monthly releases of larval parasitoids viz., *Goniozus nephantidis* and *Bracon brevicornis* were undertaken and the plot was monitored. 49.3% reduction of the pest population was noticed (**Table 49**).

Table 49: Population of various developmental stages of *O. aresnosella* (Number/100 infested leaflets) on coconut palm at Vechoor, Kottayam (2014-2015)

Period	Number/100 leaflet				
	Neonate larvae	Larva	Pre-pupa	pupa	Total population
May-14	220	3	0	0	223
Jun-14	0	77	33	75	185
Jul-14	70	116	3	3	192
Aug-14	92	16	4	28	140
Oct-14	2	51	26	23	102
Dec-14	0	14	10	3	27
Feb-15	0	118	56	14	188
Mar-15	29	50	24	10	113

Demonstration on Integrated management of *Opisina arenosella* in Karnataka

Demonstration of IPM of *Opisina arenosella* initiated in December 2013 at Jajuru village, Arasikere (Tq.), Hassan (Dist.) was monitored during 2014-15 and stage specific parasitoids *viz.*, *Goniozus nephantidis* and *Bracon brevicornis* @ 20 parasitoids/ palm were released subsequently based on pest population in the field. Significant recovery of the palms was noticed in the demonstration plot. There was no fresh feeding damage by the pest and this forms a model plot for nearby farmers to emulate the IPM strategies in the management of *O. arenosella* (**Fig 1.).**

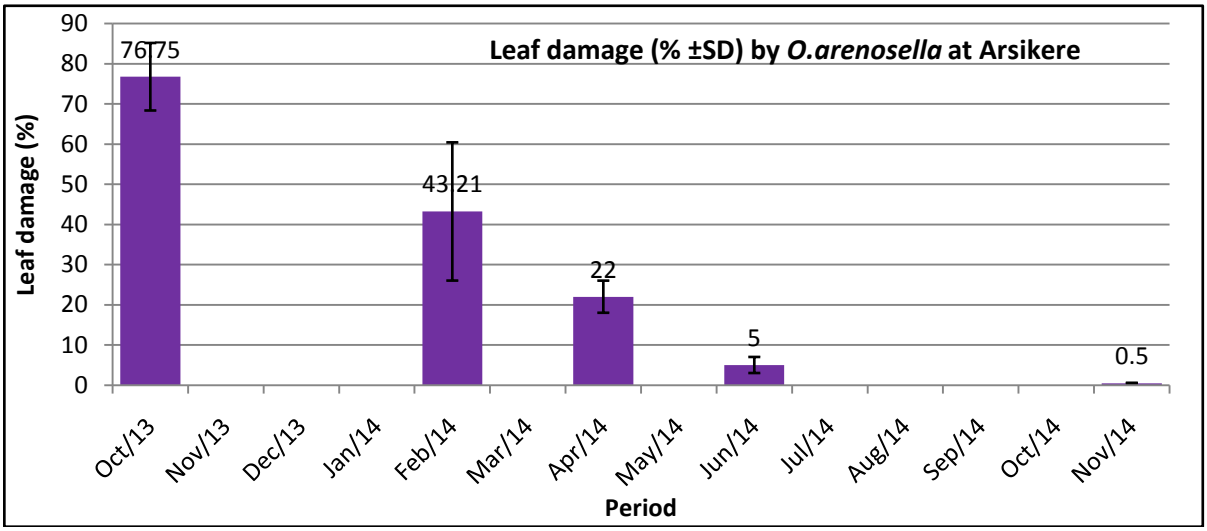


Fig. 1. Leaf damage by O arenosilla in the IPM plot at Arsikere in Karnataka

3. Scaling up and utilization of *Metarhizium anisopliae* through technology transfer (CPCRI)

Training on farm level mass production of *M.anisopliae* for biological suppression of coconut rhinoceros beetle was imparted to farmers from Punnapra, Alappuzha dist sponsored by ATMA during 10 March 2015. Awareness programmes through field level farmers interactive meetings (9 programmes) and mass media (farm

journals, Radio and Doordarshan) were utilized for technology transfer. Facilitated the already existing mass production units of Edava Womens Association (Trivandrum Dist.) and women Self Help Group of Bharanikkavu (Alappuzha dist.) by supplying mother culture as per requirement. *Metarhizium anisopliae* was mass multiplied on rice at CPCRI, Kayamkulam. Well sporulated fungal colures were packed as 100g packets and were used for field application at the breeding sites of rhinoceros beetle. 170kg of *Metarhizium anisopliae* culture were supplied to farmers for treatment of breeding sites of rhinoceros beetle in 3 panchayaths of Alappuzha Dist., Kerala (Kandalloor, Devikulangara and Krishnapuram) and Kanzikuzhi block through ATMA sponsored FFS programmes. Distribution of GMF was undertaken in collaboration with farmers club NABARD, Milk society and FFS members.

4. Entomopathogenic nematodes for management of red palm weevil (*Rhynchophorus ferrugineus*) (CPCRI)

Infestation of coconut by red palm weevil is on the rise in the recent years and many times farmers diagnose the attack only at an advanced stage of damage beyond recovery. Field efficacy of many bio-control agents failed as the rottening crown tissue of coconut due to the feeding grubs could not sustain survival of any bio-agents. Though entomopathogenic nematodes belonging to *Heterorhabditis indica* could kill *R. ferrugineus* grubs in the laboratory, delivery of *H. indica* in water suspension failed to infect the feeding grubs in the damaging coconut crown. This is mainly attributed to excess moisture regime and surplus production of alcohol in the system. Combined application of *H. indica* and imidacloprid (0.002%) was found effective in the field level bio-management of red palm weevil in coconut provided EPN is delivered in cadaver form. Delivery of EPN was thus refined by placing cadaver form on the infected palm axils in synergy with imidacloprid (0.002%). 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. Though delivery of cadaver form was successful than talc-preparation and water suspension, this strategy needs further refinement for effective suppression of red palm weevil infestation.

2.11. Tropical Fruits

1. Field evaluation of *Metarhizium anisopliae* formulations against mango hoppers *Idioscopus niveosparsus* (KAU, MPKV, TNAU)

KAU-Thrissur

Different formulations of *Metarhizium* along with chemical and botanical insecticides were evaluated against mango hoppers. Two sprays were given during January at weekly intervals. Observations on the number of hoppers per inflorescence were recorded before and after treatment imposing. Observations were made from five panicles per tree

Location: Regional Agronomic Research Station, Mannuthy
Season: January, 2015 – March 2015
Design: RBD
Treatments: 6
Replication: 5 (1 tree/replication)
Variety: Kalapady

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

The results showed that all the *M. anisopliae* treatments were on par in reducing the population of mango hoppers and the three treatments were significantly superior to control. Significant reduction in hopper population was found in trees sprayed with Imidacloprid and Nimbicidine. All the *M. anisopliae* formulations were on par in causing reduction of hopper population. They were superior over control but second to chemical and botanical insecticides (**Table 50)**.

Table 50: Effect of *M. anisopliae* formulations against *I. niveosparsus* (2015)

Treatments	Number of hoppers per panicle		% reduction over pre count
	Pre count	Post count	
M. anisopliae oil formulation @ 1ml/2l	29.0 (5.41)	12.5 (3.58)^{b}	57.4^{b}
M. anisopliae liquid formulation @ 1ml/2l	35.3 (5.93)	21.5 (4.61)^{b}	40.0^{b}
M. anisopliae talc formulation 10g/l	36.3 (6.06)	19.0 (4.36)^{b}	47.2^{b}
Imidacloprid @0.3ml/l	35.5 (5.99)	2.0 (1.54)^{a}	94.4^{a}
Nimbicidine @0.3 %	34.0 (5.87)	3.3 (1.81)^{a}	90.1^{a}
Control	32.5 (5.73)	36.5 (6.08)^{c}	15.1^{c}
Significance	NS	S**	S**
CV %		20.49	28.5

Analyzed the data after √X+0.5 transformations. Figures in parenthesis are transformed values. S**- Significant at 1% level NS-Non Significant

Data of 2013-14 and 2014-15 were pooled for getting confirmative results (**Table 51**).

In Imidacloprid and Nimbicidine sprayed trees caused significant reduction in hopper population were on par.Oil formulation of *M. anisopliae* was superior *M. anisopliae* liquid and talc formulations were on par in reducing hopper population, all the treatments were superior over control (**Table 51**).

Table 51: Effect of *M. anisopliae* formulations against *Idioscopus niveosparsus* (pooled)

Treatments	**Number of hoppers per panicle**	
	Pre count	**Post count**
M. anisopliae oil formulation @ 1ml/2l	17.88 (5.31)	7.00 (2.40)[b]
M. anisopliae liquid formulation @ 1ml/2l	30.50 (5.40)	13.63 (3.54)[c]
M. anisopliae talc formulation 10g/l	36.13 (6.04)	11.50 (3.21)[c]
Imidacloprid @0.3ml/l	38.00 (6.19)	1.00 (1.12)[a]
Nimbicidine @0.3 %	28.13 (5.29)	2.75 (1.69)[a]
Control	27.38 (5.32)	20.63 (4.17)[d]
Significance	NS	S**
CV %		6.35

Analyzed the data after √X+0.5 transformations. Figures in parenthesis are transformed values. S**- Significant at 1% level NS-Non Significant

MPKV-Pune

The trial was laid out in the mango orchards at Regional Fruit Research Station, Ganeshkhind, Pune for three consecutive years during 2011 to 2014. Each treatment block had 50 trees which further divided into five sub-plots as replicates. The planting distance was 10 x 10 m. The treatments were as *Metarhizium anisopliae* @ 1 x 10^9 spores/ml with adjuvant (sunflower oil 1 ml/l + Triton-X 100 @ 0.1 ml/l) during off-season followed by four sprays of the fungal suspension during flowering at weekly interval, four sprays of *M. anisopliae* @ 1 x 10^9 spores/ml with adjuvant during flowering, four sprays *M. anisopliae* @ 1 x 10^7 spores/ml with adjuvant during flowering, one spray of imidacloprid @ 0.3 ml/l during flowering and untreated control. The hopper population was recorded prior to imposing the treatments and post treatment observations were made a week after each spray. Observations were made from four inflorescence per tree and as such 10 trees per plot as well as number of fruits set per inflorescence. The off-season spray of *M. anisopliae* was given in the month of December and subsequent four sprays were given during flowering period. Data on hopper population were transformed into √x+0.5 values before subjecting to analysis of variance.

The pooled data of three years (**Table 52**) indicated that the spraying of *M. anisopliae* @ 1 x 10^9 spores/ml during offseason in the month of December followed by four sprays of the entomofungal pathogen mixed with adjuvant (sunflower oil 1 ml/lit + Triton- X 100 @ 0.1 ml/lit) at weekly interval during flowering found significantly superior over other treatments in suppressing the hopper population and increased fruit setting. The mean surviving population was recorded as 11.0 hoppers and 11.8 fruit sets per inflorescence in this treatment as against 54.4 hoppers and 6.0 fruits set of mango per inflorescence in untreated control block.

Table 52: Effect of *Metarhizium anisopliae* on hopper population and fruit set of mango (Pooled data for 2011-12, 2012-13 and 2013-14)

Treatments	Pre-count	Hopper population/ inflorescence, 7 days after spray. Replications					Fruit set / inflore scence
		I	II	III	IV	Average	
M. anisopliae @ 1 x 10^9 spores/ml with adjuvants - 1 spray in off-season + 4 sprays in flowering	34.8 [a]	21.2 [a]	11.0 [a]	7.4 [a]	4.3 [a]	11.00 [a]	11.8 [a]
M. anisopliae @ 1 x 10^9 spores/ml with adjuvants - 4 sprays in flowering	35.9 [a]	26.1 [b]	19.4 [b]	16.0 [b]	8.7 [b]	17.6 [b]	10.3 [b]
M. anisopliae @ 1 x 10^7 spores/ml with adjuvants - 4 sprays in flowering	36.0 [a]	27.3 [b]	20.8 [b]	17.6 [c]	13.1 [c]	19.7 [b]	8.8 [c]
Imidacloprid @ 0.3 ml/l - 1 spray at pre-flowering	36.0 [a]	15.1 [a]	19.6 [b]	23.6 [d]	27.0 [d]	21.3 [c]	8.2 [c]
Control	36.4 [a]	45.5 [c]	51.5 [c]	62.0 [e]	58.5 [e]	54.4 [d]	6.0 [d]
CD (p = 0.05)	**0.53**	**0.72**	**0.32**	**0.59**	**0.39**	**0.30**	**1.48**

Means followed by same alphabet do not differ significantly @ p=0.05DNMRT

TNAU-Coimbatore

Treatments
T1- *M. anisopliae* Liquid formulation 1ml/2 L
T2- *M. anisopliae* Oil formulation 1ml/2 L
T3- *M. anisopliae* Talc formulation 1kg/100 L
T4- Neem oil 1%
T5- Untreated check

Replications : Five
Location of the field trial : ARS, Bhavanisagar, TNAU
Variety : Salem Bengalura
Date of spraying : 22.1.2015, 6.2.2015 & 18.2.2015

Field evaluation of *Metarhizium anisopliae* against mango hoppers was carried out during January to March 2015 at Agricultural Research Station, Bhavanisagar. Three different formulations viz., liquid, oil and talc formulations of *Metarhizium anisopliae* were evaluated in comparison with neem oil 1% and insecticide (Imidacloprid 17.8 % SL 0.4ml /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 5-8 hoppers/inflorescence. Three rounds of treatments were imposed at 12-15 days interval with the help of tree sprayer. The hopper population assessed 7 days after each round of spray indicated that the liquid formulation of *M. anisopliae* 1ml/2l was more effective over talc and oil formulations. The population reduction in imidacloprid spray was maximum as compared to other treatments. The efficacy of treatments in hopper control was reflected in the fruit set / inflorescence. Maximum fruit set of 2.7 / inflorescence was recorded in liquid formulation of *M. anisopliae* treatment (**Table 53**) whereas the least fruit set of 1.1 / inflorescence was noted in untreated check. Though superior performance of imidacloprid in checking the hopper population was noted, the fruit set (2.5 /inflorescence) was comparable with *M. anisopliae* liquid formulation. The *M. anisopliae* spray recorded a fruit set ranging from 2.1 to 2.7 fruits / inflorescence (**Table 53**). The order of efficacy among the different formulations of *M. anisopliae* in checking the hopper population was liquid formulations > talc formulation > oil formulation.

Table 53. Field evaluation of *Metarhizium anisopliae* formulations (IIHR) against mango hoppers

Treatments	Pre-treatment count Population of hoppers/ inflorescence	Mango hopper population /inflorescence, 7 days after each spray			Per cent reduction over control	Fruit set / Inflorescence
		I	II	III		
M. Anisopliae Liquid Formulation1ml/2l	7.1[a]	2.3[b]	1.4[b]	1.2[b]	89.74	2.7
M. Anisopliae Oil Formulation 1ml/2l	6.3[a]	4.7[c]	3.6[c]	3.3[c]	76.10	2.1
M. Anisopliae Talc Based Formulation 10g/l	6.7[a]	4.1[c]	3.2[c]	2.8[c]	71.79	2.3
Neem oil 1%	7.8[a]	4.5[c]	3.5[c]	3.0[c]	74.73	2.1
Imidacloprid @0.3ml/l	8.3[a]	0.6[a]	0.0[a]	0.0[a]	100.00	2.5
Untreated check	7.6[a]	8.7[d]	10.4[d]	11.7[d]	-	1.1

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

2. Field evaluation *Beauveria bassiana* liquid formulation against tea mosquito bug in Guava (TNAU-Coimbatore)

Variety : Lucknow 49
No of trees selected : 10

No. of sprays : 4
Location : Agricultural Research Station, Bhavanisagar
Date of first spraying : 22.1.2015, 6.2.2015,18.2.2015 and 28.2.2015

Field trial to evaluate the liquid formulation of *Beauveria bassiana* was laid out at ARS, Bhavanisagar during January 15 –March 15. As per the requirement ten guava trees were marked. Liquid formulation of *Beauveria bassiana* at 1ml/ lit was sprayed four times at 12-15days interval using tree sprayer. The fruit damage by tea mosquito bug *Helopeltis antonii* before spraying was 20.3 per cent. After four sprays, the fruit damage in the newly harvested fruits was 10.6 per cent in treated trees. But in unsprayed trees, the fruit damage recorded was 31.4 per cent at the same period of observation (**Table 54**).

Table 54. Field evaluation of *Beauveria bassiana* liquid formulation against tea mosquito bug in guava

Particulars	Mean fruit damage by *Helopeltis antonii* (%)	
	Treated plot	Untreated plot
Pre-treatment	20.3	18.6
Post- treatment (*B.bassiana* 1 ml/l)	10.6	31.4

3. Laboratory and field evaluation of entomopathogenic fungi against Banana Pseudostem borer *Odoiporus longicollis* (KAU)

KAU-Thrissur

In the laboratory evaluation, *B. basssiana* (10^8 spores/ml) and *M. anisopliae* (10^8 spores/ml) caused mycosis on grubs of banana pseudostem weevil and were selected for field evaluation.

Field evaluation

Field evaluation of two entomopathogens was carried out during October 2013 to July 2014. Treatments were given from fifth month onwards at monthly interval. Destructive sampling was done at the time of bunch harvest to record the pest incidence.

Design: RBD
Treatments: 6
Replication: 6 (4plants/rep.)
Location: Instructional Farm, Vellanikkara

Treatments
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

Chemical and entomopathogenic fungi treated plants were at par in causing reduction in pest incidence (**Table 55**).

Table 55: Effect of entomopathogens on banana pseudostem borer *Odoiporus longicollis*

Treatments	Pest incidence on plants (%)
M. anisopliae (10^8 spores/ml) leaf axil filling	12.5 (0.34)[a]
M. anisopliae (10^8 spores/ml) spraying	21.88 (0.48)[a]
B. bassiana (10^8 spores/ml) leaf axil filling	21.88 (0.48)[a]
B. bassiana (10^8 spores/ml) spraying	22.92 (0.48)[a]
Chlorpyriphos spraying @ 2.5 ml/l	9.36 (0.30) [a]
Control	65.58 (0.96) [b]
Significance	S**
CV value	31.90

Analyzed the data after $\sqrt{X+0.5}$ transformations. Figures in parenthesis are transformed values. S**- Significant at 1% level.

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

Bio-efficacy of EPNs against citrus trunk borer, *Pseudonemophas versteegi* were 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 of the 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. Two rounds of application of the treatments were made once during last week of April and the second application at second week of May. Observations on the efficacy of the treatments were recorded at monthly interval starting from 2nd fortnight of May up to 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 86.50 and 80.00 per cent at Pasighat and Rengging, respectively. Among the EPN treatments, CAU-1 stem injection (40.5 % reduction) was observed as the best treatment and it was closely followed by CAUH-1 stem injection (36.50% reduction), NBAII-01 stem injection (33.64 % reduction) and CAUH-2 stem injection (32.08% reduction) at Pasighat (**Table 56).** However, at Rengging, CAUH-1 stem injection gave the highest reduction in trunk borer infestation among the EPNs with 36.64% reduction and it was closely followed by CAU-1 stem injection (36.00% reduction), NBAII-01 stem injection (35.56% reduction) and CAUH-2 stem injection (33.84% reduction) (**Table 56)**. The stem injections of the EPNs were found more effective than their respective cadaver treatments.

Table. 56. Bio-efficacy of entomopathogenic nematodes against citrus trunk borer *Pseudonemaphas versteegi.*

Treatments	Pasighat (average of three orchards)			Rengging (average of three orchards)		
	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	14.20 (22.14)	8.50 (16.95)	40.50 (39.23)	14.29 (22.21)	9.29 (17.75)	36.00 (36.87)
CAU-2 Stem injection	12.50 (20.70)	8.80 (17.26)	29.60 (32.96)	14.76 (22.59)	10.08 (18.51)	31.70 (34.27)
CAU-3 Stem injection	13.00 (21.13)	9.20 (17.66)	29.23 (32.73)	11.90 (20.18)	8.10 (16.54)	31.93 (34.41)
CAUH-1 Stem injection	11.68 (19.98)	7.42 (15.81)	36.50 (37.15)	14.30 (22.22)	9.06 (17.52)	36.64 (37.25)
CAUH-2 Stem injection	13.40 (21.47)	9.10 (17.56)	32.08 (34.50)	13.00 (21.13)	8.60 (17.05)	33.84 (35.57)
CAU-1 Cadaver application	12.00 (20.27)	8.90 (17.36)	25.83 (30.55)	11.95 (20.22)	9.85 (18.29)	17.57 (24.78)
CAU-2 Cadaver application	13.35 (21.43)	10.20 (18.63)	23.59 (29.06)	14.00 (21.97)	10.60 (19.00)	24.28 (29.52)
CAU-3 Cadaver application	11.70 (20.00)	9.08 (17.54)	22.39 (28.24)	13.90 (21.89)	11.25 (19.60)	19.06 (25.89)
CAUH-1 Cadaver application	13.66 (21.69)	10.00 (18.43)	26.79 (31.17)	14.20 (22.14)	10.50 (18.91)	26.05 (30.69)
CAUH-2 Cadaver application	15.10 (22.87)	11.15 (19.51)	26.15 (30.76)	12.90 (21.05)	9.55 (18.00)	27.91 (31.89)
NBAII-01 Stem injection	12.90 (21.05)	8.56 (17.01)	33.64 (35.45)	14.93 (22.73)	9.62 (18.07)	35.56 (36.61)
NBAII-01 Cadaver application	12.80 (20.96)	9.46 (17.91)	26.09 (30.72)	13.72 (21.74)	11.08 (19.44)	19.24 (26.02)
Dichlorvos Stem injection	12.80 (20.96)	1.72 (7.54)	86.50 (68.49)	14.00 (21.97)	2.78 (9.60)	80.00 (63.43)
Untreated control	12.50 (20.70)	11.85 (20.14)	7.36 (15.74)	13.20 (21.30)	12.18 (20.43)	7.72 (16.13)
SE(m)±	0.22	0.19	0.90	0.29	0.10	1.15
$CD_{0.05}$	0.68	0.58	2.68	0.86	0.32	3.44
CV%	1.88	1.98	4.60	2.32	1.04	6.07

Figures in the parentheses are angular transformed values.

5. Field evaluation of entomopathogenic fungi against pineapple mealybug, *Dysmicoccus brevipes* (KAU-Thrissur)

The field experiment was carried out in Pineapple Research Station of Kerala Agricultural University, Vellanikkara where the mealybug infestation was very severe during December 2014. Mealybugs were observed on leaves and at the base of the plants. Randomly selected three leaves per plant were tagged. Spraying on leaves and drenching at the base with entomofungal pathogen were done in the evening hours. Second spray was given on 5^{th} day after 1^{st} spray and recorded the mealybug incidence on the tagged leaves on 5^{th} day after each spray.

Design: RBD
Treatments: 5
Replication: 9 (1 plant/replication)
Location: Vellanikkara
Season: December 2014 –February 2015

T1: *Lecanicillium lecanii* @ 10^7 spores/ml
T2: *Lecanicillium lecanii* @ 10^8 spores/ml
T3: *Lecanicillium lecanii* @ 10^9 spores/ml
T4: Imidacloprid 0.3ml/l
T5: Control

Imidacloprid caused 100% reduction in mealybug population and was significantly superior to *L. lecanii* $10^{7,}10^8$ and 10^9 spores/ml that was on par in reducing the mealybug population **(Table 57).**

Table 57 Field evaluation of *Lecanicillium lecanii* against *Dysmicoccus brevipes*

Treatments	Count of mealybug / leaf		% reduction over pre count
	Pre treatment count	10^{th} day after spray	
L. lecanii @ 10^7 spores/ml	23.16 (4.80)	7.1 $(2.68)^{bc}$	65.78 ^{b}
L. lecanii @ 10^8 spores/ml	17.9 (4.22)	3.7 $(1.96)^{b}$	76.03 ^{b}
L. lecanii @ 10^9 spores/ml	13.7 (3.69)	3.9 $(1.92)^{b}$	74.04 ^{b}
Imidacloprid 0.3 ml/l	19.8 (4.51)	0 $(0.71)^{a}$	100.00 ^{a}
Control	16.14 (4.04)	18.1 $(4.27)^{d}$	-12.20^{c}
Significance	NS	S**	S**
C.V %		28.64	26.37

Analyzed the data after $\sqrt{X+0.5}$ transformations. Figures in parenthesis are transformed values. S**- Significant at 1% level

6. Laboratory evaluation of entomopathogenic fungi against banana root mealybug *Geococcus citrinus* (KAU-Thrissur)

Laboratory evaluation of entomopathogenic fungi on green gram sprouts. Spraying was given and observations were recorded from 3rd day onwards.

Design: CRD
Replication: 3
Treatments: 12

Treatments

T_1T_3 Lecanicillium *lecanii* @ 10^7, 10^8, 10^9 spores/ml
T_4-T_6 *Beauveria bassiana* @ 10^7, 10^8, 10^9 spores/ml
T_7-T_9 *Metarhizium anisopliae* @ 10^7, 10^8, 10^9 spores/ml
T_{10}-T_{12} *Paecilomyces fumosoroseus* @ 10^7, 10^8, 10^9 spores/ml
T_{13} Control

Spraying in *Lecanicillium lecanii* (@ 10^7, 10^8, 10^9 spores/ml) and *M. anisopliae* (@ 10^7, 10^8, 10^9 spores/ml) caused mycosis in Mealybugs.

7. Laboratory evaluation of entomopathogenic fungi against pepper root mealybug *Formicoccus polysperes* (KAU-Thrissur)

Pepper root mealybug was collected from Wayanad district. Healthy mealybugs were released on potato sprouts. On establishment of mealybug the entomopathogenic fungi were sprayed and they observed for mycosis.

Design: CRD
Replication: 3

Treatments
T_1T_3 Lecanicillium *lecanii* @ 10^7, 10^8, 10^9 spores/ml
T_4-T_6 *Beauveria bassiana* @ 10^7, 10^8, 10^9 spores/ml
T_7-T_9 *Metarhizium anisopliae* @ 10^7, 10^8, 10^9 spores/ml
T_{10}-T_{12} *Paecilomyces fumosoroseus* @ 10^7, 10^8, 10^9 spores/ml
T_{13} Control

L. lecanii (10^7, 10^8 and 10^9 spores/ml) caused mycosis on pepper root mealybug under laboratory condition.

8. Monitor and record of incidence of papaya mealybug and its natural enemies on papaya and other alternate hosts (AAU-A, MPKV, KAU, TNAU, IIHR, NBAIR)

AAU-Anand

Five randomly selected villages in each district of middle Gujarat region were surveyed 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.

Survey to assess 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 a few farmer's fields. The samples of mealybug infested papaya fruits were brought in the laboratory and were reared on sprouted potato. The parasitoid viz., *Acerophagus papayae* was noticed parasitizing mealybug in laboratory condition.

Grade	**Population**
1	Very low
2	Low
3	Medium
4	High
5	Very high

Observations recorded:

1. Date of survey
2. Name and full address of the farmer
3. Crop plants infested.
4. Non host's crop and weeds infested
5. Chemical pesticides if any used with dose
6. Anticipated yield loss / ha (crop - wise)
7. Existing natural enemies in 25 randomly selected plant

Thirteen papaya Orchards in eleven villages in Baroda,Anand and Sabarkatha Districts of Gujarat had PMB infestation with an intensity of 1-4 grade .

KAU-Thrissur

Random survey was carried out in different districts of Kerala. Incidence of papaya mealybug was observed in Malappuram (Manchery) and Thrissur (Pookunnam) areas. The pest incidence was low in all areas (**Table 58**).

Table 58: Details of incidence of papaya mealybug and its parasitoid

No. of villages surveyed in different districts	**Infested plants**	**Infestation grading**	**Incidence of *A. papayae***
Thrissur - 9	0.9	Very low	Present
Ernakulam - 4	Not observed		
Palakkad - 4	Not observed		
Malappuram - 4	6.6	Very low to medium	Present
Wayanad - 2	Not observed		
Kozhikode - 2	Not observed		
Trivandum -2	Not observed		

Alternate hosts of papaya mealybug were tapioca, change rose (*Hibiscus mutabilis*) and pineapple. The parasitoid suppressed the population of mealybug within two months. Parasitism level of *Aceropahgus papaya*e on *H.mutabilis* was 5.9 per cent.

MPKV-Pune

The papaya orchards were surveyed for incidence of PMB in five agro-ecological zones of western Maharashtra and recorded its natural enemies as well as alternate hosts. The pest incidence was recorded on randomly selected 25 papaya plants from each orchard. The intensity rating of mealybug in 1-5 scale (1= very low; 2=low; 3=medium; 4=high; 5= very high population) from 5 plants per orchard and population of *A. papayae* per leaf were recorded.

The incidence of papaya mealybug (PMB) was noticed to the extent of 1.0 to 12.3 per cent in Pune, Jalgaon, Dhule, Nandurbar and Ahmednagar districts in western Maharashtra. The highest incidence was recorded in Nandurbar district (12.3 %) (**Table 59**). However, PMB incidence was recorded along with *Acerophagus papayae* and *Pseudleptomastix mexicana* and new parasitoid *Aprostocetus* nr. *purpureus* were recorded in PMB colonies. The average pest population density was relatively low during this year (0.8 to 6.2 mealybugs/ leaf).

Table 59. Incidence of papaya mealybug in western Maharashtra

District surveyed	PMB incidence (%)	Pest intensity rating	*papayae* adults/leaf
Pune	9.3	2.9	6.2
Ahmednagar	2.1	1.0	2.1
Jalgaon	8.7	2.7	4.2
Dhule	11.2	3.1	5.3
Nandurbar	12.3	3.2	6.1
Nashik	1.0	1.0	0.8
Solapur	4.6	1.4	2.0
Kolhapur	2.1	1.3	1.2
Satara	2.0	1.1	1.1
Sangli	1.7	0.2	1.0
Average	**5.5**	**1.79**	**3.00**
Range	**1.0 – 12.3**	**0.2 – 3.2**	**0.8 – 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 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*) and
3. Mulberry (*Morus alba*)

TNAU-Coimbatore

Survey was conducted in five districts of Tamil Nadu *viz*., Coimbatore, Erode, Tiruppur, Karur and Salem during the period under report. Among the districts surveyed, Erode district harboured higher incidence of papaya mealybug which ranged from 3.6 to7.5 % (**Table 60**). Though the incidence of mealybug occurs throughout the years, the prevalence was at high during October 2014 and December 2014 as compared to other months. In all the districts surveyed the incidence was higher during October and December months as compared to other months.

In all the districts surveyed the natural enemies *Acerophagus papayee*, *Anagyrus lockii*, *Cryptolaemus* and *Spalgis* were observed. The population of these parasitoids and predators were present throughout the year. The association of *Acerophagus papayee, Anagyrus lockii* and *Cryptolaemus* with papaya mealybug was significant and these natural enemies were more prevalent during the months of October and December 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 without severe outbreaks.

Table 60. Incidence of papaya mealybug on papaya and its natural enemies

No.of villages surveyed	Period	*P.marginatus* incidence (%)	Population of natural enemy/5 leaves			
			A.papayae	***Cryptolaemus***	***Anagyrus lockii***	***Spalgis epius***
Coimbatore - 14	July 14	2.4	1	0	0	0
	Aug 14	3.2	3	1	1	1
	Sep 14	2.7	1	1	0	0
	Oct 14	4.8	2	2	0	1
	Nov14	3.5	1	1	0	1
	Dec 14	6.2	4	2	1	1
	Jan 15	2.3	5	3	1	0
	Feb15	2.8	3	1	2	1
Tiruppur -18	July 14	1.3	0	1	0	1
	Aug 14	2.7	2	2	0	0
	Sep 14	2.2	1	0	1	1
	Oct 14	3.5	4	3	1	0
	Nov14	2.8	2	1	1	1
	Dec 14	5.4	6	3	0	1
	Jan 15	2.5	4	1	2	2
	Feb15	3.1	2	2	1	0
Erode -24	July 14	3.6	1	1	1	1
	Aug 14	5.2	3	2	1	1
	Sep 14	4.3	3	0	0	0
	Oct 14	7.2	5	2	2	1
	Nov14	5.0	3	1	1	0
	Dec 14	7.5	6	3	0	2
	Jan 15	3.6	3	2	2	1
	Feb15	4.2	2	1	0	2
Salem -6	July 14	1.6	0	1	0	0
	Aug 14	3.8	1	2	1	1
	Sep 14	2.3	1	0	0	2
	Oct 14	5.1	4	2	0	1
	Nov14	3.4	2	1	2	0
	Dec 14	4.3	3	3	1	2
	Jan 15	2.4	3	3	2	1
	Feb15	2.7	2	1	0	0
Karur -8	July 14	1.2	1	0	0	0
	Aug 14	2.8	3	1	1	1
	Sep 14	2.1	1	1	0	0
	Oct 14	3.7	3	2	0	0
	Nov14	2.6	2	1	2	2
	Dec 14	4.1	4	3	0	1
	Jan 15	1.4	4	1	1	0
	Feb15	1.8	2	1	1	1

IIHR-Bangalore

The host plants such as papaya, citrus, pomegranate, mango, jack fruit, custard apple, sapodilla, guava, tomato, brinjal, okra, chilli, beans, peas, hibiscus and parthenium were surveyed around Bangalore during the year for the incidence of *Paracoccus marginatus* and for the presence of its parasitoid *Acerophagus papayae*. No infestation of exotic mealybug was observed in any of the above crops. This indicates that the pest is totally controlled by the introduced parasitoid, *A. papayae*.

NBAIR- Bengaluru

Monitoring of papaya mealybug and its natural enemies on papaya and other alternate hosts

Based on the survey was conducted in different parts of the state and also the feedback from various AICRP (BC) centers revealed that the papaya mealybug *Paracoccus marginatus* did not reach pest status in any of the commonly occurring crops like Papaya, Plumeria, Parthenium, Hibiscus, Mulberry, and butter fruit (Avocado). However, incidence in very low level < 5% was recorded on Tapioca in Salem and Dharmapuri area. It was recorded in New Delhi in the polyhouse at IARI, and supply of two consignments of 500 number of *Acereophagus papayae* reduced the infestation.

Papaya mealybug on Mulberry

Infestation in mulberry was surveyed in the districts of Maddur, Hassan, Tumkur, Mandya, Chamarajnagar, Ramanagar, Kollegal, Kolar and Chikballapur area. The occurrence of papaya mealybug was nil in the surveyed areas. In only two places near Chamarajnagar and Kunigal it was found associated with the *Meconellicoccus hirsutus* which was also below pest level. (<025%). Number of sericulture farmers requesting for parasitoids was negligible in the entire year showing the complete suppression of papaya mealybug in mulberry.

Occurrence of papaya mealybug on Papaya, weeds and other host plants in Karnataka

Incidence of papaya mealybug was very low in almost all the locations surveyed in Karnataka. Damages in the score of 1 (1- 5Scale) and below only were observed very sporadically in homesteads. Survey in about 41 orchards of papaya in Bangalore, Kanakapura, Mysore, Chamarajanagar, Nelamangala, Devanahalli, Kunigal, Mandya, Kolar, Tumkur road, Kollegal, Maddur and Hassan revealed not a single tree with papaya mealybug. In the homesteds > 85 % parasitization by *Acerophagus papayae* and also by *Pseudleptomastix mexicana* was found in all the places where ever papaya mealybug was observed. *Spalgius apius* was also recorded as one of the major factor for reduction of the pest.

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

Classical Biocontrol of papaya mealybug

- No incidence of papaya mealybug in Karnataka , Kerala, Andhra Pradesh, Maharashtra and Tamil Nadu.
- Reported from New Delhi and Gujarat in poly house but not in severe form. *A. papayae* was supplied to these areas and very good parasitization was observed in the new localities.
- Very high incidence of hyper parasitoids *Chartocerus sp.* was recorded in Bangalore (up to 15% in one sample collected from RT Nagar

2.12. Temperate Fruits

1. Evaluations of entomopathogenic fungi and EPNs for the suppression of apple root borer, *Dorysthenes hugelii* under field conditions (YSPUHF-Solan)

Bio-pesticides namely *Metarhizium anisopliae, Beauveria bassiana* (10^6 conidia/ cm² each), *Steinernema carpocapsae* and *Heterorhabditis indica* (80IJ/ cm² each) along with chlorpyriphos (0.06%) and untreated control were evaluated for the control of apple root borer, *Dorysthenes hugelii* in the farmer's field at Seobagh of Kullu district, Himachal Pradesh. The experiment was conducted on bearing trees of apple (cv. Royal Delicious) in randomized block design with each treatment replicated four times. The treatments were applied during the month of August, 2014 and the observations were recorded during November, 2014.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 tested, *Metarhizium anisopliae* (10^6 conidia/cm²) was the most effective (77.1% mortality) and was on par with chlorpyriphos (0.06%) which resulted in 82.9 per cent mortality of the grubs (**Table 61**). *Beauveria bassiana*(10^6 conidia/cm²), *Heterorhabditis indica* and *Steinernema carpocapsae* (80 IJ/cm² each) were only moderately effective against the pest resulting in 41.5, 39.0 and 32.8 per cent mortality of the grubs, respectively and were on par with each other. The mortality in control plants was 5.3 per cent.

Table 61: Evaluation of entomopathogenic fungi and EPNs for the suppression of Apple root borer, *Dorysthenes hugelii* under field conditions.

SN	Treatment	Larval mortality (%)
1	*Steinernema carpocapsae* (80 IJ/cm²)	32.8 (34.7)[b]
2	*Heterorhabditis indica* (80 IJ/cm²)	39.0 (38.5)[b]
3	*Beauveria bassiana* (10^6 conidia/cm^2)	41.5 (39.8)[b]
4	*Metarahizium anisopliae* (10^6 conidia/cm²)	77.1 (65.0)[a]
5	Chlorpyriphos (0.06%)	82.9 (65.7)[a]
6	Control(Untreated)	5.3 (11.3)[c]
	CD(p=0.05)	(16.2)
	CV (%)	25.0

Figures in parentheses are angular transformed values

2. Survey for identification of suitable natural enemies of codling moth (SKUAST)

Survey was conducted during 2014 in different orchards at Shanigund, Kharrol, Poyen, Hardass, Gond, Mingy, Mangmore and Bagh-e- Khomini of district Kargil for

collection of natural enemies. Braconids and ichneumonids collected on pupae were sent for identification. No indigenous *Trichogramma* was obtained.

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

The experiment was conducted in apple orchards at Kargil during 2014. Six treatments were (T_1) *Trichogramma embryophagum, (*T_2) *T. cacoeciae*, (T_3)*Trichogramma* spp. + mass trapping of adult moths through pheromone traps, (T_4) Trunk banding and destruction of infested apple, and (T5) Combination of all these approaches, were imposed in five orchards located at Shanigund, Mangmore, Bagh- e- Khomini, Kharrol and Mingy respectively. The observations were compared with untreated control (T6) selected at Hardass (Gond). Distance of these orchards varied from 2-20 Kms. Two sequential releases of *Trichogramma* spp.(@ 5000 adults/ tree) were made during May and July, 2014, coinciding with first and second generations of codling moths. Insect pheromone traps @ 4traps/ orchard were installed twice i.e. during May and late July. Trunk banding of ten apple trees were done during July- August 2013. Each location was also observed for its overwintering, larval density, trapped in trunk bands as well as adult moths trapped/ pheromone trap.

Overwintering larval density was determined by untying the trunk bands and counting the live larvae during the month of May' 2014 for each orchard. Data on larval density was based on ten trunk bands in each orchard.

Pheromone trap catches were based on counting of number of moths trapped/ 4 traps installed in each orchard during May and July.

For recording of data on last two parameters i.e. overwintering larval density/ burlap and pheromone trap catches, the experiments were laid in different orchards altogether.

As a result of above mentioned five treatments, average fruit damage varied from 54.9 to 74.0 per cent, when compared with untreated control (83.9%). Fruit damage on tree (F= 44.35**;d.f.= 5(45); p=0.00), dropped fruits (F= 15.07**;d.f.= 5(45); p=0.00) as well as overall fruit damage (F= 59.45**;d.f.= 5(45); p=0.00) differed significantly treatment wise, when data was analyzed through one way ANOVA. Efficacy of *Trichogramma cacoeciae* (T2) was better than *T. embryophagum* (T1) as it caused 15.7% reduction in fruit damage as compared to 9.9% as shown by the latter. Use of *Trichogramma* spp. along with mass trapping of adult moths using pheromone traps (T3) indicated an overall decline in fruit damage (58.2) thereby increased reduction in fruit damage (25.7 %). Trunk banding and destruction of overwintering larvae (T4) though showed some positive result, but this approach in combination with all other approaches in combination (T5) resulted in much better results in terms of overall fruit damage (**Table 62**) but statistically on par with T3 in terms of % reduction in damage.

Trunk banding of apple tree during overwintering period of codling moth larvae showed average catch ranging 26.3- 41.3 per tree (**Table 63**) differing statistically orchard wise (F= 4.1*; d.f.= 5(45); p= 0.004).

Mass trapping of adult moths using pheromone traps showed an average catch ranging 30.2 to 70.5 and 60.0 to 145.2/ trap in to first and second generation respectively (Table 2). Although differences in number of moths caught during second generation were

statistically non significant location wise ((F= 2.36 NS; d.f.= 5(15); p= 0.091), however, it was found significant for the first generation (F= 4.41*; d.f.= 5(15); p= 0.011) as well as when mean of two generations taken (F= 5.55*; d.f.= 5(15); p= 0.004). Mass trapping displayed a very important approach for managing the codling moth at Kargil.

Recovery of the released parasitoids could not be done because of loss of a majority of Tricho cards due to heavy winds at Kargil.

Table 62: Effect of Pheromone traps, *Trichogramma* spp. and trunk banding on apple fruit damage in the orchards of Kargil, during 2014

	Damage on tree (%)	**Dropped fruits (%)**	**Overall fruit damage (%)**	**% reduction in damage over control**
Shanigund (T1)	60.4 (51.3)^{b}	87.6 (70.0)^{d}	74.0 (59.5)^{b}	9.9 (16.7)^{c}
Mangmore (T2)	42.3 (40.5)^{c}	94.2 (76.4)^{c}	68.2 (55.7)^{c}	15.7 (23.2)^{b}
Bagh-e- Khomini (T3)	27.5 (31.4)^{d}	88.9 (70.9)^{d}	58.2 (49.7)^{d}	25.7 (30.4)^{a}
Kharrol (T4)	41.6 (40.1)^{c}	96.1 (78.9)^{c}	68.9 (56.2)^{c}	15.0 (22.5)^{b}
Mingy (T5)	16.7 (23.8)^{e}	93.2 (75.3)^{b}	53.6 (47.0)^{e}	30.3 (33.4)^{a}
Gond (T6) (Untreated check)	71.2 (57.6)^{a}	96.7 (80.0)^{a}	83.9 (66.4)^{a}	--
C.D.(0.05)	**4.4**	**2.5**	**2.13**	**3.48**

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

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

Table 63: Average catch of larvae and adults through trunk banding and pheromone traps during 2014

	Av. Larvae/ burlap	Av. adults / trap during May' 2014	Av. adults / trap during July' 2014	Total average moths/ trap
Shanigund	34.5 (5.8)[a]	51.7 (7.2)[a]	124.0 (10.9)[a]	87.8 (9.03)[a]
Mangmore	26.3 (5.0)[b]	43.7 (6.4)[ab]	98.0 (9.9)[a]	70.8 (8.2)[ab]
Bagh-e-Khomini	28.1 (5.2)[b]	32.2 (5.6)[b]	69.7 (8.2)[ab]	51.0 (6.9)[b]
Kharrol	37.5 (6.0)[a]	34.5 (5.6)[b]	123.5 (10.9)[a]	79.0 (8.3)[ab]
Mingy	28.4 (5.3)[b]	30.2 (5.4)[b]	60.0 (7.6)[b]	45.1 (6.5)[b]
Gond	41.3 (6.4)[a]	70.5 (8.3)[a]	145.2 (11.8)[a]	107.8 (10.0)[a]
CD	**0.61**	**1.33**	**2.7**	**1.4**

- Figures in first column represent mean of 10 observations
- Values in parentheses are √n transferred values

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

Fresh apple leaves collected from the apple block of the Shalimar campus of the University were examined in laboratory under stereoscopic binocular, for the presence of ERM eggs. The nymphs and adults of red mites, including eggs of two- spotted spider mites, *Tetranychus urticae*, and also eggs of predatory mites were removed from the upper and undersurface of the leaves. The number of ERM eggs were counted and exposed to fixed number of pre starved 8 days' old nymphs of anthocorid bugs in a plastic box (30x25x16 cm) with sufficient aeration. The petioles of leaves were covered with moistened cotton to keep the leaves fresh and prevent desiccation of host eggs. After three days, the leaves were taken out of the box and eggs of ERM were examined. Number of eggs which failed to hatch indicated the feeding effect of the bugs.

The prey ratios evaluated were 1:5, 1:10, 1:15, 1: 20 and an untreated control. With number of predator being constant (N=10), number of preys was kept as 50, 100, 150 and 200. The data on per cent mortality was compared with untreated control (N= 100 mites). The experiment was replicated five times.

At 1:5 predator prey ratio, maximum per centage of failure of egg hatching (91.6%) was observed (**Table 64**).

Table 64. Potential predation of *Blaptostethus pallescens* against eggs of European Red mites, *Panonychus ulmi*

Predator : Prey ratio	No. of predators used	No. of ERM eggs used	% failure of egg hatch	Corrected % mortality (Abbott's formula)	Av. Eggs' consumption/ bug during 3 days
1:5	10	50	91.6 (73.2)[d]	89.7	9.16
1:10	10	100	49.2 (44.5)[c]	37.9	9.84
1:15	10	150	29.5 (32.8) [ab]	13.9	8.8
1:20	10	200	21.7 (27.7) [a]	4.3	8.7
Control	--	--	18.2 (24.6) [a]	--	--
CD (0.001)	--	--	**6.08**		

- Figures in last three columns represent mean of 5 replications
- Values in parentheses are arc sin transformations
- Similar alphabets in a column indicate values statistically on par

2.13. Vegetables

Tomato

1. Field demonstration of BIPM package for the management of key pests of tomato (TNAU-Coimbatore)

The experiment were conducted at Madampatty on tomato variety :Abhinav 2
The BIPM package comprised of the following

T_1 BIPM package

- Seedling root dip with *Pseudomonas* 2% solution
- Raising African Marigold as trap crop
- Installation of yellow sticky trap @ 50 No's /ha.
- Installation of bird perches @ 10/ha.
- Installation of pheromone trap 12/ha
- Release of *Trichogramma pretiosum* @50,000 /ha
- Release of *Chrysopa* grubs @ 50,000 No's /ha.
- Sucking pests management through Azadirachtin spray

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

- Population of thrips and whiteflies were recorded at 15 days interval. The fruit borer incidence was recorded as fruit damage.
- Natural enemy activity were also monitored

Experimental plot of BIPM, farmers practice and control showed the presence of sucking pests like thrips and whiteflies. In addition, the damage due to *Helicoverpa armigera* was also observed at fruiting stage. The population of sucking pests like thrips (2-4 per plant) and whiteflies (1-3 per plant) were recorded in BIPM plots were low as compared to farmer's practice which had a thrips population of 7-11 per plant and whitefly population of 4-6 per plant. The BIPM package was able to contain the sucking pests population up to 60 DAT better than the farmer's practice plots which fewer insecticide sprays alone (**Table 65**). The fruit damage due to *H. armigera* was higher in plots of farmer's practice with a mean per cent fruit damage of 10-13 per cent as compared to 4-6 per cent in BIPM plots. The population of sucking pests and the 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 **(Table 66)**.

The occurrence of predators like greenlace wings and coccinellids were higher in plots which received the BIPM package and lower in plots of farmer's practice. The total fruit yield spread in more than ten harvests recorded was 32.6 t/ha as against 28.3 t/ha in farmer's practice. The untreated plot showed a fruit yield of 25.6 t/ha (**Table 66**). The cost benefit ratio in BIPM plot was 1:3.0 whereas farmer's practice with insecticide sprays showed 1: 2.6.

This has clearly indicated that the BIPM module was able to contain the pests to below injury level with minimal damage to natural enemies realising higher yield.

Table 65: Field demonstration of BIPM package for the management of sucking pests of Tomato

Treatments	Population of Sucking pests- DAT (5 plants)					
	Thrips			whiteflies		
	30	45	60	30	45	60
BIPM	3.8 [a]	2.4[a]	1.8[a]	1.8[a]	2.5 [a]	2.8[a]
Farmer's practice	6.7[b]	9.3[b]	10.6[b]	5.3[b]	4.8[b]	4.5[b]
Control	8.4[c]	10.8[c]	14.3[c]	6.8[bc]	7.4[c]	8.2[c]

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

Table 66: 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	4.2[a]	4.9[a]	5.6[a]	5.0[a]	4.0[a]	3.0[a]	4.0[a]	5.0[a]	6.0[a]	32.6[a]	1:3.0
Farmers practice	10.6[b]	9.8[b]	12.8[b]	0.0[c]	2.0[b]	0.0[c]	0.0[c]	1.0[c]	2.0[b]	28.3[b]	1:2.6
Control	12.3[c]	15.6[c]	17.2[c]	1.2[b]	2.3[b]	0.6[b]	1.2[b]	1.8[bc]	2.0[b]	25.6[c]	-

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

2 a. Validation of *Ha* NPV against *H. armigera* in tomato (MPUAT)

MPUAT-Udaipur

Location: Horticulture Farm RCA, MPUAT, Udaipur
Experiment Details:
Treatment 5
Replication: 4
Design: RBD
Crop of Variety: Tomato, Mahyco
Date of Transplant: 20-10-2014

Treatments:-

1. Installation of pheromone trap 5/ha.
2. One spray of Ha NPV 250 LE at flowering stage.
3. Two sprays of Bt @ 1kg/ha first at flowering stage and second after 15 days of first
4. Two sprays of Ha NPV first at flowering stage and second after 15 days of first spray.
5. Farmer practices.

Minimun per cent of infested fruits (3.2) was observed in the treatment of two sprays of *Ha* NPV at flowering stage and second after 15 days of first spray as compared to the 11.53 and 4.17 per cent of infested fruits in control and Farmers Practices plots. Higher yield of healthy fruits 172.22 q/ha was observed in the treatment of two sprays of *Ha* NPV compared to the lower yields of 127.52 and 142.56 q/ha in control Farmers Practices plots (**Table 67**).

Table 67: Validation of *Ha* NPV against *H. armigera* in tomato (MPUAT)

Sr. No.	Treatments	Per cent infested fruit	Yield in (q/ha)	
			infested	Un-infested
1	One spray of *Ha* NPV 250 LE at flowering stage and followed by one spray of azardirectin	7.15 (15.50)	35.56	162.52
2	Two sprays of *Ha* NPV first at flowering stage and second after 15 days of first spray	3.2 (10.30)	25.55	172.22
3	Farmer Practices	4.17 (11.78)	52.9	142.56
5	Control	11.53 (19.84)	71.7	127.52
	Sem±	0.22		
	CD 5%	0.67		

2 b. Validation of *Ha N*PV in tomato against *H. armigera* at Farmers field (MPUAT)

The transplanting was done on 20-11-2014

IPM module comprises of 5 weekly release of *T. Chilonis* @ 1 lac/ha followed with 2 sprays of Ha NPV, first at the occurrence of 3-4 adult moths and second spry 15 days after first spray**.** Farmer practices of three applications of insecticides.

Result indicated (**Table 68**) that the fruit damage was significantly reduced in IPM modules (12.5%) as against 18.2% fruit damage observed in Farmer practices. The yield observed in IPM module was higher (240 q/ha) than the yield recorded in Farmer practices (225 q/ha).

Table 68: Validation of *Ha* NPV against *H. armigera* in tomato (Navaniya, Bhinder)

Treatments	Percent Fruit Damage	Yield (Q/ha)	C:B Ratio
IPM Module	12.5	240	1:1.06
Farmers practices	18.2	225	

3. Demonstration of bio intensive pest management package for the tomato pests (AAU-Jorhat)

The experiment was conducted at Uttar Garumora, Jorhat with three treatments

T1= BIPM package comprised of

- Seedling root dip treatment with *Pseudomonas* 2%solution
- Installation of yellow sticky trap @ 50 no/ha
- Spray of NSKE @ 5 % against sucking pests
- Use of pheromone traps @ 15 /ha against *Helicoverpa armigera*
- Six releases of *Trichogramma chilonis* @ 1,00,000 /ha from flower initiation stage at weekly intervals
- Spray of Bt @ 1 kg/ha (two rounds of spray)
- Rouging of leaf curl disease affected plants.

T2 = Chemical control plots

T3= Untreated control

The field trial on demonstration of bio intensive pest management package for the pest of tomato was evaluated in comparison with farmers' practice (chemical control) and untreated check in the farmers' field. The treatment blocks were raised at 50 m isolation distance. Each block was divided into 10 segments as replication. Releases of parasitoids were made at weekly interval starting from 45 days after transplanting. Observations on pre and post treatment count for larvae of *H. armigera* were made on 10 randomly selected plants per plot before and after each spray. Per cent fruit damage and weight of the marketable tomato fruits per plot were recorded at the time of harvesting. Under Farmers practise, four rounds of methomyl 40 @ 1 Kg/ha was sprayed at 15 days interval, starting from 45 DAP. No pest management practice was followed in untreated plot.

Chemical control was significantly superior to BIPM in reducing the larval population of *H. armigera.* The mean population of *H. armigera* per 10 plants was 2.70 in chemical control whereas it was 4.10 in BIPM. Maximum number of larval population (16.20 /10 plants) was observed in untreated check. Plots receiving chemical spray had minimum fruit damage (11.8%) with higher yield of 153.82 q/ha as against 17.3 % fruit damage with 147.20 q /ha in BIPM. Highest fruit damage of 32.9% and minimum yield of 85.86 q/ha was recorded in untreated control plot. Abundance of coccinellids was noticed in BIPM throughout the cropping season (**Table 69)**.

Table 69: Effect of BIPM module on incidence of against *Helicoverpa armigera* on tomato

Treatment	Pre treatment count (larval population/ 10 plants)	Post treatments* (larval population/ 10 plants)	% damage fruit	Yield (q/ha)
BIPM	10.9	4.10[c]	17.3 (24.58) [c]	147.20[b]
Chemical Control	11.2	2.70[b]	11.8 (20.09) [b]	153.82[a]
Untreated control	11.4	16.20[a]	32.9 (35.00) [a]	85.86[c]
CD (=0.05)	NS	1.04	0.22	5.34
CV %		14.40	5.21	4.41

*Mean of three observations

Figures in parenthesis are transformed angular values

Means followed by the same letter in a column are not significantly different

4. Large scale demonstration of BIPM technology for management of *Helicoverpa armigera* in tomato (AAU-A)

AAU-Anand

Large scale demonstration was carried out in 50 Farmers fields at Runaj village near Sojitra (Dist. Anand) for management of *Helicoverpa armigera* in tomato using pheremone traps, neem oil spray and Tricho cards. The result indicated lower per centage of fruit damage (2.25-7.0%) in BIPM module as againt 9% fruit damage in the Farmers pracise of insecticidal spray.

Brinjal

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

The experiment was laid out on the Research Farm of Entomology Section, College of Agriculture, Pune. Transplanting of brinjal seedlings var. Panchaganga was done with a spacing of 75 x 60 cm in 15 x 6 m size blocks. Each block further divided into 3 subplots as replicates. Seven treatments compressed of biological components like *Nomuraea rileyi*, *Metarhizium anisopliae*, *Beauveria bassiana*, *Trichogramma chilonis*, *Bacillus thuringiensis* and NSKE @ 5% suspension was compared with farmer's practice of three sprays of chlorpyriphos 0.04%. Untreated control block was maintained separately. Each treatment block surrounded with paired row of maize.

Hand collection and destruction of infested shoots along with larval stages of *L. orbonalis* was done prior to flowering in all the treatment plots. Application bioagents with release of parasitoids and/or spraying of *N. rileyi*, *M. anisopliae*, *B. bassiana*, *Trichogramma*

chilonis, NSKE and *Bt* were given at weekly interval starting from 15/11/2014, Whereas, three sprays of chlorpyriphos 0.04% were given at fortnightly intervals as farmer's practice.

The observations on per cent shoot infestation before initiation of treatments and shoot and fruit infestation at weekly interval during treatment applications were recorded from 5 randomly selected plants per treatment plot. Egg parasitism by *T. chilonis* was recorded through retrieval by placing sentinel egg-cards of *Corcyra* at 3 spots in each treatment blocks. Data on per cent shoot and fruit damage of marketable fruits per plot at each picking was summed and converted into q per ha prior to analysis.

Three sprays of chlorpyriphos 0.04% at fortnightly interval found superior in reducing the shoot (10.8%) and fruit (9.0%) infestation and gave maximum yield of marketable brinjal (226.7 q/ha). These were followed by treatment consisting spraying of *B. thuringiensis* @ 1 kg/ha twice at weekly interval that caused 13.3% shoot and 13.1% fruit infestation with an yield 218.0 q/ha (**Table 70)**.

Table 70. Effect of different treatments consisting of biological components on infestation of *L. orbonalis* and yield of brinjal

Treatment	Shoot damage (%)		Fruit damage (%)		Parasitism (%)	Yield (q/ha)
	Pre-count	Post count	No. basis	Wt. basis		
T1: *N. rileyi*	19.2 [a]	18.8 [d]	20.8 [d]	20.7 [d]	-	196.8 [c]
T2: *M. anisopliae*	18.8 [a]	20.7 [e]	24.4 [e]	24.5 [e]	-	184.8 [d]
T3: *B. bassiana*	18.6 [a]	20.4 [e]	23.9 [e]	23.9 [e]	-	185.5 [d]
T4: *T. chilonis*	19.3 [a]	16.6 [c]	17.4 [c]	17.3 [c]	65.0	206.4 [c]
T5: *B. thuringiensis*	18.4 [a]	13.3 [b]	14.0 [b]	13.1 [b]	-	218.0 [b]
T6: NSKE 5%	18.3 [a]	15.8 [c]	17.4 [c]	17.4 [c]	-	207.9 [c]
T7: Chlorpyriphos	20.4 [a]	10.8 [a]	10.5 [a]	9.0 [a]	-	226.7 [a]
T8: Untreated control	19.1 [a]	27.1 [f]	51.9 [f]	52.94 [f]		173.0 [e]
CD (p = 0.05)	**NS**	**1.51**	**1.77**	**0.85**		**10.36**

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

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

MPKV-Pune

The experiment was laid out on the research farm of Entomology Section, College of Agriculture, Pune. Transplanting of brinjal seedlings var. Panchaganga with 75 x 60 cm spacing in 15 x 6 m size blocks. Each block was further divided into three sub-plots as replicates. Five modules formed with combination of biological components like *Trichogramma chilonis* @ 50,000 parasitoids/ha, NSKE @ 5% suspension and *Bacillus thuringiensis* @ 1 lit./ha compared with farmer's practice of three sprays of profenophos 0.05%. Untreated control block was maintained separately. Each treatment block surrounded with paired row of maize. Hand collection and destruction of infested shoots along with larval stages of *L. orbonalis* was followed before flowering in all the treatment plots. Application bioagents with release of parasitoids and/or spraying of NSKE and *Bt* were given

at weekly interval starting from 25/01/2014, Whereas, three sprays of profenophos 0.05% were given at fortnightly intervals as farmer's practice. The observations on per cent shoot infestation before initiation of treatments and shoot and fruit infestation at weekly interval during application of treatment were recorded from five randomly selected plants per treatment. Egg parasitism by *T. chilonis* was recorded through retrieval by placing sentinel egg-cards of *Corcyra* at 3 spots in each treatment blocks. Data on per cent shoot and fruit damage and yield of marketable fruits per plot at each picking was summed and converted into quintals per ha was recorded.

The data in **Table 71** indicated that three sprays of profenophos 0.05% at fortnightly interval was effective by causing lowest shoot (9.1%) and fruit (9.4%) damage and gave maximum yield (228.6 q/ha). However, the BIPM module consisting release of *T. chilonis* @ 50,000 parasitoids/ha followed by spraying of NSKE 5% and *B. thuringiensis* @ 1 lit./ha twice at weekly interval was the next best treatment showing 10.6% shoot and 15.3% fruit infestation with 42.5% parasitism of *T. chilonis* and gave 217.8 q/ha yield. It was on par with modules consisting *T. chilonis* + *Bt* (T3) and NSKE +*Bt* (T4).

Table 71. Effect of different BIPM modules on infestation of *L. orbonalis* and yield of brinjal

PAU-Ludhiana

Treatments	Shoot damage (%)		Fruit damage (%)		Parasitism (%)	Yield (q/ha)
	Pre-count	Post count	No. basis	Wt. basis		
BIPM with *T. chilonis*	21.2[a]	14.4[c]	17.4[c]	17.9[c]	62.0	203.5[c]
BIPM with *T. chilonis* + Neem	21.0[a]	13.2[c]	17.3[c]	17.3[b]	48.5	209.8[b]
BIPM with *T. chilonis* + *Bt*	22.0[a]	13.0[c]	16.4[c]	15.9[b]	45.6	214.1[b]
BIPM with Neem + *Bt*	21.9[a]	11.7[b]	15.8[b]	15.9[b]	12.0	214.8[b]
BIPM with *T. chilonis* + Neem +*Bt*	20.4[a]	10.6[b]	14.7[b]	15.3[b]	42.5	217.8[b]
Chemical control	21.0[a]	9.1[a]	10.7[a]	9.4[a]	0.0	228.6[a]
Untreated control	21.4[a]	16.0[d]	20.3[d]	21.2[d]	0.0	171.5[d]
CD (p = 0.05)	**NS**	**1.34**	**1.08**	**1.55**		**10.65**

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

7. Biological control of Brinjal mealybug *Coccidohystrix insolitus* (TNAU)

Experiment was conducted at Arasur, Coimbatore on tomato variety Rasi local. Three replications were maintained per treatment.

Treatments:

T_1 Release of *cryptolaemus* @ 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 *Chrysopa* 50,000 first instar grubs/ha
T_6 Profenphos 50 EC 2ml /l
T_7 Control

Predators were released twice and two rounds of spray were given. Observations on the Mealybugs were made on three leaves/plant. Number of predators were observed per plant and the yield data was recorded.

The insecticide treated plot showed minimum number of mealybug per plant (1.4) after 15 days of first spray and 1.8 mealybugs per plant after 15 days of second spray with highest yield of 70 t/ha.The next best treatment was release of *Cryptolaemus.*@ 1500/ha with a population of mealybugs of 32.4/plant after 15 days of 1st release and 5.3/plant after 15 days of second release with an yield of 67.8t/ha. The fruit yield in different coccinellid released treatment plots was on par (T1, T2, T3) which ranged 64.9-67.8 t/ha. In the untreated control plot highest number of mealybugs/plant was observed with the least yield of 58.7 t/ha. Highest number of predators were found in the treatment with *Cryptolaemus*.@ 1500/ha (5.3 and 8.6/10 plants after 1st and 2nd release respectively) (**Table72**)

Table 72. Biological control of brinjal mealybug *Coccidohystrix insolitus*

Treatments	Pre Treatment	7 days after I release/spray		15 days after I release /spray		7 days after II release/spray		15 days after II release /spray		Yield t/ha
	Mealybug/ Plant	Mealybug/ Plant	Predator/10 Plants	Mealybug/ Plant	Predator/ 10 Plants	Mealybug/ Plant	Predator/ 10 Plants	Mealybug/ Plant	Predator/ 10 Plants	
Release of *Cryptolaemus* @ 1500/ha	74.6[a] (44.85)	53.6 [b] (35.30)	3.8	32.4[b] (26.01)	5.3	14.6[b] (16.84)	7.8	5.3[b] (10.00)	8.6	67.8[b]
Release of *Scymnus*@ 1500/ha	62.8 [a] (39.33)	56.6[b] (36.58)	2.3	35.8[bc] (27.56)	3.4	24.8[c] (22.37)	4.3	10.4[c] (14.09)	4.8	64.9[b]
Release of *Brumus suturoides* @ 1500/ha	69.5[a] (42.41)	59.4[b] (37.81)	2.0	38.2[c] (28.65)	3.1	17.6[bc] (18.55)	4.7	8.2[bc] (12.46)	5.3	66.2[b]
Verticillium lecanii 10^8 cfu /ml	82.4[a] (48.96)	78.8[d] (46.94)	0.8	71.5[e] (43.32)	1.4	56.4[e] (36.53)	3.4	44.6[e] (31.45)	3.6	61.2[c]
Chrysopa 50,000 first instar grubs/ha	78.3[a] (46.72)	70.4[c] (42.81)	1.4	52.7[d] (34.90)	2.2	38.2[d] (28.64)	2.8	30.5[d] (25.15)	3.5	62.3[c]
Profenophos 2 ml/l	86.2[a] (51.20)	15.4[a] (17.31)	0.0	1.4[a] (5.01)	0.0	0.7[a] (4.05)	1.2	1.8[a] (5.57)	0.0	70.3[a]
Control	71.7 [a] (43.42)	76.6[d] (45.84)	0.8	83.6[f] (45.83)	1.2	58.6[e] (37.49)	2.4	61.7[f] (38.82)	3.0	58.7[d]
CD (P= 0.05)		2.95	-	4.11	-	3.12	-	3.94	-	-

In means followed by a common letter(s) are not significantly different by DMRT (P = 0.05); Figures in parentheses are arc sine transformed values

8. Bio-efficacy of microbial insecticides against *Spodoptera litura* in cabbage (AAU, Anand)

The efficacy of microbial insecticides against S. *litura* infesting cabbage was evaluated at Agronomy farm, BACA, Anand Agricultural University, Anand on tomato local variety. Three replications were maintained per treatment, the treatments were as follows

T_1 : *Bacillus thuringiensis*1.0 kg/ha
T_2 : *Bacillus thuringiensis*2.0 kg/ha
T_3 : *Beauveriabassiana*(2 x 10^8cfu) @ 30 g /10 litres water
T_4 : *Metarhiziumanisopliae*(2 x 10^8cfu) @ 30 g /10 litres water
T_5 : *Metarhiziumanisopliae*(2 x 10^8cfu) @ 40 g /10 litres water
T_6 : *Nomurea rileyi* (2 x 10^8cfu) @ 30 g /10 litres water
T_7 : *Nomurea rileyi* (2 x 10^8cfu) @ 40 g /10 litres water
T_8 : *SI* NPV 1 x 10^{10} POB/ha
T_9 : Recommended insecticide
T_{10} : Control (water spray)

Standard agronomical practices were followed for raising the crop. The first spray of respective microbial insecticides was applied at the appearance of *Spodoptera* and subsequently two sprays were given at 15 days interval. Observation of larval count (No./plant) was recorded from 5 randomly selected and tagged plants from each plot. The observations were recorded before, 3 and 7 days after spray. Similarly, per cent cabbage heads damage by *S. litura* will was assessed by counting the healthy and damaged cabbage heads during each picking. Treatment wise fruit yield was recorded separately.

As pest incidence was negligible no conclusion, could not be drawn during the period under report.

Cauliflower

9. Field evaluation of biocontrol based IPM module against pests of cauliflower/ (*Plutella xylostella, Spodoptera litura, Pieris brassicae*) (PAU)

(PAU-Ludhiana)

The experiment was conducted at Entomological Research Farm PAU, Ludhiana during second year 2014-15. Cauliflower (S-41 hybrid) was transplanted in the month of October 2014 and the experiment was done in the plot size of 25 m^2 in randomized block design with three replications. There was no incidence of *Plutella xylostella* and *Spodoptera litura* during the period of experiment. However, there was incidence of *Lipaphis erysimi* and *Pieris brassicae* during the second week of February and early March 2015 respectively. Accordingly, following treatments for these two pests were applied during the period of study in March 2015.

Treatments:

I. 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 Neemazal (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

II. Chemical control: Success 2.5 SC (Spinosad) @ 250 ml/ acre at weekly interval – Three sprays

III. Control (no treatment)

The pre-treatment data of population of *P. brassicae* larvae and *L. erysimi* was recorded before the first release of bioagent or first spray of Neemazal/ Delfin on the cauliflower and thereafter the execution of treatments of bioagents/ Neemazal/ Delfin was done. The data was recorded three times at 15 days interval from five plants/ replication and analyzed.

The chemical control treated plots and Biocontrol based IPM module showed minimum number of *Pieris* larvae / plant (4.27 & 3.32 respectively) and aphids/plant (11.08 & 8.82 respectively) and were on par with each other. The untreated control plot showed higher *Pieris* larvae / plant (37.27) and aphids/plant (15.13). The BIPM module showed maximum population of natural enemies per plant (4.41 coccinellids + 2.5 syrphid larva + 2 cocoon cluster of *Cotesia glomeratus*).where as insecticidal treated plot did not show any population of natural enemies. The highest marketable yields were obtained in chemical treated plots and BIPM module plots (47.32 and 43.12 q/acre) as against 29.56 q/acre recoded in the untreated plots (**Table 73**).

73. Field evaluation of biocontrol based IPM module against pests of cauliflower (*Plutella xylostella, Spodoptera litura, Pieris brassicae*) (2014-15) (PAU)

Treatments	*Pieris* larvae / plant		Aphids/ plant		Mean population of natural enemies/ plant*	Marketable yield** q/acre
	Before	After*	Before	After*		
Biocontrol based IPM module	18.96	3.32[a]	30.66	8.82[a]	4.41 coccinellids + 2.5 syrphid larva + 2 cocoon cluster of *Cotesia glomeratus*	43.12[a]
Chemical control	25.00	4.27[a]	36.92	11.08[b]	-	47.32[a]
Untreated control	24.20	37.27[b]	54.65	25.76[b]	2 coccinellids + 1.5 cocoon cluster of *Cotesia glomeratus*	29.56[b]
CV (%)	19.84	15.23	21.17	15.13	-	13.82

Note: * Mean of three observations; ** Sum of three pickings

10. Evaluation of *Bacillus thuringiensis* formulation *against* cauliflower butterfly, *Pieris brassicae* (PAU-Ludhiana)

The experiment is being conducted at Entomological Research Farm, PAU Ludhiana in randomized block design with plot size of $18m^2$ during 2014-2015 in cauliflower. There were ten treatments with three replications. These ten treatments of liquid formulation of *Bacillus thuringiensis* were PDBC Bt1 (1%), PDBC Bt 1 (2%), NBAII Bt1 (1%), NBAII Bt 1(2%), Delfin (1%), Delfin (2%), PAU Bt (1%), PAU Bt (2%), Spinosad 2.5SC @ 240 ml/ acre and untreated control. The incidence of *Pieris brassicae* larvae was recorded from five randomly selected plants per replication. Per cent plant infestation and yield was recorded. The experiment is in field and will be completed in April end

11. Efficacy of *Bt* strains against Diamond back moth in cauliflower (TNAU-Coimbatore)

The details of the experiment are as follows.

Name of the Farmer : Th.Rengasamy, Alanthurai
Variety :Suhashini
Date of Transplanting :23.07.2014
I spray : :16.09.2014
II spray :01.10.2014
III spray :16.10.2014
Date of harvest :28.10.2014

Treatments:

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* @ 2.0kg/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.
Observations**:**
1. Pest population at 15 days interval
2. Yield data at harvest

The efficacy of *Bt*. strains against DBM was assessed in cauliflower through field experiment. The larval population of DBM ranged from 10-14 per plant at 54 days after transplanting. As per the protocol, three rounds of *Bt*. strains formulations of PDBC BT1 and NBAII BTG 4 were applied as 1 and 2 % concentrations at 15 days interval.

The data revealed that both *Bt* strains @ 2% spray were effective in reducing the larval population up to 59 per cent over control after 1st round of spray. But, these B.t strains were found less effective as compared to insecticides which had 79 per cent reduction of larval population over control. After three rounds of spraying, the *Bt* strains were able to reduce the larval population of DBM up to 84 per cent (NBAII BTG 4 @ 2%) as compared to 90 per cent reduction of larval population in insecticide treated plot (**Table 74**). Both *Bt* strains were on par in their efficacy in checking the larval population of DBM. The other treatments like *Beaveria bassiana* 2kg/ha and NSKE 5% showed a reduction of 52-57 per cent after three rounds of sprays indicating their moderate efficacy. The curd yield was maximum in insecticide treated plot (12.4t/ha) as against 11.32 to 11.86 t/ha in *Bt* strains treated plots. Minimum yield was recorded in untreated check 9.65t/ha. The order of efficacy among the B.t strains in containing the larval population of DBM was NBAII BTG4 2% > PDBC BT1 2% > NBAII BTG4 1% > PDBC BT1 1%.

Table 74.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 larvae/ plant	No. of larvae/ plant	% reduction over control	No. larvae /plant	% reduction over control	No. of larva /plant	% reduction over control	
PDBC-BT1 @ 1% spray	13.40[a]	7.8[c]	51.6	6.2[c]	67.4	4.8[c]	77.2	11.41[bc]
PDBC-BT1 @ 2% spray	11.30[a]	6.2[bc]	54.4	5.6[bc]	65.0	3.2[b]	82.0	11.80[b]
NBAII-BTG4 @ 1% spray	13.06[a]	8.3[c]	47.2	6.7[c]	63.8	4.2[bc]	79.6	11.32[bc]
NBAII-BTG4 @ 2% spray	11.56[a]	5.7[b]	59.0	4.8[b]	70.7	3.0[b]	83.5	11.86[b]
Beauveria bassiana @ 2 kg/ha	13.10[a]	11.8[d]	25.2	10.3[d]	44.5	9.8[d]	52.4	10.25[cd]
NSKE 5%	13.23[a]	13.8[e]	24.7	11.6[de]	46.3	10.3[d]	57.0	10.53[c]
Chlorpyriphos @ 0.04 % spray	11.06[a]	2.8[a]	79.0	2.2[a]	86.0	1.3[a]	90.5	12.40[a]
Control	10.30[a]	12.4[d]	-	14.6[e]	-	16.2[e]	-	9.65[d]

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

Chilli

12. Evaluation of fungal pathogens against sucking pest of hot chilli (*Capsicum sinensis*) AAU-Jorhat)

Experimental details:

Location: Instructional cum Research farm, AAU, Jorhat
Target pests: *Aphis gossypi, Scirtothrips dorsalis,*
Plot Size: 3m x 3.5m

Variety: Local
Replication: 4
Date of planting: 27. 12. 2013
Fertilizer dose: 120:60:60 kg N: P; K/ ha
Spacing: 100cm x 100cm

Treatments
1. *Metarhizium anisopliae* (AAU strain) @ 10^9 cfu/ml
2. *Beauveria bassiana (*AAU strain*)* @ 10^9 cfu/ml
3. *Metarhizium anisopliae*(Ma-4) NBAIR strain@ 10^9 cfu/ml
4. *Metarhizium anisopliae* (Ma-35)NBAIR strain@ 10^9 cfu/ml
5. *Beauveria bassiana* (Bb-5a)NBAIR strain@ 10^9 cfu/ml
6. *Beauveria bassiana* (Bb-23)NBAIR strain @ 10^9 cfu/ml
7. Imidacloprid @ 20 g ai/ha
8. Untreated control

Observations were recorded on number of sucking pests (*Aphis gossypi, Scirtothrips dorsalis, Bemisia tabaci* and *Polyphagotersonemus latus*) before treatment as well as 10 days after each spray on 5 randomly selected plants from each plot at ten leaves (top, middle and bottom). Three rounds of microbial agents @ 10^9 cfu/ml and imidacloprid @ 20 g a.i/ha were given to the crop 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. As the mite and white fly population was negligible during the cropping season, population of these two sucking pests were not included in the investigation. Yield data was recorded at each harvesting.

The results in (**Table 75**) showed that three rounds of spraying of imidacloprid @ 20 g ai/ha at 15 days interval significantly reduced the mean population of *A. gossypi* and *S.dorsalis* in hot chilli in comparison to untreated control. The mean population of *A. gossypi* and *S. dorsalis* was 6.25 and 1.25 per 10 leaves in imidacloprid treated plot followed by Bb 5a (NBAIR strain) with 8.50 and 2.50 per 10 leaves after third spray and both the treatments was on par in their efficacies. However, the rest of the entomopathogenic fungi of NBAIR strains (Ma-4, Ma-35, Bb-23) and local strains (Bb-Biosona, Ma-Biometa) was effective after third spray and found to be statistically on par with each other in reducing the sucking pests compared to untreated control plot. In untreated control plots, the sucking pest's population were persistently high throughout the experimental period. Maximum number of *A. gossypi* (32.00 /10 leaves) and *S. Dorsalis* (15.5 /10 leaves) was recorded in untreated control plot.

Highest yield of hot chilli (53.8q/ha) was recorded in imidacloprid @ 20g ai/ha treated plot. This was followed by NBAIR strain, Bb5a (51.29q/ha) and Bb23 (48.5 q/ha), respectively. However, no significant difference of yield was obtained in case of NBAIR strains (Bb-5a, Bb-23) with the local strain of Bb-biosona where the yield was 40.20 q/ha. Minimum yield of 26.75 q /ha was obtained in untreated control plot and it was on par with Ma-35, Ma-4 (NBAIR strain) and Biometa (Local strain). The yields of M35, Ma-4 and Biometa were 30.58, 29.75 and 28.75 q/ha respectively.

Table 75 : 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. gossypi (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	25.00	10.25	20.25^{b}	15.25^{b}	12.00^{b}	7.00^{b}	6.00^{b}	4.50^{b}	28.75^{d}
B. bassiana (AAU strain) Biosona	22.00	11.00	18.00^{bc}	14.75^{bc}	11.00^{bc}	6.50^{bc}	5.25^{c}	3.50^{bc}	40.20^{c}
M.anisopliae (Ma-4) NBAIR strain	21.00	10.50	16.75^{cd}	14.50^{bcd}	11.25^{bcd}	5.25^{cd}	4.75^{cd}	3.50^{bc}	29.75^{d}
M.anisopliae (Ma-35) NBAIR strain	20.50	12.25	16.75^{cd}	12.75^{cd}	10.25^{bc}	6.50^{bc}	5.00^{c}	3.25^{cd}	30.38^{d}
B.bassiana (Bb-5a) NBAIR strain	21.00	9.50	15.75^{cd}	12.00^{e}	8.50^{de}	3.50^{ef}	3.00^{de}	2.50^{cd}	51.20^{ab}
B.bassiana (Bb-23) NBAIR strain	21.5	10.75	17.75^{bc}	12.50^{de}	9.00^{d}	4.25^{de}	3.25^{d}	3.00^{cd}	46.00^{b}
Imidacloprid	21.75	12.25	14.50^{d}	9.00^{f}	6.25^{e}	2.75^{f}	2.00^{e}	1.25^{d}	53.83^{a}
Untreated control	23.75	12.25	27.75^{a}	27.00^{a}	32.00^{a}	15.75^{a}	17.25^{a}	15.50^{a}	26.75^{d}
CD =0.05	NS	NS	2.60	2.03	2.25	1.34	1.17	1.27	5.92
CV %			9.61	9.37	12.21	14.13	13.73	18.72	10.49

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

Onion

13. Validation of BIPM on thrips of onion (IIHR-Bangalore)

Validation of BIPM trial against *Thrips tabaci* on onion was conducted on var. Arka Niketan. Maize was raised as boarder row for every 400 m^2 Spraying was initiated at 40 DAP and continued at weekly intervals till 85 DAP. The experiment was carried out in exploded block design with 400 m^2 for each treatment. Spraying of the formulations was carried out at weekly intervals from 45 DAP to 85 DAP. Acephate was sprayed at 15 days interval during the same period. Observations on thrips population per plant at ten days interval were recorded. In each treatment, about 10 per cent plants were randomly selected and the number of thrips/plant were recorded using a magnifying lens.

There was a significant reduction in thrips population/plant in all treatments except control. A mean population of 11-13 thrips/plant was recorded in the biological control

treatments and were at par with each other and significantly lower than the control plot. Control plots recorded a mean of 47 thrips/plant. Results indicated that border crop of maize and weekly spraying of formulation of *M. anisopliae*@ 1ml/ 2l or *B. bassiana* @ 1ml/l (IIHR) could effectively control thrips on onion **(Table 76)**

Table 76: Field efficacy of entomopathogens formulations on *T.tabaci* on onion.

S. No	Treatments	% reduction over control
1	*M. anisopliae* @1x10^7 spores/ml (liquid formulation	79
2	*B. bassiana* @1x107 spores/ml (liquid formulation)	73
4	Acephate @0.7 g/L	78
5	Control	----------

14. Biological suppression of onion thrips, *Thrips tabaci* with predatory anthocorid and microbial agents (MPKV)

The experiment was laid out on the research farm of Entomology Section, College of Agriculture, Pune. Transplanting of onion seedlings var. Phursungi was done at 12.5 x 8 cm spacing in 15 x 6 m size blocks. Each block further divided into three sub plots as replicates. Seven treatments composed of biological components like *Blaptostethus pallescens*, *Metarhizium anisopliae*, *Beauveria bassiana*, *Verticillium lecanii* compared with farmer's practice of three sprays of Profenophos 0.05% Untreated control block was maintained separately. Each treatment block surrounded with paired row of maize.

Six releases of anthocorids at weekly interval and three sprays of entomopathogenic fungi and chemical insecticide at fortnightly interval were given. Sandovit 0.1% was added in the spray fluid before spraying. Observations were recorded on pre-treatment thrips population before treatment, post count of nymphs and adults at 7 days after each application of bioagents, the intensity of white patches due to feeding of thrips in 1-5 scale and yield of onion bulbs per plot **(Table 77)**.

Pooled analysis of three years data (**Table 77**) revealed that three sprays of profenophos 0.05% at fortnightly interval found significantly superior over other treatments in suppressing the thrips population and gave maximum 20.0 t/ha yield of onion bulbs. However, three sprays of *M. anisopliae* @ 10^8 cfu/ml (av. 7.6 thrips/plant) and six releases of *B. pallescens* @ 20 nymphs/m row (av. 9.9 thrips/plant) were the next best treatments in the bio suppression of pest population.

Table 77: Effect of anthocorid and microbial agents on suppression of thrips on onion (Pooled data for 2011-12, 2012-13 and 2013-14)

Treatments	Precount	Thrips population/plant 7 DAS				Grading of white patches	Yield (q/ha)
		I	II	III	Average		
B. pallescens @ 10 nymphs/m row	18.9[a]	16.5[c]	12.1[c]	8.6[d]	12.4[d]	2.5	16.2[b]
pallescens @ 20 nymphs/m row	19.7[a]	13.1[b]	9.4[b]	7.2[c]	9.9[c]	2.1	18.1[a]
M. anisopliae @ 10^8 cfu /ml	19.3[a]	11.4[b]	7.4[b]	3.9[b]	7.6[b]	1.4	18.7[a]
bassiana @ 10^8 cfu /ml	20.2[a]	17.7[c]	13.9[c]	11.6[d]	14.4[d]	2.4	15.3[b]
V. lecanii @ 10^8 cfu/ml	19.3[a]	15.2[c]	12.8[c]	7.5[c]	11.8[d]	2.1	16.8[b]
Profenophos @ 0.05%	19.1[a]	7.5[a]	1.6[a]	0.3[a]	3.1[a]	1.0	20.0[a]
Control	20.5[a]	24.8[d]	29.9[d]	35.6[e]	30.1[e]	3.6	14.1[c]
CD (p = 0.05)	**NS**	**0.43**	**0.67**	**0.15**	**0.24**	-	**1.85**

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

Potato

15. Evaluation of Local and NBAIR entomopathogenic strains against soil insects in potato (AAU-Johrat)

Target pests: *Agrotis ipsilon*(Cut worm), *Dorylus orientalis* (Red ant)

Experimental details:

Location : Maran Gaon, Jorhat
Plot Size : 4X4.5 m
Replication : Four
Design : RBD
Fertilizer dose: 133:312:83 kg/ha in the form of urea, SSP and MOP
Date of planting: 18.12.2014
Variety: Kufri Jyoti

Treatments

1. *Metarhizium anisopliae* (AAU strain, Biometa) 15 kg/ha
2. *Beauveria bassiana* (AAU strain, Biosona) 15 kg/ha
3. Bb 5a (NBAIR strain) 15 kg/ha
4. Bb 23 (NBAIR strain) 15 kg/ha
5. Ma-4 (NBAIR strain) 15 kg/ha
6. Ma-35 (NBAIR strain) 15 kg/ha
7. Malathion 5 % dusts 40kg/ha as soil application.
8. Imidacloprid 20 g a.i./ha as soil drenching
9. Untreated control

Local and NBAIR strains of *M. anisopliae*, *B. bassiana*, malathion 5% dust were evaluated and applied as soil application at sowing time, 35 and 55 days after sowing. Similarly, three sprays of imidacloprid @ 20 g a.i/ha. were given as soil drenching. Per cent tuber damage due to attack of *Dorylus orientalis* (Red ant) and *Agrotis ipsilon* (cut worm) was recorded per plot at the time of harvesting of the crop.

The results indicated (**Table 78**) that imidacloprid @ 20 g ai/ha significantly reduced the infestation of soil insects (*D.orientalis* and *A.Ipsilon*) with higher yield of 89.5 q/ha compared to different entomopathogenic fungi tested in the experiment. The per cent infested tubers of *D. orientalis* and *A. ipsilon* in imidacloprid treated plot was 10.25 and 9.00, respectively and showed 67.19 % increased yield over untreated check. Among the different entomopathogenic fungi, Bb-5a (NBAIR strain) was the next best treatment which showed 15.5% damage by *D. orientalis* and 17.25% damage by *A. ipsilon* with next higher yield of 85.00 q/ha. Significantly less incidence of *D.orientalis* and *A.ipsilon* was registered in all microbial treated plots over untreated check. Except Bb5a of NBAIR strain, plots treated with microbial insecticides exhibited more or less same level of incidence to that of recommended insecticide (malathion @ 40 Kg/ha). The per cent incidence of different microbial insecticides ranged from 19.00 to 24.00 per cent for both the insects. Maximum number of infested tubers due to attack of *D.orientalis* and *A. ipsilon* was 34.25 and 36.5 per cent, respectively in untreated check.

It was observed that Bb-5, NBAIR strain was the next best treatment which could suppress the attack of soil insects with higher yield compared to imidacloprid @ 20g ai/ha.

Table 78: Effect of Local and NBAIR strains against soil insects in potato

Treatments	Dose kg/ai/ha	% infested tubers by *D. orientalis*	% infested tubers by *A. ipsilon*	Yield (q/ha)	Increase in yield over control (%)
M.anisopliae (local strain)Biometa	15	23.25 (28.84)^{b}	23.75 (29.18)^{b}	76.25^{d}	42.52
B. bassiana (local strain)Biosona	15	22.00 (27.99)^{bc}	20.00 (26.58)^{de}	80.75^{c}	50.93
B.bassiana (Bb-5a) NBAIR strain	15	15.50 (23.20)^{e}	17.25 (24.55)^{f}	85.00^{b}	58.87
B.bassiana (Bb-23) NBAIR strain	15	19.50 (26.22)^{d}	22.50 (28.33)^{bc}	79.00^{cd}	47.67
M.anisopliae (Ma-4) NBAIR strain	15	20.75 (27.11)^{cd}	21.25 (27.46)^{cd}	78.75^{cd}	47.19
M.anisopliae (Ma-35) NBAIR strain	15	21.25 (27.46)^{cd}	19.25 (26.04)^{e}	80.75^{c}	50.93
Malathion 5% dust	40	22.25 (28.15)^{bc}	20.00 (26.57)^{de}	81.25^{c}	51.87
Imidacloprid	20 g *ai*.	10.25 (18.66)^{f}	9.00 (17.46)^{g}	89.50^{a}	67.29
Untreated control	----	34.25 (35.82)^{a}	36.5 (37.18)^{a}	53.50^{e}	
CD =0.05		1.96	1.62	3.59	
CV %		4.97	4.10	3.14	

- Figures in parenthesis are transformed angular values
- Means followed by the same letter in a column are not significantly different

Okra

16. Biological suppression of fruit borer, *Erias vitella* in okra (MPKV-Pune)

The experiment was laid out on the Research Farm of Entomology Section, College of Agriculture, Pune. The planting of okra seeds var. Parbhani Kranti was done on 16/08/2014 at 30 x 15 cm spacing in 15 x 6 m size blocks. Each block further divided into 3 subplots as replicates. Eight treatments composed of biological components like *Lacanicillium lecanni*, *Metarhizium anisopliae*, *Beauveria bassiana*, *Trichogramma chilonis*, *Bacillus thuringiensis*, NSKE 5% suspension compared with Farmer's practice of three sprays of Chlorpyriphos @ 0.04% Untreated control block was maintained separately. Each treatment block surrounded with paired row of maize.The observations are recorded on five randomly selected plants/ plot. Pre and post-treatment counts on fruit infestation at weekly interval and yield of healthy marketable fruits at each picking.

Data presented in (**Table 79**) indicated that the three sprays of *B. thuringiensis* @ 1 kg/ha at fortnightly interval was superior in reducing the shoot (8.8 %) and fruit (19.5 %) infestation and gave maximum yield of marketable brinjal (180 q/ha). However, this was on par with Chlorpyriphos @ 0.04% that recorded 10.7 % shoot and 24.2 % fruit infestation with 173.2 q/ha yield.

Table 79: Effect of different biocontrol agents for management of fruit borer, *Erias vitella* in okra.

Treatments	Shoot damage (%)		Fruit damage (%)		Yield (q/ha)
	Pre-count	Post count	Number basis	Wight basis	
Lacanicillium lecanni @ 10^8 conidia/ ml	13.3 [a]	17.1 [c]	29.3 [c]	33.8 [c]	156.0 [b]
Metarhizium anisopliae @ 10^8 conidia/ ml	11.4 [a]	24.3 [d]	31.0 [c]	36.6 [d]	146.3 [c]
Beauveria bassiana @ 10^8 conidia/ ml	10.2 [a]	23.8	27.0 [c]	31.5 [c]	153.7 [c]
Trichogramma chilonis @ 60,000 /ha,	12.0 [a]	19.9 [c]	27.7 [c]	33.4 [c]	158.0 [b]
B. thuringiensis @ 1 kg/ha	12.3 [a]	8.8 [a]	19.5 [a]	22.7 [a]	180.1 [a]
NSKE 5%	10.6 [a]	13.0 [b]	27.9 [d]	30.9 [c]	164.0 [b]
Chlorpyriphos @ 0.04%	10.8 [a]	10.7 [a]	24.2 [b]	27.6	173.2 [a]
Untreated control	10.9 [a]	25.7 [d]	39.6 [e]	45.6 [d]	133.0 [d]
CD (p = 0.05)	**NS**	**2.93**	**2.65**	**1.46**	**9.42**

Means followed by the same letter in a column are not significantly different

17. Evaluation of Bio-intensive IPM module against *Aleurodicus dispersus* on cassava (TNAU-Coimbatore)

Name of the Farmer Th.Kalisamy, Ganesapuram, Coimbatore
Variety :Mulluvadi local
Area :2.5 acres

Evaluation of BIPM against *A. disperses* on cassava was carried out using the variety Mulluvadi local. The BIPM treatments included

- 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 per liter, acephate 75 SP @ 1.5 g per liter
-

Farmer's 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.

The implementation of BIPM module effectively reduced the spiralling whitefly population which showed 86.34 whiteflies per plant as compared to insecticide sprays 335.41 whiteflies per plant. The untreated check harboured 450.61 whiteflies per plant. The population reduction of spiralling whitefly achieved by BIPM was 77.03% as compared to 25.89 % in farmer's practice with three rounds of insecticide sprays. The plots imposed with BIPM was free from sooty mould whereas the plots with insecticide sprays and untreated had severe incidence sooty mould indicating the presence of spiralling whitefly population.

The yield of tubers in BIPM plot was 33.25t/ha which was superior to the tuber yield of 29.62 t/ha recorded in farmer's practice. The untreated plot showed a tuber yield of 25.30 t/ha. The BCR was 1:3.26 in BIPM plot and 1:2.34 in farmer's practice (**Table 80**).

Table 80. Effect of BIPM module on *A. dispersus* population and yield on cassava

Treatments	Pre treatment count	*A. dispersus*/ 5 plants*	Per cent reduction over control	Yield (t / ha)	BCR
BIPM module	398.5[a]	86.34[c] (9.10)	77.03	33.25	1 : 3.26
Farmer's practice	472.45[a]	335.41[b] (18.40)	25.89	29.62	1 : 2.34
Control	431.72[a]	450.61[a] (21.03)	0.00	25.30	-
CD (P = 0.05)	NS	34.0426			

*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)

Saffron

18. Evaluation of predatory mite, *Blaptostethus pallescens* against saffron thrips, *Haplothrips* sp. on saffron (Laboratory Studies) SKUAST-Srinagar

Preliminary evaluation of anthocorid bug *Blaptostethus pallescens* was initiated first time in SKUAST Srinagar during 2nd week of October' 2014 with the onset of flowering of saffron. Flowers were examined for the presence of thrips. Three infested flowers were kept on a white paper in plastic boxes (30x25x16) cm with provision of good aeration. Ten numbers of 8-10 days' old nymphs of anthocorid bugs were released in boxes and kept in BOD (27±2°C, 60±5 % RH and Photoperiod of 14: 10). The experiment was replicated five times. The samples were examined twice after every three days for the mortality as well as survival ability of the bugs. Data was compared with untreated control.

Per cent mortality of saffron thrips on third and sixth day was 5.5 and 25.8 respectively. Calculated mortality of the total (after using Abott's formula) was however 22.0 per cent (Table 4). Data on mortality when compared with control (Student's t- test) was found significant for mortality on 6th day (t= 4.55*; d.f.= 6; P=0.0039)as well as total mortality (t= 4.85*; d.f.= 6; P=0.0028) . Our result also showed survival of 93.0 per cent bugs at the end of experiment (**Table 81**).

Although the present result eludes the positive response of the bugs against saffron thrips, however real cause of mortality of the saffron thrips needs careful investigation in view of the bugs being exclusively oophagus.

The bugs were also released in field condition but none could be recovered after three days. Low temperature at night during October might have led to their death in field condition.

Table 81: Response of anthocorid bugs, *Blaptostethus pallescens* against saffron thrips, *Haplothrips* sp. during 2014-15

	% mortality (3^{rd} day)	% mortality (6^{th} day)	Total mortality %	Corrected mortality %	% survival of bugs
Predatory mite treated	5.5 (13.5)	25.8 (30.2)	31.3 (56.0)	22.0	93.0
Control	3.4 (10.1)	8.5 (16.2)	11.9 (19.6)	--	--
Students- t- test	t= 1.35 NS	t= 4.55*	t= 4.85*	--	--

Figures in columns represent mean of 5 replications
Values in parentheses are arc sin transformations
Similar alphabets in a column indicate values statistically on par

2.14. Tea Mosquito Bug

1. Evaluation of *Beauveria bassiana* (IIHR isolate) against Tea mosquito bug in Tea

AAU-Johrat

Experimental details:

Location: Kachagaral, JORHAT
Area: 1 hectare
Variety: TV -23
Replication: 4
Plot size: One hectare area was divided into 20 equal plots
Year of commencement: 2013 -14

Tratments:

1. Thiamethoxam @30 g ai/ha
2. Pestoneem @3 ml/lit
3. *Beauveria bassiana* (Commercial product, Helocone L) @ 2.5 lit/ha
4. *Beauveria bassiana* (IIHR strain)
5. Untreated Control

To evaluate the *Beauveria bassiana* (IIHR strain) *B.bassiana* (Commercial product) and botanical insecticides (Pestoneem) against tea mosquito bug (*Helopeltis theivora*), an organic tea garden area of 1 ha was selected at Kachagaral area of Jorhat. For spraying thiamethoxam @ 30g ai/ha against *H. theivora,* a separate area of 0.2 ha was also selected at an isolated distance about 1 km away from Kachagaral. Two rounds of sprays were given against *H. theivora* maintaining an interval of 30 days in between the sprays. First spray schedule was taken in August at the occurrence of pest the pest and second was at September.

Methodology:

Observations on pre treatment count was recorded before imposing the treatments and in case of post treatment count, adults were counted on 10 randomly selected plants from each replication at 15 and 30 days interval after each spray. Eggs of *H. theivora* and predatory spiders were also collected from each treatment and observed in the laboratory for emergence of natural enemies.

The result (**Table 82**) indicated that among the bioinsecticides, IIHR strain of *Beauveria bassiana* recorded minimum population of *H. theivora* (18.60 adults /10 plants) compared to untreated control (53.0 adults /10 plants) and was on par with Pestoneem @ 5ml/l (20, 30 adults/ 10 plants) recorded after 30 days of second spray. Insecticidal treatment against *H. theivora* , thiamethoxam @30 gm ai/ha was found superior to *B. Bassiana* (IIHR strain) The lowest population of 8.90 adults /10 plants was recorded in thiamethoxam treated plot.

Table 82: Efficacy of *Beauveria bassiana* (IIHR strain) on *Helopeltis theivora* in tea

Treatments	Pre treatment count (Adults/ 10 plants)	Post treatment count (Adults/10 plants)			
		15 days after Ist spray	30 days after Ist spray	15 days after IInd spray	30 days after IInd spray
Thiamethoxam @ 30g ai/ha	46.90	28.80[b]	19.60[d]	11.40[d]	8.90[d]
Pestoneem	44.40	33.90[b]	29.00b	24.60[bc]	20.30[bc]
Beauveria bassiana (Commercial formulation)	45.80	34.50[b]	30.50[b]	27.60[b]	25.40[b]
B.b (IIHR strain)	50.20	31.60[b]	24.90[c]	22.70[c]	18.60[c]
Control	48.50	49.80[a]	50.90[a]	50.60[a]	53.00[a]
CV %	--	10.86	13.38	8.78	11.83
CD (=0.05)	NS	3.52	3.76	2.18	2.71

Means followed by the same letter in a column are not significantly different

2.15. Mealybugs

i. Monitoring the diversity and outbreak of invasive mealybugs on major horticultural crops (TNAU, IIVR)

TNAU-Coimbatore

The survey on invasive mealybug was made in four districts *viz*., Coimbatore, Tiruppur, Erode and Salem districts during the period under report. The incidence of *Phenacoccus* was noticed in tapioca and Bhendi. The incidence of *Paracoccus marginatus* was noted in mulberry, tapioca, papaya, jatropha and not observed on bhendi. The occurrence of *Pseudococcus jackberdislei* was recorded only on papaya and tapioca. Among the parasitoids *Acerophagus papayee* was constantly associated with papaya mealybug on all hosts infested with the pest. The occurrence of *Cryptolaemus montrouzieri* and *Spalgis epius* were noted in all the hosts infested with papaya mealybug (**Table 83**).

Table 83. Incidence of invasive mealybugs in horticultural crops in Tamil Nadu

Places surveyed	Crop	Mealybug incidence (%)			Natural Enemy/5 leaves		
		Phenacoccus solenapsis	*Paracoccus marginatus*	*Pseudococcus jackbeardsleyi*	*A.papayae*	*Cryptolaemus*	*Spalgis epius*
Coimbatore	Mulberry	-	0-4.3	0.0	0 – 2.0	0 – 2.0	2
	Tapioca	1.0-2.0	2.5-5.6	0.0	1.5 - 3	1.0 -4.0	2
	Papaya	-	2.3 -6.2	0.0-1.5	1.0-5.4	3.5 -6.5	3
	Jatropa	-	0.5-3.0	0.0	1.0 – 3.0	1.0 -2.0	1
Tiruppur	Mulberry	-	3.0-6.2	0.0	1.0 -4.0	0.5 – 3.5	2
	Tapioca	-	3.5-7.4	0.0-1.5	2.5 – 5.0	1.0 – 3.2	2
	Bhendi	1.0-2.3	0.0	0.0	0.0	0.0	-
Erode	Mulberry	-	1.5-4.5	0.0	3.0 -5.5	1.0 – 4.5	2
	Tapioca	1.0- 2.5	2.0-7.3	0.0-2.1	3.0- 7.5	1.5 – 3.5	2
	Papaya	-	3.6-7.5	0.0-2.0	0.0 -4.5	0.0 -4.0	1
	Bhendi	2.5-3.2	0.0-0.0	0.0	0.0	0.0	-
Salem	Mulberry	-	1.5-4.0	0.0	3.5 – 5.0	1.5 -4.5	2
	Tapioca	-	3.0-10.5	4.5-12.5	3.0 -7.5	0.0 – 3.5	2
	Bhendi	1.5-3.2	0.0	0.0	0.0	0.0 – 2.5	-

IIVR-Varanasi

Extensive surveys conducted in and around Varanasi revealed the occurrence of two mealybug species *viz*., *Phenacoccus solenopsis* (Tinsley) and *Centrococcus insolitus* (Green) (Pseudococcidae: Homoptera) infesting major vegetables during April, 2014 to March, 2015. The dominant species was identified as *P. solenopsis* infesting several vegetables namely tomato, brinjal, *Capsicum*, okra and cucurbits. Incidence of this mealybug was observed almost thorough out the year on one or other vegetable crops available in the region except in

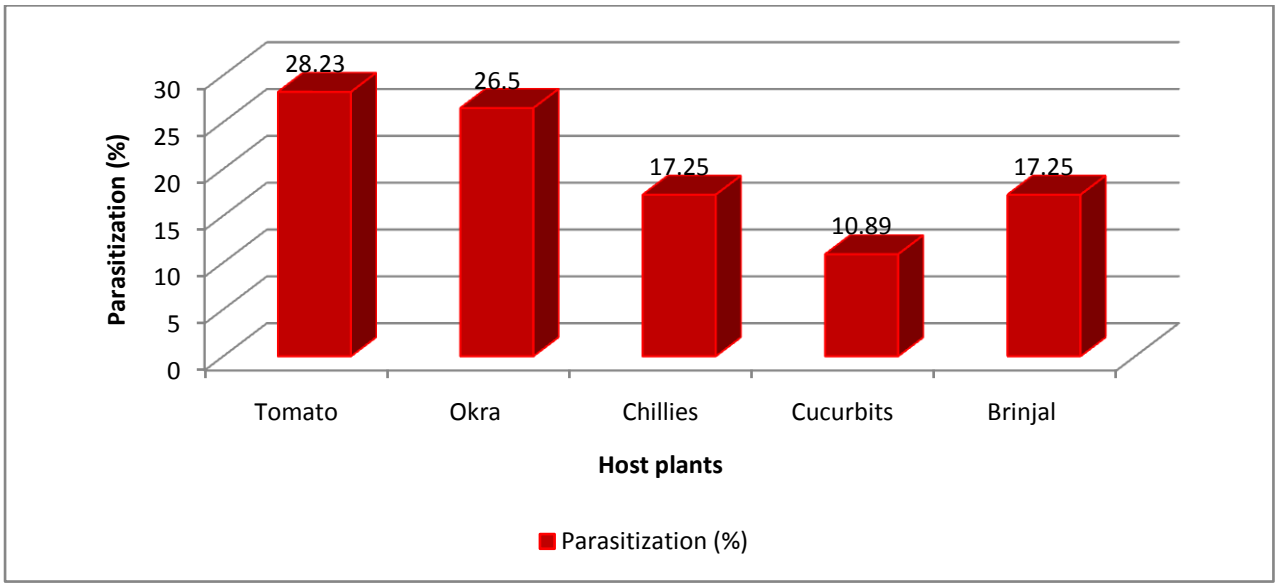
peak summer during May-June. In case of tomato, this mealybug existed from February to April where as in brinjal the infestation was recorded during March –April (**Table 84**). Similarly, in cucurbits and okra its infestations were noted during July- August and September to October, respectively. From October to December its incidence was documented on *Capsicum* grown mainly poly-house condition. During peak summer (May-June) the incidence of *P. solenopsis* was restricted to weeds particularly *Parthenium hysterophorus*. In case of brinjal, another mealybug species *i.e.,C.insolitus* was recorded particularly during September - October.

Table 84: Occurrence of *P. solenopsis* on different vegetables in Varanasi

Month	**Peak period of activity**				
	Tomato	***Capsicum***	**Brinjal**	**Cucurbits**	**Okra**
January-15					
February-15					
March-15					
April-14					
May-14					
June-14					
July-14					
August-14					
September-14					
October-14					
November-14					
December-14					

During the study, one prominent nymphal endoparasitoid *viz.,Aenasius bombawalei* Hayat (Encyrtidae: Hymenoptera) of *Phenacoccus solenopsis* was recorded. Tritrophic interaction (Host plant – *P. solenopsis* – parasitoid) was observed during the recovery of the parasitoids from different hosts. Highest cumulative recovery was obtained from tomato (28.23%) followed by okra (26.5%) whereas lowest recovery (10.89%) was in case of cucurbits (**Fig. 2**).

Fig. 2 Host preference of *Aenasius bombawalei*, parasitoid of *Phenacoccus solenopsis* of different vegetables



2.16. Biological suppression of polyhouse crop pests

1. Monitoring of pests and natural enemies in *Chrysanthemum* under polyhouse conditions. (TNAU-Coimbatore)

Survey on the pests of *chrysanthemum* grown in polyhouse was carried out in different places viz., Kothagiri, Yercaud and Kodaikanal. The survey revealed the occurrence of whitefly (*Bemisia tabaci*), serpentine leaf miner (*Liriomyza trifolii*) and tetranychid mite (*Tetranychus urticae*). The population of whitefly ranged 0-3 nos./plant, whereas, tetranychid mites population was 3-12 /2cm^2. The population of serpentine leaf miner as indicated by leaf mined damage 3-8 nos. /plant. The natural enemies associated with leaf miner were collected and sent to NBAIR, Bengaluru for identification. Presence of coccinellid *Stethorus* sp. and predatory mite were also noted in chrysanthemum. **(Table 85)**.

Table 85: Pest incidence in chrysanthemum under polyhouse condition

Locations	Period	Per cent incidence / plant		
		whitefly	Leaf miner damage	Mite incidence per 2 sq.cm
Kothagiri	August 2014	0.0 - 3.5	3 .0 -8.2	0.0 – 5.4
Yercaud	September 2014	0.0 – 5.2	3.4 – 5.8	0.0 – 7.2
Kodaikanal	December 2014	0.0 – 1.3	1.5 – 4.6	0.0 – 4.1

2. Evaluation of entomopathogenic fungi against spider mite, *Tetranychus urticae* on capsicum /bell pepper under protected cultivation

PAU-Ludhiana

The capsicum seedling was transplanted in March under protected conditions according to agronomic practice norms. The entomopathogenic fungi will be evaluated against spider mite/sucking pest and the results will be submitted thereafter

3. Evaluation of anthocorid predators against spider mites, *Tetranychus urticae* under insect net cage condition (Brinjal, Chilli, Okra) (PAU-Ludhiana)

The experiments on evaluation of anthocorid predator, *Blaptostethus pallescens* against spider mite, *Tetranychus urticae* on brinjal, chilli and okra under net house condition is being conducted at Entomological Research Farm, PAU, Ludhiana with the following

Treatments

a) *Blaptostesthus pallescens* @ 10 nymphs per m row
b) *Blaptostesthus pallescens* @ 20 nymphs per m row
c) *Blaptostesthus pallescens* @ 30 nymphs per m row
d) Chemical control: Omite @ 300 ml/ acre
e) Untreated control

The crops of brinjal, chilli and okra have been transplanted/ sown in the poly house in in the 1st week of March-2015 and the experiment is in progress.

4. Biological management of red spider mite *Tetranychus urticae* infesting rose in polyhouse conditions MPKV-Pune

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. On the Variety - Passion, Entomopathogenic fungi formulations and predatory mites obtained from the NBAIR, Bangalore. The trial is in progress.

5. Evaluation of efficacy of predators against cabbage aphids in polyhouse (SKUAST-Srinagar)

Cabbage saplings were planted in three blocks during end of May' 2014 in the poly house of Biocontrol unit and allowed for sufficient aphid infestation for evaluation of predation propensities of released grubs of *Coccinella septempunctata* (T1) and *Chrysoperla zastrowi* (T2). The data was compared with control (T3), in the same poly house, covered with net.

The culture of predators was maintained in the Biocontrol laboratory by rearing both on aphids as well as eggs of *Corcyra cephalonica*. Five weekly releases of 2nd instar grubs of *C. septempunctata* and *C. zastrowi* were made on a total of ten plants @ five grubs/ plant, during ending June to July' 2014. An up- to-date data was maintained for the aphid density from ten randomly selected plants, before and after release of predators every week, for each treatment. The data was statistically analyzed using Minitab.

The aphid density before release of predators varied from 541.0 to 634.8 per leaf in the three blocks but was found statistically identical block wise (F= 2.12ns; d.f.= 2(18); p= 0.149). The number of aphids in untreated block continued to rise from 541.0 to 1067.7 within a month with slight decline afterwards. However average number of aphids were found to be 834.8/leaf. On the other hand, T2 and T3 blocks which were treated weekly with five grubs each, indicated a gradual decline in aphid density/ plant, with average number of aphids being 293.05 and 395.2/ leaf at the end of the experiment (**Table 86**).

Analysis of data indicated difference in aphid density statistically significant block wise, just after first release of the grubs (F= 5.91*; d.f.= 2(18); p= 0.011), although the effect of the two predators was statistically on par during this period. *C. septempunctata* was found superior to *C. zastrowi* in terms of pest suppression, as evident from statistically significant differences in aphid densities after second release of predators (**Table 86 & 87**). Per cent reduction in aphid density which was worked out as 23.6 to 55.3 and 13.9 to 38.4 for *C. septempunctata* and *C. zastrowi* respectively indicated the supremacy of the former. Differences in per cent reduction in aphid density when compared for the two predators were found statistically significant from after first to fifth release (**Table 86 & 87**). Overall reduction in pest density by *Coccinella septempunctata* and *Chrysoperla zastrowi* was worked out as 40.6 and 23.8 per cent respectively (**Table 86 & 87**), which however was found as 62.7 and 50.7 per cent over control (**Table 86 & 87**).

Table 86: Per cent reduction in aphid density after every release of predators during 2014-15

Predators	% Reduction in aphid density					
	After 1st release	After 2nd release	After 3rd release	After 4th release	After 5th release	Average reduction
Coccinella septempuctata	23.6 (28.7)[a]	36.2 (36.8)[a]	40.2 (39.2)[a]	48.0 (43.8)[a]	55.3 (48.1)[a]	40.6 (39.5)[a]
Chrysoperla zastrowi sillemi	13.9 (21.2)[b]	22.3 (27.8)[b]	23.4 (28.7)[b]	21.1 (26.5)[b]	38.4 (38.1)[b]	23.8 (29.0)[b]
CD (0.05)	**4.00**	**1.9**	**3.39**	**5.45**	**6.1**	**1.89**
Student's t-test	t= 2.69**	t= 3.13**	t= 4.39**	t= 5.21**	t= 3.41**	t= 6.01**

Figures in each column represent mean of 10 replications
Values in parentheses are arc sin transformations
Similar alphabets in a column indicate values statistically on par

Table 87. Effect of weekly releases of predators on cabbage aphids in poly house during 2014-15

Predators	Average no. of aphids- 10 leaves							
	Pre treatment	After 1st release	After 2nd release	After 3rd release	After 4th release	After 5th release	Average no. of aphids	% reduction in aphid over control
Coccinella septempuctata	632.7 (25.0)[b]	487.8 (21.8)[b]	309.7 (17.4)[c]	185.9 (13.4)[b]	98.7 (9.7)[c]	43.5 (6.4)[c]	293.05 (16.9)[c]	62.7
Chrysoperla zastrowi sillemi	634.8 (24.9)[b]	554.8 (23.2)[b]	430.5 (20.4)[b]	327.6 (17.8)[b]	258.7 (15.7)[b]	164.8 (12.4)[b]	395.2 (19.6)[b]	50.7
Control	541.0 (22.9)[a]	659.0 (25.4)[a]	874.4 (29.2)[a]	999.1 (31.1)[a]	1067.7 (32.2)[a]	868.0 (28.7)[a]	834.8 (28.5)[a]	--
CD (0.05)	**1.91**	**1.82**	**2.25**	**2.5**	**2.71**	**3.43**	**1.9**	

- Figures in each column represent mean of 10 replications
- Values in parentheses are √n
- Similar alphabets in a column indicate values statistically on par

6. Evaluation of predatory mite, *Neoseiulus longispinosus* against phytophagus mite in carnation under polyhouse conditions (YSPUHF-Solan)

Predatory mite, *Neoseiulus longispinosus* at predator: prey ratio of 1:10, 1:20 and 1:30 and Neem Baan (1500 ppm; 3ml/l) were evaluated against *Tetranychus urticae* on carnation (cv Master) under polyhouse conditions at Nauni, Solan during September-October 2014. Recommended acaricide, fenazaquin (0.0025%) and untreated control were also included in the experiment for comparison. Three releases of predatory mite of each treatment were made

at 7 days interval during September-October, 2014. Similarly, three sprays each of Neem Baan (3ml/l) and fenazaquin(0.0025%) at 7 days interval were made. The experiment was conducted in a randomized block design with 4 replications for each treatment. Mite count was recorded before spray/release and 7days 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 different treatments of bio-pesticides and bio-agents, *N. longispinosus* at 1:10 predator: prey ratio was the most effective resulting in 84.7 per cent reduction in mite population over control which was on par with fenazaquin (0.0025%) resulting 92.1 per cent reduction (**Table 88**). *N. longispinosus* at predator: prey ratio of 1:20 and 1:30 resulted in 72.5 and 69.2 per cent reduction in population over control and were also statistically on par with its predator: prey ratio of 1:10. However these treatments were also on par with Neem Baan (1500ppm; 3ml/l) which resulted in 55.3 per cent reduction in mite population over control.

Table 88: Evaluation of *Neoseiulus longispinosus*and neem against phytophagus mite in carnation under polyhouse condition.

SN	Treatment	Reduction (%) in mite population over control
1	*N. longispinosus* (1:10)	84.7 (67.5)[a]
2	*N. longispinosus* (1:20)	72.5 (58.8)[abc]
3	*N. longispinosus* (1:30)	69.2 (56.6)[abc]
4	NeemBaan (1500 ppm;3ml/L)	55.3 (48.6)[c]
5	Fenazaquin (0.0025%)	93.9 (76.4)[a]
	CD(p=0.05)	(12.6)
	CV (%)	13.1

Figures in parentheses are angular transformed values

7. Evaluation of biocontrol agents against sap sucking insect pests of ornamental/vegetables in polyhouses (YSPUHF-Solan)

An experiment for the evaluation of biocontrol agents viz. *Lecanicillium lecanii, Beauveria bassiana, Metarhizium anisopliae* ($2x10^7$ conidia/ml each), *Coccinella septempunctata* (10 beetles/plant) and Neem Baan (1500ppm;3ml/L) against rose aphid, *Microsiphum rosaeiformis* on rose was conducted under polyhouse conditions at Nauni, Solan during October-November 2014. Methyldemeton (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 subjected to Abbott's correction to get percent reduction over control.

Data presented in **Table 89** revealed that Methyldemeton (0.025%) treatment and Neem Baan (1500ppm;3ml/L) were found to be the most effective in reducing the pest population (98.4 & 96.0 % respectively) compare to other treatments. The next best

treatments were spraying of *L. lecanii*/release of *C. septempunctata* with a reduction of 77.4 & 79.4 % respectively).

Table 89: Evaluation of bio-control agents against *Microsiphum rosaeiformis***on rose under polyhouse conditions**

SN	Treatment	Reduction(%) in aphid population over control
1	*L. lecanii* ($2x10^7$ conidia/ml)	77.4 (62.9)[b]
2	*Beauveria bassiana* ($2x10^7$ conidia/ml)	37.3 (37.4)[c]
3	*Metarrhizium anisopliae* ($2x10^7$ conidia/ml)	54.0 (47.3)[c]
4	*Coccinella septempunctata*(10/plant)	79.4 (63.9)[b]
5	Neem Baan (1500 ppm;3ml/L)	96.0 (82.0)a
6	Methyldemeton (0.025%)	98.4 (84.9)[a]
	CD(p=0.05)	(14.9)
	CV (%)	15.5

Figures in parentheses are angular transformed values

8.Validation of BIPM of thrips on capsicum on polyhouse (IIHR-Bengaluru)

The effectiveness of two formulations of entomopathogens of IIHR against *Scirtothrips dorsalis* on capsicum F1 hybrid, Indra was carried out. The experiment is in progress.

9. Identification and evaluation of predatory mite potential on *Tetranychus spp* in tomato under greenhouse condition (UAS,Raichur).

Standardization of mass multiplication technique for predatory mite was done under insectary by raising a susceptible cultivar of soybean in earthen pots and by stapling technique. Tomato variety Hima sona is transplanted on 13-02-2015 under greenhouse condition and the effectiveness of predator will be evaluated during the peak activity of *Tetranychus spp*.The experiment in progress.

2.17. Biological suppression of storage pests

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

Objectives:

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 pigeonpea seed under storage
4. To monitor the effect of *Uscana* sp. release on seed quality attributes particularly seed viability during storage

Treatments

T1-Release of 10 *Uscana* sp. + 50 eggs of *Callosobruchus* sp.
T2-Release of 20 *Uscana* sp. + 50 eggs of *Callosobruchus* sp.
T3- Release of 30 *Uscana* sp. + 50 eggs of *Callosobruchus* sp.
T4-Release of 40 *Uscana* sp. + 50 eggs of *Callosobruchus* sp.
T5-Control: 50 eggs of *Callosobruchus* sp.

Methodology

Certified seeds of pigeon pea with very high percentage of germination and low moisture content (about 10%) were taken for the experiment. Cards were prepared by pasting pigeon pea seeds (12-15 no.) with gum and kept in test tubes. Freshly emerged bruchids were allowed into test tubes for egg laying on the seeds pasted on cards. Bruchids after egg laying were removed from the test tubes. Cards with eggs were transferred into new test tubes and maintained equal no. of eggs on each card were maintained (50 no.). Required number of freshly emerged *Uscana* sp. were released into test tubes containing eggs. Test tubes were closed with cotton plug and kept in room under ambient conditions. The temperature and relative humidity of the room were recorded on standard weekly basis.

Observation 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

Observations were recorded 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 results of the experiments showed that increase in number of *Uscana* sp. is directly proportional to the level parasitization (**Table 90**). The highest parasitization of 42 per cent was observed in the treatment T4 (40 *Uscana* sp released). Lowest egg parasitization

of 18% was noticed in in T1 treatment. No parasitization was observed in Control (T5) with no *Uscana* sp released.

Bruchids emerged from all the treatments. Cent percent seed infestation was observed in T5 (control). Lowest infestation of seed was noticed in T4 (78.67 per cent) followed by T3 (82.67 per cent). More seed infestation with 90 and 87.67 per cent was observed in T1 and T2 respectively (**Table 90**).

There was drastic increase in the moisture content as and when the infestation started. The highest of 15.50 per cent moisture content was observed in control (T5) where as 12.17, 12.40, 13.67 and 14.50 per cent per cent was recorded in T1, T2, T3 and T4 respectively (**Table 90**).

The germination of pigeon pea seeds was highest in T4 which was 82.33 per cent. In control only 75% of seeds germination was observed. The germination per cent recorded in other treatments (T1, T2 and T3) were 80.00, 81.33 and 80.67 respectively (**Table 90**). The insect infestation reduced the germination to 10 per cent (initial germination 95 per cent).

The highest root length with 11.70 cm was recorded in the seedlings of T4 followed by 10.18 cm in the seedlings of T3. The lowest root length of 7.33 cm was recorded in T5 (control), remaining showed moderate root length (**Table 90**). Similar trend was observed in shoot length.

Table 90. Parasitization effect of *Uscana* sp. on eggs of *Callosobruchus maculatus* in Pigeonpea

Treatment	Parasitazation (%)	Seed infestation (%)	Moisture content (%)	Germination (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Vigour Index	Dry weight (g)
T1 (10*Uscana* sp)	18.00 (4.24)	90.00 (9.49)	12.17 (3.49)	80.00 (8.94)	8.33	7.47	15.79	1263.2	0.38
T2 (20*Uscana* sp)	28.67 (5.35)	87.67 (9.36)	12.40 (3.52)	81.33 (9.02)	10.17	8.60	18.76	1525.7	0.29
T3 (30*Uscana* sp)	38.33 (6.19)	82.67 (9.09)	13.67 (3.70)	80.67 (8.98)	10.18	8.37	18.02	1453.4	0.24
T4 (40*Uscana* sp)	42.00 (6.48)	78.67 (8.87)	14.50 (3.81)	82.33 (9.07)	11.70	10.63	19.96	1643.3	0.23
T5 Control	0.00 (0.00)	100.00 (10.00)	15.50 (3.94)	75.00 (8.66)	7.33	6.77	14.09	1056.7	0.02
Sem±	**0.63**	**0.48**	**0.31**	**1.08**	**0.95**	**0.50**			
CD (0.05)	**3.12**	**2.41**	**1.54**	**5.32**	**4.68**	**4.47**			

2.18. Biological suppression of weeds

1. Biocontrol of *Cromolaena odorata* in forest and waste land area of Chhattisgarh utilizing *Cecibochares connexa* by inoculative release (DWSR, Jabalpur)

Cromolaena odorata, a problematic weed of North-East, Western Ghats, Karnataka and Tamil Nadu has spread its tentacles in Baster area of Chhattisgarh. It has infested large area of community land, wasteland and forest lands in this area. During survey in 2014 revealed increase in its infestation area during past two years. The present study of has been taken up keeping in view of its seriousness and to check its further invasion from this region of Chhattisgarh to Maharashtra and Madhya Pradesh.

In this region, the first attempt of classical biological control was made in 2012, when about 3000 galls infested with gall fly were released in the infested area. Symptoms of establishment of bioagent were not observed in 2013. Therefore, again 1500 infested galls were released in the three different sites of Jabalpur area in September 2013. Again in 2014, about 500 galls were released in teak plantation site. Survey done during 2014 revealed the presence of galls on *Chromolaena odorata* indicating the start of establishment process. Samples taken from nine different plots for gall formation revealed the presence of galls varying from 1.67 to 7.08/ 25 m^2

Attempts were made to establish *C.odorata* in net house and field conditions at DWR for mass multiplication of bioagent but only meager success achieved.

2.19. Enabling large scale adoption of proven bio control technologies

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

AAU-Johrat

Large scale demonstration of bio control based IPM package in rice was carried out in the farmer's field at village Borholla in Jorhat district on variety 'Ranjit' covering an area of 30 ha. The crop was transplanted in 27.7.2014. The BIPM package as per technical programme was evaluated in comparison with Farmer's practice (chemical control) where chlorpyrifos 20 EC / bifenthrin 10 EC @ 400 g.ai/ha was applied. Three rounds of chemical sprays were made at 40, 50 and 60 DAT in farmers practice plots. The BIPM package comprised of

- 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 @ 5ml/lit) against foliar as well as sucking pests
- Spray of *P. fluorescens* 10g/lit 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, hairy caterpillar was not found during observation. As regards to case worm infestation the population was negligible (<1%). Statistical analysis was carried out using 't' test and the results are given in **Tables 91, 92, 93, 94 & 95.**

There was no significant difference in population of *Nephotettx sp*/hill in BIPM and farmers practice (**Table 91**). The incidence of dead hearts (3.41%) and damaged leaves due to *Cnaphalocrocis* sp.(3.85 %) was significantly high in farmers' practice plots whereas they were 2.60 and 2.57% in BIPM after 65 DAT, respectively. In case of WEH, the per cent incidence was 2.77 in BIPM plots which was significantly superior to farmers' practice plots (3.76) at 125 DAT (**Table 92**). Maximum yields of 4126.0 Kg / ha was registered in IPM package which was at par with farmers practice. The yield of farmers' practice plots was 3984.4 Kg/ha (**Table 92**).

The population of natural enemies like spiders and coccinellids were significantly high in BIPM when compared to farmers' practice. (**Table 93 & 94**). Higher number of spider and coccinellids population of 1.50 /m^2 and 1.80/m^2 was recorded in BIPM plots as against 0.60/m^2 and 0.70/m^2 in farmers' practice plots after 65 DAT. The important predatory spiders recorded were *Oxyopes javanus, Tetragnattha sp.* and *Lycosa pseudoannulata.* In case of coccinellids beetles, *Micraspis* sp was more predominant up to paenicle initiation stage of the crop. The investigation revealed that IPM 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. 36709 /ha in BIPM package as compared to Rs. 29250/ha in farmers' practice (**Table 95**)

Table 91: Observations on incidence of *Nephotettix* sp./ hill

Treatments	Precount (*Nephotettix* sp./ hill)	Post count (*Nephotettix* sp./ hill)	
		1st Spray	2nd Spray
BIPM Package	5.20	3.60	1.50
Farmers practice	5.60	3.20	1.10
"t" value	0.646	0.801	1.809
Remarks	NS	NS	NS

Table 92: Observations on incidence of Dead heart, White ear head (WEH), Leaf folder damage (LFD) and grain yield of rice

Treatments	Dead heart (%)		WEH (%)	LFDL (%)		Grain yield (kg/ha)
	45DAT	65DAT		45DAT	65DAT	
BIPM Package	4.00	2.60	2.77	3.88	2.57	4126.0
Farmers practice	4.92	3.41	3.76	4.26	3.85	3984.4
"t" value	1.561	2.29	3.89	0.797	5.74	0.837
Remarks	NS	S	S	NS	S	NS

Table 93: Observations on spider population/m^2

Treatments	Pre count (spider/m^2)	Post count (spider/ m^2)	
		45 DAT	65 DAT
IPM package	1.10	1.00	1.50
Farmers' practice	0.90	0.70	0.60
't' value	0.801	1.00	3.250
Remarks	NS	NS	S

Table 94; ObservationS on coccinellids population/m^2

Treatments	Pre count coccinellids /m^2	Post count coccinellids /m^2	
		45 DAT	65 DAT
BIPM package	1.30	1.60	1.80
Farmers' practice	1.10	0.90	0.70
't' value	0.801	2.33	3.972
Remarks	NS	S	S

Table 95: 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	4126.00	141.60	53,638.00	16935.00	36709.00
Farmers' practice	3984.40		51,797.20	22547.00	29250.00

Rs. 13/kg of rice grain

KAU-Thrissur

Location : Thrissur (Cherpu, Avinissery, Koorkkenchery, Chazhur and Adat Panchayaths)
Season : December 2014 to March 2015
Area : 100 ha
Variety : Jyothi & Uma

The practices followed in IPM are given below

- Seed treatment with *Pseudomonas* @ 10g/kg of seeds
- *Trichogramma japonicum* and *T. chilonis* @ 1 lakh/ha were released from 20 days after transplanting and 40 days after sowing. Five releases were made at 10 days interval.
- Sprayed *Pseudomomas* @ 2% against foliar diseases.
- Sprayed Fish amino acid and Nimbicidine 0.3% against sucking pests.

The practices followed in conventional farming are given below

- Seed treatment with *Pseudomonas* @ 10g/kg of seeds
- Flubendiamide @ 50 ml/ha against rice stem borer and leaf folder
- Nimbicidine 0.3% against sucking pests

Observations on the population of pests were recorded before and after the release of parasitoids. The incidence of pests was below ETL. Natural enemies were found high in IPM plots. There was no significant difference in grain weight in IPM and Conventional farming (**Table 96**). Presently, IPM is practiced in paddy in all the districts of Kerala.

Table 96: Details of grain yield

Grain yield/ ha	IPM	Conventional	t value	Significance
	8860 kg	8890 kg	-0.156	NS

NS-Non Significant

PAU-Ludhiana

Large scale demonstration of biocontrol of yellow stem borer, *Scirpophaga incertulas* and leaf folder, *Cnaphalocrocis medinalis* were conducted at four locations in village Saholi (Patiala) in organic *basmati* rice (var. Pusa 1121) over an area of 50 acres. The demonstration area was divided into three blocks representing three treatments, *viz*. six releases of *T. chilonis* and *T. japonicum* each @ 1,00,000 parasitoids/ha starting from 30 days after transplanting (DAT), 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 leaves in biocontrol treatment. Farmers' practice included two sprays of Econeem Plus (1%) @ 1000 ml/ha using 250 litres of water per ha. 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 97**), mean dead heart incidence in biocontrol fields was 1.45 and 1.92 per cent at 45 and 60 DAT, respectively. The corresponding figures in farmer' practice was 1.55 and 2.15 per cent. Both the treatments were comparatively better than untreated control both at 45 DAT (4.48 %) and 60 DAT (5.72 %). The mean incidence of white ears was significantly better in biocontrol field (2.01 %) as against farmer's practice (2.99 %) and untreated control (6.63 %). Leaf folder damage in biocontrol fields was 1.20 and 1.78 per cent at 45 and 60 DAT, respectively as compared to 1.15 and1.49 per cent in farmer's practice and 5.09 and 6.45 per cent in untreated control. Grain yield in biocontrol field (32.00 q/ha) was significantly better as compared to 30.05 and 26.88 q/ha in farmer's practice and untreated control, respectively. The net returns over control in biocontrol package were Rs 14652/- as compared to Rs. 8379/- in farmers' practice with cost benefit ratio of 1: 3.88 and 1: 2.76, respectively (**Table 98**).

It can be concluded that six releases of *T. chilonis* and *T. japonicum* each @ 1, 00,000/ha resulted in lower incidence of rice insect pests, higher grain yield, more net returns with higher cost: benefit ratio as compared to farmers' practice in organic *basmati* rice.

Table 97: Large scale demonstration of biocontrol of stem borer and leaf folder in organic *basmati* rice during 2014

Treatments	Stem borer damage (%)			Leaffolder damaged leaves (%)		Yield (q/ha)
	Dead hearts		White ears			
	45 DAT	60 DAT		45 DAT	60 DAT	
Biocontrol (*T. chilonis* and *T. japonicum*)*	1.45[a]	1.92[a]	2.01[a]	1.20[a]	1.78[a]	32.00[a]
Farmer's Practice**	1.55[a]	2.15[a]	2.99[b]	1.15[a]	1.59[a]	30.05[b]
Untreated control	4.48[b]	5.72[b]	6.63[c]	5.09[b]	6.45[b]	26.88[c]

DAT – days after transplanting; * 6 releases of *T. chilonis* and *T. japonicum* each @ 1,00,000/ha at weekly interval starting from 30 DAT; ** Two sprays of Econeem Plus @ 1000 ml/ha; Number of locations: Four

Table 98: Cost Benefit analysis (2014)

Treatments	Yield (q/ha)	Additional yield over control (q/ha)	Gross returns (Rs.)	Cost of treatment* (Rs/ha)	Net return over control (Rs/ha)	Cost: benefit ratio
Biocontrol (*T. chilonis* and *T. japonicum*)	32.00	5.12	18432	3780	14652	3.88
Farmer's Practice	30.05	3.17	11412	3033	8379	2.76
Untreated control	26.88	-	-	--	-	

Price of *basmati* Rs. 3600 per quintal during 2014; * include trichocard/insecticide + labour cost
Price of Econeem Plus Rs 1100/ lt

OUAT- Bhubaneshwar

Large scale adoption of BIPM in Paddy

BIPM adopted

- Seed treatment with *Pseudomonas* @ 8g/kg of seeds/seedling.
- Spray of *Beauveria bassiana* 10^{13} spores/ha against sucking pests.
- Bird perches erected @10/ha.
- Release of *Trichogramma japanicum* @1 lakh/ha when either the leaf folder or stem borer occurrence is noticed. Releases was initiated as soon as the moth activity was seen. Six releases were made at weekly intervals.
- Spray of *Bt*@2g/ha, 2sprays given at 15 day interval.
- Spray of *Pseudomonas fluorescens* @1.5kg/ha against foliar diseases.
- Spray of Neemazol @2.5lit/ha twice at 45 and 60DAT.

Farmers' practice

- Six to eight rounds of spray with insecticides like Monocrotophos, Chlorpyriphos, Rynaxypyr, Imidacloprid, Acetamiprid etc.

The data in **Table 99** indicated that the IPM practice was superior to the farmers' practice in all locations. Dead heart and white ear were recorded as 5.2 and 8.2% in IPM package while in farmers' practice the corresponding figures were 9.3 and 13.6% respectively. Leaf folder, case worm and skipper population in IPM plots were 4.8, 3.2 and 1.8 % respectively whereas, in the non-IPM plots it was 8.1, 6.3 and 3.9%. The GLH population in IPM fields was 5.1/hill as against 9.3/hill in non IPM fields. It was observed that the beneficial fauna like spiders and ladybirds were more in number in IPM plots which were 7.1/hill and 4.9/hill whereas, the corresponding population in non IPM plots was 1.9 and 1.1/hill respectively. Yields obtained in IPM plots were significantly higher than the non IPM plots. The farmers obtained a net profit ranging from ₹24,640/ha over farmers' practice in different locations.

The results indicated that the IPM package was more effective in managing the insect pests of rice in comparison to the farmers' practice of only chemical pesticide application. The incidence of YSB, GLH and other foliar pests were significantly less in IPM package with significant increase in yield over the farmers' practice. In IPM package, the dead heart, white ear, leaf folder, case worm, Skipper and GLH population were significantly lower than that of the farmers' practice. On the contrary, the spider and ladybird populations were significantly high fetching higher net return over non IPM farmers' practice.

Table 99: Effect of IPM package & Farmers' practice on pest of rice and yield

Treatments	DH (%)	WE (%)	LF (%)	CW (%)	S (%)	GLH/ Hill	Spider/ Hill	LB/ Hill	Yield (Kg/ha)	C:B Ratio	Net Return over Farmer's Practice (₹/ha)
IPM Package	5.2	8.2	4.8	3.2	1.8	5.1	7.1	4.9	4721	1:3.8	24,640
Farmers' Practice	9.3	13.6	8.1	6.3	3.9	9.3	1.9	1.1	3489	1:2.3	

- DH: Dead Heart, WE: White ear, LF: Leaf folder, CW: Case worm, LB: Lady Bird beetle S: Skipper

GBPUAT- Pantnagar

Large scale demonstration of Bio-control technologies in rice

During Kharif season 2014, large scale field demonstration of bio-control technologies was conducted at different villages of district Nainital on the fields of 42 Farmers covering an area of 36.8 hectares (92 Acre) with the plot size ranging from 0.25-2.0 hectares. The Pant bio-agent-3 was applied as soil application with FYM/ vermicompost (5-10 t/ha colonized with PBAT-3), as seed treatment (10 g/kg seed), seedling dip treatment (10 g/lit. water) and need-based foliar sprays of PBAT-3 (10g/lit. water). Stem borer incidence was upto 12-18 %. Among diseases, occurrence of brown spot (*Drechslera oryzae*), sheath blight (*Rhizoctonia solani*), bacterial blight (*Xanthomonas campstris* pv *oryzae*) has been observed. By adopting

bio-control technologies an average yield of 43.0 q/ha was obtained as compared to conventional farmer's practices (36.0 q/h).

2. Sugarcane – PAU, OUAT

PAU-Ludhiana

1. Large scale demonstration of proven biocontrol technologies against sugarcane early shoot borer, *Chilo infuscatellus*

In collaboration with sugar mills

Large scale demonstration of effectiveness of *T. chilonis* (tts) against early shoot borer, *Chilo infuscatellus* over an area of 1000 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. The egg parasitoid, *T. chilonis* was released during mid April to end June, at 10 days interval @ 50,000 per ha. The incidence of *C. infuscatellus* at Nawanshahar and Morinda in release fields was 3.7 and 0.9 per cent, respectively (**Table 100**). The corresponding figures in control fields were 7.9 and 2.0 per cent. The reduction in damage over control in these two mills was 53.2 and 55.0 percent, respectively.

It can be concluded that in large-scale demonstration, eight releases of *T. chilonis* (tts) @ 50,000 per ha at 10 days interval during mid-April to end June reduced the incidence of early shoot borer by 54.1 per cent.

Large-scale demonstrations of effectiveness of *T. chilonis* (tts) against early shoot borer, *C. infuscatellus* were carried out on an area of 100 acres at villages Paddi Khalsa (Distt Jalandhar) and Rawalpindi (Distt. Hoshiapur). 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. Padan 40G @ 25 kg/ ha applied 45 days after planting and untreated control. The incidence of early shoot borer in release fields (5.1%) and chemical control (3.3%) and was significantly better than untreated control (12.8%). The reduction in incidence over control was 60.2 and 84.4 per cent in release fields and chemical control, respectively. The mean parasitism of eggs of *C. infuscatellus* in release fields was 50.4 per cent as compared to 4.1 percent in chemical control and 5.0 per cent in control (**Table 101**). The yield in control (630.0 q/ha) was significantly lower than release fields (710.2 q/ha) and chemical control (777.5 q/ha).

It can be concluded that eight releases of *T. chilonis* at 10 days interval during mid-April to mid-June @ 50,000 per ha were better than untreated control, however these were inferior to chemical control against early shoot borer. However the cost: benefit ratio (1: 35.92) was more in biocontrol as compared to chemical control (1: 17.40) (**Table 102**).

Table 100: Demonstration of *T. chilonis* (tts) against *C. infuscatellus* in collaboration with two sugar mills of Punjab during 2014

Mill area	Area covered (acres)	Incidence of *C. infuscatelus*		
		IPM*	Non- Adopted	Per cent reduction over control
Doaba Co-op Sugar Mills Ltd, Nawanshahar	500	3.7	7.9	53.2
Morinda Co-op sugar Mills Ltd, Morinda	500	0.9	2.0	55.0
Total/ Mean	**1000**	**-**	**-**	**54.1**

Note: Eight releases of *T. chilonis* were made @ 50,000/ha at 10 days interval during mid-April to end June.

Table 101: Demonstration of *T. chilonis* (tts) against *C. infuscatellus* by PAU, Ludhiana during 2014

Treatments	Incidence (%)	Per cent reduction over control	Per cent parasitism	Yield (q/ha)
T. chilonis @ 50,000 per ha*	5.1^{b}	60.2	50.4^{a}	710.2^{b}
Padan 40G @ 25 kg/ ha	3.3^{a}	84.4	4.1^{b}	777.5^{a}
Control	12.8^{c}		5.0^{b}	630.0^{c}

* 8 releases at 10 days interval

Table 102: Cost Benefit analysis (2014)

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
T. chilonis @ 50,000 per ha	710.20	80.20	23258.00	630.00	22628.00	1: 35.92
Padan 40G @ 25 kg/ ha	777.50	147.50	42775.00	2325.00	40450.00	1:17.40
Control	630.00	-	-	-	-	-

Price of sugarcane: Rs. 290/ quintal during 2014; * include trichocard/insecticide + labour cost
Price of Padan Rs 85/ kg

2. Large scale demonstration of proven biocontrol technologies against sugarcane stalk borer *Chilo auricilius* (PAU)

a. In collaboration with sugar mills

Large scale demonstration of effectiveness of *T. chilonis* against stalk borer, *C. auricilius* over an area of 3800 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 103**). 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 Nawanshahar and Morinda in IPM fields was 5.8 and 1.5 per cent respectively. The corresponding figures in control (non-adopted) fields were 11.8 and 3.7 per cent. The reduction in damage over control in these two mills was 50.8 and 59.5 per cent, respectively.

It can be concluded that in large-scale demonstration, 12 releases of *T. chilonis* @ 50,000 per ha at 10 days internal during July to October reduced the incidence of stalk borer by 55.2 per cent.

Table 103: Large-scale demonstration of biocontrol based IPM on sugarcane pests in two fields under sugarcane mills in Punjab during 2014

Mill area	**Area covered (acres)**	**Incidence of *C. auricilius***		
		IPM*	**Non- Adopted**	**Per cent reduction over control**
Doaba Co-op Sugar Mills Ltd, Nawanshahar	1800	5.8	11.8	50.8
Morinda Co-op sugar Mills Ltd, Morinda	2000	1.5	3.7	59.5
Total/ Mean	**3800**	**-**	**-**	**55.2**

Note: Twelve releases of *T. chilonis* @ 50,000 per ha at 10 days interval during July to October.

b. PAU, Ludhiana and Regional Station, Abohar

Large-scale demonstrations of effectiveness of *T. chilonis* against stalk borer, *C. auricilius* were carried out on an area of 140 acres at Paddi Khalsa (Dist. Jalandhar), Rawalpindi (Distt. Hoshiapur), Fazilka and Abohar areas. The parasitoid, *T. chilonis* was released 12 times at 10 days interval from July to October @ 50,000 per ha and was compared with untreated control. The incidence of stalk borer in release fields (5.7 %) was significantly lower than untreated control (14.1 %). The reduction in incidence over control was 59.6 per cent. The mean parasitism of eggs of *C. auricilius* in release fields was 53.8 per cent as compared to 5.2 percent in control

It can be concluded that twelve releases of *T. chilonis* at 10 days interval during July to October @ 50,000 per ha were better than untreated control against stalk borer.

3. Large scale demonstration of proven biocontrol technologies against sugarcane top borer, *Scirpophaga* (PAU)

a. In collaboration with sugar mills

Large scale demonstration of effectiveness of *T. japonicum* against top borer, *Scirpophaga excerptalis* over an area of 900 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 104**). The egg parasitoid, *T. japonicum* was

released from mid April to end June, at 10 days interval @ 50,000 per ha. The incidence of *S. excerptalis* at Nawanshahar and Morinda in release fields was 4.5 and 1.0 per cent, respectively. The corresponding figures in control fields were 9.8 and 2.1 per cent. The reduction in damage over control in these two mills was 54.1 and 52.3 percent, respectively.

It can be concluded that in large-scale demonstration, eight releases of *T. japonicum* @ 50,000 per ha at 10 days internal during mid April to end June reduced the incidence of top borer by 53.2 per cent.

Table 104: Large scale demonstration of *Trichogramma japonicum* against *Scirpophaga excerptalis* in collaboration with sugar mills of Punjab during 2014

Mill area	**Area covered (acres)**	**Incidence of *S. excerptalis***		
		IPM*	**Non-Adopted**	**Per cent reduction over control**
Doaba Co-op Sugar Mills Ltd, Nawanshahar	500	4.5	9.8	54.1
Morinda Co-op sugar Mills Ltd, Morinda	400	1.0	2.1	52.3
Total/ Mean	**900**			**53.2**

Note: Eight releases of *T. japonicum* were made @ 50,000/ha at 10 days interval during mid-April to end-June.

b. PAU-Ludhiana

Large-scale demonstrations of effectiveness of *T. japonicum* against top borer, *S. excerptalis* were carried over an area of 175 acres at villages Paddi Khalsa (Distt Jalandhar) and Rawalpindi (Distt. Hoshiapur). The parasitoid, *T. japonicum* was released 8 times at 10 days interval from mid-April to mid-June @ 50,000 per ha and was compared with chemical control (Phorate 10G @ 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 release (6.2 %) and chemical control fields (5.8 %) were at par with each other. However, both the treatments were significantly better that untreated control (13.6%). The reduction in incidence over control was 54.4 and 57.4 per cent in release fields and chemical control, respectively. The mean parasitism of eggs of *S. excerptalis* in release field was 36.4 per cent as compared to 1.8 per cent in chemical control and 2.8 per cent in control (**Table 105**). The yield in control (651 q/ha) was significantly lower than release fields (726.3 q/ha) and chemical control (740.2 q/ha), the latter two were at par with each other.

It can be concluded that eight releases of *T. japonicum* at 10 days interval during mid-April to mid-June @ 50,000 per ha proved as effective as chemical control for the control of top borer. The cost benefit ratio (**Table 106**) was more in biocontrol (1: 35.66) as against chemical control (1: 8.95).

Table 105: Large scale demonstration of *Trichogramma japonicum* against *Scirpophaga excerptalis* during 2014

Treatments	Incidence (%)	Per cent reduction over control	Per cent parasitism	Yield (q/ha)
T. japonicum @ 50,000 per ha	6.2[a]	54.4	36.4[a]	726.3[a]
Phorate 10 G @ 25 kg/ha	5.8[a]	57.4	1.8[b]	740.2[a]
Control	13.6[b]	-	2.8[b]	651.0[b]

*8 releases at 10 days interval

Table 106: Cost Benefit analysis (2014)

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
T. japonicum @ 50,000 per ha	726.30	75.30	21837.00	630.00	21207.00	1: 35.66
Phorate 10 G @ 25 kg/ha	740.20	89.20	25868.00	2600.00	23268.00	1:8.95
Control	651.00	-	-	-	-	-

Price of sugarcane: Rs. 290/ quintal during 2014; * include trichocard/insecticide + labour cost Price of Phorate 10G Rs 80/ kg.

OUAT-Bhubaneshwar

Large-scale Demonstration on the use of *T.chilonis* against early shoot borer and internode borer of Sugarcane in Farmers' field

Village: Korada, Dist. Angul

Area Covered :100 Acres

The crop was planted in the month of November-December; 2013 .First release of *T.chilonis* was done on 5th December after taking pre-release ESB infestation which ranged from 14.4 to 18.8 % and 11.9 to 13.2%. Release of *T.chilonis* for ESB continued till 2nd week of April,2014. Observation on incidence of ESB was taken each week starting from 2nd week of December till the 4th week of April, 2014. The mean incidence of ESB ranged from 6.7 to 9.3%, in *T.chilonis* released plots. On the contrary, the incidence of ESB in the fields where no parasitoids have been released and farmers took their own control measures of pesticide application ranged from 29.4 to 39.1%. Parasitoid release resulted in significant reduction of ESB population as compared to pesticide application.

Similarly, internode borer incidence was also least in parasitoid released plots (13.8% and 16.3%) as compared to 24.45% and 30.3% in farmers practice. As regards to Top Shoot Borer, the incidence before release of parasitoid was 4.5 to 5.9%. The pest incidence was least in parasitoid treatment (2.1% to 3.2%) as compared to the fields where no parasitoid has

been released (7.9% to 9.8%). The yield was higher in parasitoid released plots (149.8/ha to 159.4t/ha) whereas, it was 111.5 t/ha to 115.8 t/ha in farmers practice.

3. Maize (PAU)

PAU

1. Large scale demonstration of proven biocontrol technologies against maize stem borer, C*hilo partellus* using *Trichogramma chilonis* (PAU)

The demonstrations on the biological control of maize stem borer, C*hilo partellus* were conducted at farmer's fields on an area of 202 acres in Hoshiarpur and Ropar districts of Punjab in collaboration with Maize Section, Department of Plant Breeding & Genetics, FASS & 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), Decis 2.8 EC (deltamethrin) @ 200 ml/ha was sprayed two 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 pooled mean (**Table 107**), mean dead heart incidence in fields with release of *T. chilonis* (6.2 %) was at par with chemical control (4.7 %). However, both the treatments were significantly better than untreated control (14.8 %). Similarly, yield in release (47.89 q/ha) and chemical control (50.10 q/ha) fields were at par, whereas, it was significantly lower in untreated control (41.17 q/ha). The net returns over control in biocontrol package was Rs. 8630.20/- as compared to Rs.10978.30/- in farmers' practice with cost benefit ratio of 1: 47.91 and 1: 15.25, respectively (**Table 108**).

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 farmers' practice.

Table 107: Effect of *T. chilonis* releases on incidence of *C. partellus* and yield in *Kharif* maize during 2014

Treatments	Dose / ha	Dead hearts (%)	Yield (q/ha)
T.chilonis @1,00,000/- per ha*	1,00,000	6.2[a]	47.89[a]
Farmers' practice (Decis 2.8 EC @ 200 ml/ha	200 ml	4.7[a]	50.10[a]
Untreated control		14.8[b]	41.17[b]

*Single release; Number of locations: Two

Table 108: Cost Benefit analysis (2014)

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*)	47.89	6.72	8803.20	180	8623.20	1:47.91
Farmer's Practice (Chemical control)	50.10	8.93	11698.30	720	10978.30	1:15.25
Untreated control	41.17	-	-	--	-	

Price of maize Rs. 1310 / Q; * include trichocard/insecticide + labour cost; Price of Decis Rs 550/ litre

4. Coconut: CPCRI, Kayangulam

Large area field validation of integrated biocontrol technology against *Oryctes rhinoceros*

Area: 1500 ha homestead coconut garden

This work initiated during 2013 under CDB funded project in1500 ha area covering Krishnapuram, Devikulangara, Kandalloor panchayaths and Kayamkulam Municipality was continued during 2014-15 also. Farmer Field School (FFS) was one of the main technology transfer methods adopted in this programme. Four Farmer's Field Schools were conducted in different Wards of Kandalloor Panchayat and farmers enriched their knowledge level in health management of coconut. About 235 and 284 palms were treated for red palm weevil infestation and leaf rot disease, respectively. Large scale mass multiplication of *M. anisopliae* in semi-cooked rice-based media was undertaken and 899 breeding sites of rhinoceros beetle were treated in the project area. PVC traps with RB pheromone lure obtained from PCI Ltd., Bengaluru were installed in the project area and the average catch of beetles per month ranged from 8-13 beetles. Pheromone traps were not placed in farms having juvenile palms and in those gardens with taller intercrops. There was significant reduction in leaf damage (65.2 to 85.5%) in the project area. Palm damage was also suppressed in these locations ranging from 21.9 to 34.3%. Knowledge test developed indicted that the pre project knowledge level was 28% with regard to identification of pest/symptoms and management practices. An average of 65.4% improvement on Knowledge on rhinoceros beetle & Integrated management was attained for FFS group farmers over Non FFS farmers.

5. Brinjal

OUAT- Bhubaneshwar

Large scale demonstration of BIPM in brinjal

Area covered :100 Acres

Village : Karatapeta Dist. Angul

BIPM adopted

- Pheromone traps erected @ 25/ha after 15 DAP
- Weekly release of Egg parasitoid *Trichogramma chilonis* @50,000/ha / week after 20 DAP (total of 15 releases) (released till the final harvest)
- Two spray Bt (Dipel) @ 2 ml/l at 10 days intervals at peak flowering

Farmers' practice

Rynaxypyr (Coragen) @ 0.3ml/l at fortnightly intervals or other insecticide application as per availability

The shoot borer and fruit borer incidence was significantly low in IPM plots recording 12.8 and 21.9 % respectively whereas, it was 29.1 and 43.7 % in farmer's practice plots. Consequently the yield was also higher in the IPM plots (20,321 kg/ha) with the cost: benefit ratio of 1:5.1 whereas, the yield in farmers practice plot was 12,209 kg/ha with C:B ratio of 1:1.22 The IPM practice produced a net return of ₹1,62,240 over the farmers practice (**Table 109)**

Table 109: Large scale demonstration of BIPM in brinjal in Orissa

Treatments	Shoot borer incidence (%)	Fruit borer incidence (%)	Marketable fruit Yield Kg/ha	C:B ratio	Net return over Farmers' practice (₹/ha)
IPM package	12.8	21.9	20,321	1: 5.1	1,62,240
Farmer's practice	29.1	43.7	12,209	1: 2.2	

6. Pea: GBPUAT, Panthnagar

During Rabi 2014-15, large scale field demonstrations of bio-control technologies was conducted on pea variety Arkil, at 25 farmer's fields at Golapar area of District Nainital covering an area of about 36 acres. Pant bioagent-3 ((PBAT-3) was applied as soil application with FYM/ vermicompost (5-10 tons/ha) colonized with PBAT-3 followed by seed bio priming (10 g/kg seed). During the year the farmers used bio-control agent for the management of seed rot and wilt problems. Due to the successive application of bio-control, the farmers got desired yield of green pea of 50-55q/acre as compared to conventional farmers practices (25-30 q/acre).

2.20. Tribal Sub Plan Programme (TSP)

1. AAU-J: Popularization of Bio-intensive IPM in vegetables in Assam.

Details of the location of tribal areas

Farmers of the following TSP villages were selected

i) Nam Deory, Under Deory autonomous council, Jorhat District
ii) Kareng Chapori, Under Missing autonomous council, Golaghat District
iii) Dangdhara, Under Thengal Kochari autonomous council, Jorhat District

Number of villages, No. of farmers, area (ha) covered under TSP project

a) Villages : 3
b) Number of farmers :8 in each village
c) Area of demonstration: 0.5 ha per demonstration in each crop

Crops dealt: Major winter vegetables (Cabbage, Tomato, Brinjal and Frenchbean) and summer vegetables (Okra and Chilli).

Biocontrol/ IPM technologies implemented for pest and disease management

The BIPM technology validated under AICRP on biological control in respect of winter and summer vegetables implemented for pest and disease management programme. The technologies were as follows:

a) Use of resistant varieties
b) Soil application of FYM/ vermicompost enriched microbial pesticticides
c) Release of *Trichogramma chilonis*/ *T. brassicae* @ 1 lakhs /ha at weekly interval
d) Use of Yellow Sticky Traps @ 15 traps / ha
e) Use of pheromone trap @ 20 nos /ha.
f) Removal and destruction of infested fruits and shoots
g) Rouging of disease infested plants
h) Spray of *Beauveria bassiana* @ 2 X 10^7 per ml
i) Spray of Bt products @ 1 kg per ha
j) Spray of neem products (NSKE 5%)
k) Need based application of insecticides

Materials supplied to the TSP farmers

a) Seed of high yielding hybrid varieties
b) Biopesticides
c) Bio agents (*Trichogramma)*
d) Biofertilizers
e) Need based pesticides

Name of the farmers associated with the projects:

Village	Name of the farmers	District
Nam Deori	Gangadhar Kutum	Jorhat
	Ramen Deori	
	Bitopan Deori	
	Ajit Kardong	
	Lalit Pegu	
	Bhaity Pegu	
	Nabin Chandra Yein	
	Krisna Pegu	
Kareng chapari	Sri Ramnath Kardong	Golaghat
	Nabin kardang	
	Diganta Panging	
	Nabin Mili	
	Ranjan Pegu	
	Bipin Kutum	
	Ramen Patir	
	Nabajit Paging	
Dangdhara	Sri Rajeev Morang	Jorhat
	Devajeet Morang	
	Monoj Saikia	
	Bhutulu Morang	
	Kanu Morang	
	Hemkanta saikia	
	Rudai Kachari	
	Someswar Saikia	

Crop wise achievement of BIPM demonstration in tribal areas

Sl no.	Crop	Transplanting/ sowing	Yield (q/ha)*
1.	Cabbage	October	184.5
2.	Tomato	October-November	186.8
3.	Brinjal	September	194.5
4.	French bean	October	63.5 (green pod)
5.	Chilli	March	Crop is in vegetative stage
6.	Okra	March	Crop is in flowering stage

*Average yield of 3 villages

The tribal peoples were interested to implement the different components of bio-intensive integrated pest management practices. The farmers' participation in developing BIPM at their field showed immense scope to bridge the gap in farmer's knowledge on application of biological control.

Impact of TSP project

The farmers under TSP programme were economically benefited. Consumers, on the other hand benefitted from receiving pesticides free produce at lower prices. The inputs provided to the farmers and the benefit derived from them significantly helped the farmers in

creation of wealth of the areas. Moreover, the BIPM technology is now being promoted the farmers of those localities towards organic mode of farming.

2. AAU-Anand

TSP on biocontrol technologies for management of *Fusarium* wilt and pod borer (*Helicoverpa armigera*) in chickpea in Gujarat

Under the TSP project 50 tribal farmers were selected from Panchmahal and Mahisagar districts of the Gujarat. Primarily the selected farmers were inspired to grow the chick pea with the improved seed. The farmers were ready to use the improved seed. Farmers were inspired to use biocontrol based IPM techniques to avoid crop losses due to pest and diseases and to get better production. Biocontrol agents like *Trichoderma viride*, biopesticides like Azardiractin and pheromone traps were provided as inputs to control pests and diseases. Farmer's meet was carried out on 21st February, 2015 at Tribal Research and Training Centre, Devgadhbariya to train them and get feedback on BIPM module for the control of *Helicoverpa armigera* and wilt disease in chick pea. The feedback from the farmers indicated that the BIPM package was very effective in minimizing the losses due to pests and diseases and in increasing the yields of chick pea.

3. GBPUAT: Promoting Bio-intensive IPM through a Common Minimum Programme amongst Buksa tribe in district U.S. Nagar in Uttarakhand state.

Under TSP programme during Kharif season (2014) and Rabi season (2014-15) a total of 531 farmers from 4 blocks and 28 villages. were adopted and were given following inputs.

1. 5.5 quintals of bioagent (Pant Bioagent 3) was distributed.
2. 50 kg earthworms were distributed for vermicomposting.
3. Polysheet for soil solarization.

Interventions were given in the following crops

i). Kharif season: Rice, French bean, cowpea, okra, cucumber, bittergaurd, bottlegaurd, green chilli and brinjal
ii). Rabi season: Cauliflower, cabbage and onion.

A total of nine trainings were held during the two cropping seasons whereby various interventions were introduced to the farmers.

Adoption of farmers in the district Udham Singh Nagar under TSP programme

S.No.	Village	Block	Tribe	Farmers adopted
1	Behrainee	Bajpur	Buksa	10
2	Chanakpur	Bajpur	Buksa	10
3	Chandanpura	Bajpur	Buksa	10
4	Maholijangal	Bajpur	Buksa	10
5	Haripurajabran	Bajpur	Buksa	10
6	Santoshpur	Bajpur	Buksa	10
7	Gaganpur	Sitarganj	Tharu	24
8	Pindari	Sitarganj	Tharu	17
9	Sainjani	Sitarganj	Tharu	22
10	Kanpura	Sitarganj	Tharu	21
11	Khempur	Sitarganj	Tharu	18
12	Baanusa	Khatima	Tharu	20
13	Bigrabagh	Khatima	Tharu	23
14	Kutra	Khatima	Tharu	26
15	Thotupura	Bajpur	Buksa	15
16	Majrapacchu	Bajpur	Buksa	24
17	Totaboria	Bajpur	Buksa	17
18	Beriadaulat	Bajpur	Buksa	23
19	Kalpaathapuri	Bajpur	Buksa	15
20	Lalpuri	U S Nagar	Buksa	17
21	Bhatvolachi	U S Nagar	Buksa	25
22	Tillpuri	U S Nagar	Buksa	09
23	Kulha	U S Nagar	Buksa	25
24	Kopakrupali	U S Nagar	Buksa	25
25	Thotopur	Bajpur	Buksa	28
26	Majhrapacchu	Bajpur	Buksa	27
27	Sheetpuri	Bajpur	Buksa	25
28	Totabairia	Bajpur	Buksa	25

Impact analysis

The Buksa and Tharu tribes of the adopted villages in Udham Singh Nagar have developed confidence in adopting common minimum programme, a low cost technology using on farm resources in growing quality vegetables. Now they are well aware about the ill effects of pesticides especially in vegetables.

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

Tribal (ST) dominating areas of Harsul and Daltpatpur in the Taluka Trimbak of Dist Nasik in Maharashtra were selected for implementation TSP in collaboration with Bharatiya Agro Industries Foundation (BAIF), Maharashtra Institute of Technology Transfer for Rural Areas (MITTRA), Nasik. Fifty *Wadis* (fruit orchards) of tribal farmers established by BAIF MITTRA at Harsul and Daltpatpur are selected to carry out operation under TSP. The *Wadi* of 0.40 ha consisting 9-10 years old plantation of fruit crop 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.

Crops to be dealt and pest problems encountered in the tribal villages

Sr. 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
3	**Forest trees**	Stem borer and bark eating caterpillar
4	**French bean**	Aphids and pod borer
5	**Rain fed tomato**	Fruit borer and leaf miner

Training programme:

One day training programme was organized on 6.2.2015 at Harsul. The Power Point Presentation on different pests of fruit crops, marks of identification, nature of damage, symptom and their management etc are taught to the group of 100 tribal farmers. The talk is delivered on identification of natural enemies with the help of PPT. The information on 3 P mission programme was given to protect the parasitoids, predators and pollinators in nature.

Supply of input:

The following Bio fertilizer and bio pesticides and fruit fly and yellow sticky trap has supplied to fifty selected tribal farmers.

1. PSB : 1 litre
2. KSB : 1 litre
3. Phule Trichoderma + *Paecilomyces lilacinus* : 1 kg
4. Phule *Pseudomonas* : 2 kg
5. *Phule Metarhizium anisopliae* : 2 kg
6. *Phule lecaniicillium lecanii* : 2 kg

Total quantity: 9 kgs supplied to each wadi owner

Participatory Approach demonstration:

Three practical demonstrations were organized on Enrichment of FYM with biofertizer and Biopesticides, Pasting of Sealer cum Healer and use of pheromone and yellow sticky traps for the tribal farmers of these villages.

The material supplied to the TSP farmers with clear financial details:

Sr. No	Components	Price of component (Rs.)	Quantity	No. of farmers	Area covered (Acres)	Total expenditure (Rs.)
I st Year						
1	Bio fertilizers	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**

Achievements of First year TSP:

- Awareness among the tribal farmers was created on the pest problems of Fruit orchard and IPM practices.
- Management of mango stem borer and bark eating caterpillar by doing self demonstration with PRA techniques.
- Extension principal, "Learning by Doing and seeing is Believing" adopted by them.
- The use of biopesticides is increased instead of chemical pesticides.
- They were able to identify the pest as well as natural enemies.
- Due to preventive sprays of biopesticides, fruit drop of mango and cashew nut was reduced and fruit setting increased and tribal farmers were convinced with effectiveness of biopesticides in spite of unfavorable weather conditions.
- Increase the beneficial fauna near the rhizosphere of the fruit tree to reduce the pest and diseases.
- The cost of plant protection in horticulture crops is reduced by Ecofriendly pest management.

Anticipated impact of TSP Project on economic improvement of the tribal people and wealth creation in tribal areas

The anticipated impact of TSP Project on economic improvement of the tribal people and wealth creation in tribal areas actually will be known after harvesting and selling the mango fruits and cashew nuts. Impact of first year TSP project will be calculated on the basis of the increased yield of the fruit orchard over to last year yield. The monitory benefit will be worked out.

5. MPUAT: Popularization of bio intensive IPM modules in kharif maize crop under tribal sub plan programme in Udaipur District of Rajastan.

Location: 75 tribal farmers were selected in five villages of the panchayat Girwa of District Udaipur in Rajastan for implementation of TSP programme.

Sr. No.	Name of village	No of beneficiaries
1	Pai,	20
2	Alsigarh,	20
3	Dodawali	12
4	Dhar,	11
5	Pipiliya	12
	Total	75

In puts provided to the tribal farmers

1.Maize seed (var. HQPM-1)
2.*Trichogramma chilonis*
3.HaNPV

Treatments

- Four releases of *Trichogramma chilonis* @150000 parasitoids/ha at 10 days intervals starting 25 days after germination.
- One spray of HaNPV@ 250LE at cob formation stage

Plot Size: 0.2 ha

Observations:

- Each village served as replication.
- Dead harts from 50 randomly selected plants.
- Grain yield from plots
- The data will be analyzed using ‘t’ test.

Trainings imparted to the tribal farmers

Training on IPM for maize stem borer was imparted to the tribal farmers through Farmer Field Schools (5) and village level training (2) during September-October 2014 at the initiation of the TSP programme.

Impact of TSP implementation

TSP programme implemented in the five villages revealed that four releases of *T. chilionis* @ 150000 parasitoids/ha at 10 days intervals initiating first release at 25 days after germination was found the most effective against maize stem borer which reduced dead heart to 1.83-3.5% as compare to the higher per cent of dead hearts (15.5-18.7%) in the untreated plots. The yield in the TSP implemented plots were higher (19.7-22.5 q/ha) compared to the yields in the untreated plots (12.82-15.2 q/ha). The details are given in the following table.

Demonstration of *Trichogramma chilonis* against Maize stem borer *Chilo partellus* (MPUAT)

SN	Treatments	Pai		Alsigarh		Dodavali		Dhar		Pipiliya	
		dead hearts (%)	Grain yield (q/ha)	dead hearts (%)	Grain yield (q/ha)	dead hearts (%)	Grain yield (q/ha)	dead hearts (%)	Grain yield (q/ha)	dead hearts (%)	Grain yield (q/ha)
1	IPM Module	2.67 (1.65)	22	3.0 (1.7)	27	1.83 (1.51)	22.5	2.11 (1.55)	19.7	3.5 (1.95)	20.5
2	Control	16.5 (23.3)	15.20	18.7 (23.7)	14.40	17.77 (24.3)	12.85	15.55 (22.9)	14	16.11 (23.3)	14.5
	Sem±	1.91	3.22	2.29	2.98	6.51	1.25	6.51	1.26	1.21	1.25
	CD	5.59	10.12	7.12	8.78	18.19	4.05	18.19	4.05	3.62	4.05

Note:- Heavy rainfall in October first week reduced yield

6. SKUAST: Bio intensive management of Codling moth under TSP in J & K.

TSP programme was implemented in the selected tribal farmer's fields for management of apple codling moth through an IPM module. Eighteen small groups of farmers, each comprising 8-10 farmers, from eight different localities including Slikchey, Poyen, Bagh-e-Khomini, Chanigund, Majed Dass, Gound Minji, Hardass and Mangmore were selected for distribution of desired items for use in their apple orchards during 2014-15. Of each group, a team leader was selected to coordinate with his group and help implement the program as per directives. Details of each beneficiary i.e. name, address and contact number etc. was recorded to communicate with them about the ongoing programme.

List of beneficiaries of District Kargil (J&K) under Tribal Sub Plan (2014-15)

S.No.	Name	Address	No. of trees	Age of trees
1.	Md. Jaffer	Kaku Slikchey	150	10-30
2.	Ahmad Ali	Slikchey	300	10-30
3.	Akbar Ali	Slikchey, Biathang	300	10-30
4.	Anwar Hussain	Slikchey	500	10-50
5.	Md. Hussain	Poyen	400	10-50
6.	Manzoor Ali	Bagh-e-Khomini	300	20-40
7.	Md. Ibrahim	Chanigund	50	12- 20
8.	Haji Ibrahim	Chani gund	20	10-15
9.	Abdul Rahman	Chanigund	28	15-25
10.	Haji Hassan	Majed Dass	300	40
11.	Haji Hussain	Gound Minji	180	10
12.	Haji Fida Ali	Gound Minji	150	10
13.	Ahmed	Gound Minji	70	12
14.	Md. Hussain	Gound Minji	200	10
15.	Md. Ibrahim	Hardass	500	10-40
16.	Mohammad Ali	Hardass (Thang)	3500	10-30
17.	Haji Ghulam Mohd.	Mangmore	800	10-40
18.	Md. Javed	Mangmore	700	15-65

Inputs given to the tribal farmers

- Pheromone traps
- Neem formulations
- *Bt* fomulations
- Sprayers

Training was given to the tribal farmers on following management practices

- Use of spray of chlorpyriphos (20EC) @ 2.0 ml/ lit. during the period of hibernation of larvae, as well as before emergence of the moth i.e. during ending April'2015.
- Fortnightly installation of pheromone traps @ 4traps/ orchard during May- July' for mass trapping of adult moth
- Use of Neem and Bt sprays in some orchards to deter the moths for egg laying and infecting the newly hatched larvae
- Use of trunk banding in late July to August to trap and kill the overwintering larvae
- Disposal of codling moth infested fruits
- To be in touch with the Project Leader.

The impact of the implementation of the TSP programme will be assessed in 2015 when harvesting takes place

7. TNAU: Bio control methods for vegetable pest management in Tamil Nadu

Under the TSP, two trainings to tribal farmers were organised during the period under report. First training was organised at Sengadu village, Yercaud taluk of Salem district. In this training forty tribal farmers were trained on the establishment of kitchen garden and its utility on nutritional security with free supply of vegetable seeds and other inputs. They were explained about the bio intensive pest management of vegetable crop to obtain pesticide 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.

In the second training 30 tribal farmers of Thadiyankudisai village, Kodaikanal taluk, Dinidigul district were given training on skill development. The farmers were explained about the kitchen garden development and their usefulness in nutritional security. The farmers were also shown the budding technique in avocado and vine selection in pepper for developing bush pepper. Biocontrol based insect pest and disease management was discussed for the major vegetable crops. In addition, the farmers were also explained about the beekeeping techniques with the free supply of Indian beehive. The farmers were shown the demonstrations of botanical pesticide preparation, release of biocontrol agents and seed treatment with bioagents.

Date	Location	District	No. of farmers trained	Inputs supplied
03.09.2014	Sengadu village, Yercaud Tk.	Salem	40 (28 male, 12 female)	*Pseudomonas fluorescents*, *Trichoderma viride*, *Beauveria bassiana*, *Metarhizium anisopliae*, Neem seed kernel, Neem oil, Vegetable seeds like, cluster bean, lab lab, bhendi, tomato and bitter gourd.
04.12.2014	Thadiyankudisai, Kodaikanal Tk.	Dindigul	30 (20 male, 10 female)	Indian bee hives, *Pseudomonas fluorescens*, *Trichoderma viride*, *Beauveria bassiana*, *Metarhizium anisopliae*, Neem seed kernel, Neem oil, Vegetable seeds like, cluster bean, lab lab, bhendi, tomato and bitter gourd.

8. UAS-Raichur: IPM in paddy in Northern Karnataka.

PROJECT PROPOSAL ON TRIBAL SUB PLAN (TSP) BIO CONTROL

Sl No.	Particulars	Details
1	Name of the project proposal	: Tribal Sub Plan
2	Location	: Vaddepalli, Raichur
3	No. of farmers selected	: 11 Farmers
4	Crop	: Paddy
5	Biocontrol/IPM technologies	1. Entomopathogenic Fungi
6	Materials supplied to the TSP farmers	1. Formulations of Entomopathogenic Fungi 2. Vermibeds for production of vermicompost
7	Training	Training programs on paddy IPM
8	Anticipated impact of TSP Project on economic improvement of the Tribal people and wealth creation in Tribal areas.	Production of vermicompost helps tribal youths to engage themselves in mitigating the purchase of fertilizers

List of beneficiaries selected for implementation of TSP project

S N.	Name of the farmers	Mobile No.
1.	Narashima Nayak (Co coordinator cum facilitator)	9972241692
2.	Tayappa	9880853825
3.	Govinda	9535380694
4.	Thimappa	9740913504
5.	Veeresh	9591702283
6.	Erappa	-
7.	Ananad	9972557311
8.	Rangappa	8095868357
9.	Anjanayya	9632291693
10.	Thimappa Nayak	7259581387
11.	Channappa	9611213851

9. CAU-Pasighat: Demonstration on "Management of insect pests of cabbage with bio-control based IPM" under TSP in Arunachal Pradesh.

TSP was carried out during *Rabi*, 2014-15. Three locations were selected in the farmer's field namely at Jhampani, Ruksin and Pasighat. A total of 149 farmers were selected from these areas. The benefited farmers were provided with plant protection materials for the management of insect pests. Each location was divided into 10 blocks. In the first location, IPM module was followed for management of insect pests; in the second, farmer's practice was followed and no pest management practice was adopted in the third location. In the farmer's practice profenophos @0.05% was sprayed at 30 DAT, 45 DAT and 60 DAT. In the IPM module, beside intercropping with mustard (pair rows of mustard for every 15 rows of cauliflower), mechanical collection of egg mass and early instars larvae, release of *Trichogramma brassicae* at weekly interval from 30DAT to 65DAT (6 releases @1, 00,000/ha) pheromone traps of *Spodoptera litura* was installed @ 15 traps /ha.

Results: Incidence of *Plutella xylostella* was low during the cropping season and highest incidence of 1.05, 1.09 and 1.03 larvae/leaf was recorded in untreated plot at 70DAT at Jhampani, Ruksin and Pasighat respectively. Farmer's practice with three round sprays of profenophos 0.05% gave maximum protection with average infestation of 0.40, 0.47 and 0.44 larvae/leaf at Jhampani, Ruksin and Pasighat respectively. Biocontrol based IPM recorded significantly lower incidence (0.67, 0.68 and 0.65 larvae/ leaf) of the pest than untreated control (0.89, 0.93, 0.89 larvae/ leaf) at Jhampani, Ruksin and Pasighat respectively. The incidence of *P. xylostella* gradually decreased with the increased in the number of *T. brassicae* releases. Against *Spodoptera litura*, no significant difference was observed in the incidence between the biocontrol based IPM (0.26, 0.31and 0.28 larvae/plant) and farmer's practice (0.23, 0.28, 0.25 larvae/plant) at Jhampani, Ruksin and Pasighat respectively. Average infestation of 0.41 larvae plant was recorded in untreated control at Jhampani whereas it was 0.43 at Ruksin as well as at Pasighat. The total 149 farmers family was benefited due to demonstration of different practice under TSP. The benefited farmer family 54, 46 and 49 was observed at Jhampani, Ruksin and Pasighat respectively.

10. YSPUHF, Solan: Use of eco-friendly methods of pest management for apple and vegetable crop pests in Himachal Pradesh.

Details of the location of tribal areas/STs where TSP was implemented: District Kinnaur

No of village covered:

Sr. No.	Village/block	Date of training/demonstration	No of farmers	Remarks
1	Kalpa i)Roghi ii) Chini iii) Duni	 17-09-2014 18-09-2014 18-09-2014	 36 65 29	Conducted as per schedule
2	Ribba	13.05.2015	70	The trainings were fixed in the month of March 2015, but due to heavy snow fall and landslides could not be conducted and were conducted on 13th and 14th May, 2015
3	Kamroo	14.05.2015	70	
		Total	**270**	

Crops covered

Apple, cauliflower, cabbage, peas and beans

IPM technologies implemented:

- Use of light traps for monitoring apple root borer
- Use of entomopathogenic fungus & neem product for the control of apple root borer
- Safe use of pesticide for the conservation of parasitoids of apple woolly aphid
- Use of pheromone traps for DBM in cole crops
- Use of *Bt* & neem products for the control of caterpillar pests in cole crops
- Use of yellow sticky traps for the control of white flies on beans
- Use of predatory mites for the control of mites on beans
- Use of blue sticky traps for pea leaf miner.

Material supplied to the farmers

Sr. No.	Material	Number/ quantity
1	Water traps	100
2	Delta sticky lines	100
3	Delta sticky traps	100
4	Yellow sticky traps	100
5	Blue sticky traps	100
6	Neem Baan	100x100 ml
7	*Helicoverpa* pheromone lure	100
8	*Spodoptera* pheromone lure	100
9	DBM pheromone lure	100
10	*Trichoderma viride*	10 kg
11	*Pseudomonas fluorescens*	10 kg
12	Literature regarding the management of apple root borer	For all farmers

Training/ demonstration conducted

Trainings and demonstrations were organized at Roghi, Chini and Duni villages of Kalpa block of District Kinnaur and Ribba, Sangla of Pooh and Sangla Block in which 270 farmers participated. Farmers were trained and demonstrated regarding the use of biopesticides for the management of pests of apple, cabbage, cauliflower, peas and beans.

Sanctioned amount : Rs. 90,000/-
Amount spent during Training at Kalpa: Rs .44,000/-
Amount spent for Training at Riba and Kamroo : Rs. 46,000/-

Target achievements

270 farmers/ families of villages Roghi, Chini, Duni, Ribba and Sangla of district Kinnaur were benefited from the TSP programme.

Impact of the TSP project

The farmers of the tribal area were exposed to the use of biopesticides for pest management for the first time. In case of vegetable crops like cabbage, cauliflower, peas and beans, there was a reduction of 30 to 40 per cent in chemical pesticide application. In case of apple, however, only the application of chlorpyriphos for the management of apple root borer was saved where the plants were treated with *Metarhizium anisopliae*.

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. (Ms.) J. Poorani	Principal Scientist, Ento.	01.08.1996	Continuing
9	Dr. A. N. Shylesha	Principal Scientist, Ento	04.08.2007	Continuing
10	Dr. T. Venkatesan	Principal Scientist, Ento	29.10.1994	Continuing
11	Dr. P. Sreerama Kumar	Principal Scientist, Path.	31.07.1995	Continuing
12	Dr. K. S. Murthy	Principal Scientist, Ento	04.04.2001	Continuing
13	Dr. Sunil Joshi	Principal Scientist, Ento	04.11.1994	Continuing
14	Dr. R. Rangeshwaran	Principal Scientist, Micr.	05.03.1997	Continuing
15	Dr. T. M. Shivaling Swamy	Principal Scientist, Ento.	2009	Continuing
16	Dr. K. Subhaharan	Senior Scientist, Ento.	2014	Continuing
17	Dr. G. Siva Kumar	Senior Scientist, Micr.	2009	Continuing
18	Dr. Mohan	Senior Scientist, Ento.	01.06.2012	Continuing
19	Dr. Mahesh Yandigeri	Senior Scientist, Micr.	04.06.2012	Continuing
20	Dr. M. Pratheepa	Senior Scientist, CS	23.09.1999	Continuing
21	Dr. Deepa Bhagat	Senior Scientist, OC	30.03.2007	Continuing
22	Dr. Gandhi Gracy	Scientist, Ento.	2009	Continuing
23	Dr. Ankitha Gupta	Scientist, Ento.	2010	Continuing
24	Mr. K.J. David	Scientist, Ento.	28.12.2011	Continuing
25	Mrs. S. Salini	Scientist, Ento.	28.12.2011	Continuing
26	Dr. Jagdesh Patil	Scientist, Nemat.	2012	Continuing
27	Dr. Richa Varshney	Scientist, Ento.	2015	Continuing
28	Ms.Rachana R R	Scientist, Ento.	2015	Continuing
Central Tobacco Research Institute, Rajahmundry				
1.	Dr. S.Ramakrishnan	Principal Scientist (Nem.)	2014	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	
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	Continuing
2	Dr. P. N. Ganga Visalakshy	Senior Scientist (Ent.)	1987	Continuing
Directorate of Weed Science Research, Jabalpur				
1	Dr. Sushil Kumar	Princ. Scientist (Ent.)	2006	Continuing
Directorate of Soybean Research, Indore				
1	Dr. Y. Sridhar	Senior Scientist (Ent.)	2013	Continuing
National Centre for Integrated Pest Management, New Delhi				

1	Dr. Naved Sabir	Princ. Scientist (Nemat.)	2014	Continuing
Directorate of Sorghum Research, Hyderabad				
1	Dr. V.R. Bhagwat	Princ. Scientist (Ent.)	2013	Continuing
Directorate of Seed Research, Mau				
1	Dr. Arvind Nath singh	Senior Scientist (Ent.)	2013	Continuing
2	Dr. Raghavendra	Scientist (Ent.)	2013	Continuing
Central Institute of Sub-Tropical Horticulture, Lucknow				
1	Dr. H. Kesava Kumar	Scientist (Nematology)	2013	Continuing
2	Dr. Gundappa	Scientist (Ent.)	2013	Continuing
Directorate 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	01-07-2012	Continuing
2	Dr. (Mrs.) Harsha. N. Shelat	Asst. Res. Sci. (Micro)	01.03.2013	Continuing
3	Dr.P. H. Godhani	Asso. Res. Scientist	20-09-2012	Continuing
Acharya N. G. Ranga Agricultural University, Hyderabad				
1	Dr. S. J. Rehman	Prin. Scientist & Head	19.02.2007	Continuing
2	Smt. G.Anitha	Scientist (Ent.)	06.01.2009	Study leave
Assam Agricultural University, Jorhat				
1	Dr. D. K.Saikia	Principal Scientist (Ent.)	23.03.2001	Continuing
2.	Dr.Rudranarayana Borkakati	Scientist (Ent.)		
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. K. R. Lyla	Professor (Ent.)	23-11-95	Continuing
2.	Dr. Madhu Subramanian	Asst. Professor (Ent.)		
Mahatma Phule Krishi Vidyapeeth, Pune				
1	Dr. R. V. Nakat	Entomologist	21/8/2007	Continuing
2	Dr. S.M. Galande	Asst. Entomologist	2013	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	Senior Entomologist	June, 2009	Continuing
2	Dr. P. L. Sharma	Entomologist	16.05.2008	Continuing
Central Agricultural University, Pasighat				
1	Dr. K. Mamocha singh	Asso. Prof. (Ent.)	2007	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. B.K. Mishra	Dean Agriculture	2007	Continuing
University of Agriculture Sciences, Raichur (Voluntary Centre)				
1	Dr. Arunkumar Hosmani	Asso. Prof. (Ent.)	2007	Continuing

3.2. Budget for AICRP on Biocontrol 2014-15 (Rupees in Lakhs)

AICRP on Biocontrol, NBAIR, Bangalore

Head	**Plan (Rs. in lakhs)**	**Non-Plan**	**Total (Rs. in lakhs)**
Pay & Allowances	342.00	-	342.00
Recurring Contingencies	30.50	-	30.50
TA	14.50	-	14.50
Other charges including Equipment	0.00	-	0.00
TSP	10.00	-	10.00
Total	397.00	-	397.00

AAU-Anand

Item of Expenditure	**ICAR Share (75 %)**	**State Share (25 %)**	**Total Amount (Rs)**
Pay and allowances	25,91,950=00	8,63,983=00	34,55,933=00
Rec. Contingencies	4,00,000=00	1,33,333=00	5,33,333=00
T.A	42,311=00	14,104=00	56,415=00
TOTAL	30,34,261=00	10,11,420=00	40,45,681=00
Grant total	30,34,261=00	10,11,420=00	**61,88,719=00**

AAU-Jorhat

Head	**Budget allotted (Lakhs)**	**Expenditure (Rs)**	**ICAR -75%**	**State 25%**	**Remarks**
Pay and allowances	30.00	Officers 25,97,130.00 Estt 19,15,398.00	19,47,847.50 1436548.50	649282.50 478849.50	Some bills are under process
TA	Nil	28,400.00			
Recurring Contingencies	36,000.00	48,000.00	36,000.00	12,000.00	

KAU-Thrissur

Sl. No.	**Item**	**Budget (Rs. in lakhs)**	**Expenditure (Rs.) (up to 25/03/2015)**
1.	Pay & allowances	30.60	3369803
2.	TA	1.50	58591
3.	Contingencies	2.50	**116019**
	Total	**34.60**	**35,44,413**

MPKV – Pune

Sr. No.	Items	Sanctioned and allotted grants (Rs. in lakh)	Total expenditure (Rs. in lakh.)
1	Est. charges (Pay & allow.)	29.41	39,68,647
2	Recurring contingencies	2.70	2,69,507
3	T. A.	0.37	26,558
4	Non-recurring contingencies	-	
	Total	**32.97**	**42,38,647**
	ICAR share (75%)	24.31	31,78,985
	State share (25%)	8.10	10,59,662
	Tribal Sub-Plan	0.90	0.90

PAU-Ludhiana

ICAR Share

Sub Head	Revised Estimate (RE) 2014-15 (Lakhs)	Remittance up to March, 2015 (Lakhs)	Expenditure up to 31st March, 2015
Pay and Allowances	61.20	61.20	44,49,106/-
Travelling Allowances	2.00	2.00	1,18,820/-
Recurring Contingency	4.50	4.50	4,49,478/-
Total	67.70	67.70	50,17,404/-

SKUAST-Srinagar

Budget Head	ICAR share	State share	Total	Expenditure
Salary	30,60,000.00	10,20,000.00	40, 80,000.00	23, 89,650.00
T.A.	100,000.0	33, 333.00	1,33,333.0	72, 711.00
Contingency	200,000.00	66,666.0	2,66,667.00	2,66,667.00
TSP	90, 000.0	--	90, 000.0	90, 000.0
Gross Total	34, 50,000.00	11, 20,000.00	45,70,000.00	

3.3 Problems encountered during the year 2014-15

AAU-Jorhat

As there was no allocation under TA and RC head in the approved budget against AICR on Biological control, Assam Agricultural University, Jorhat centre, difficulties had to be faced for conducting different demonstration trials under TSP and AICRP on bio control.

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.

SKUAST, Srinagar

Lack of decision on exact funding towards TSP was a little problem in implementing the program

CPCRI, Kayangulam

Shortage of manpower, TA/DA and contingency for executing the wor

4. General

4. 1. Meteorological data (2014-15)

AAU-Jorhat

Month	Temperature (^{0}C)		R/H		Total rainfall	Evaporation (mm)	Wind speed	BSSH	Rainy days
	Temp		Morn.	Even.					
April	30.8	19.5	88	49	31.0	3.3	2.7	6.2	6
May	30.1	23.7	93	75	236.1	2.9	2.8	4.3	18
June	32.9	25.6	92	74	373.7	2.8	2.2	3.8	22
July	33.1	25.7	94	76	305.3	2.7	2.1	4.9	29
August	32.6	25.4	94	79	260.4	2.8	1.9	4.1	26
September	32.8	25.5	95	80	286.0	2.0	1.3	3.5	21
October	33.5	21.7	95	73	17.2	2.0	0.9	6.6	4
November	28.4	16.6	94	69	1.2	1.5	1.0	7.1	1
December	25.5	11.1	97	60	0.0	1.2	0.9	6.6	-
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

KAU-Thrissur

Month	Temperature ^{O}C		Relative Humidity (%)	Rainfall (mm)
	Min.	Max.		
April 2014	25.7	35.3	89	61.0
May	24.2	33.2	90	323.6
June	24.4	30.9	95	469.8
July	23.1	29.5	95	768.0
August	23.2	29.5	97	599.8
September	23.3	31.3	95	215.1
October	23.7	31.9	93	224.6
November	23.2	31.6	84	85.3
December	22.5	31.9	78	9.6
January 2015	22.1	32.5	75	0
February	23.0	34.3	73	0

MPKV-Pune

Met. Week	T_{max} ^{0}C	T_{min} ^{0}C	RH-I (%)	RH-II (%)	Rain (mm)	Rainy days	BSS (hrs)
1	29.0	12.2	91.8	40.9	0.0	0	8.6
2	30.2	12.0	93.9	33.7.	0.0	0	8.9
3	29.8	12.0	92.4	36.7	0.0	0	8.9
4	29.2	14.5	90.4	39.7	0.1	0	6.2
5	29.7	11.3	93.1	34.1	0.0	0	8.9
6	32.0	10.6	89.5	20.3	0.0	0	9.5
7	28.3	10.9	88.9	31.0	0.0	0	9.8
8	31.5	15.0	89.4	34.7	0.0	0	8.4
9	30.6	14.0	87.3	33.4	0.0	0	8.1
10	31.2	16.4	87.3	33.7	2.0	0	7.9
11	34.7	18.5	83.6	27.1	1.6	0	8.3

12	36.4	16.5	66.4	19.6	0.0	0	9.6
13	37.6	18.5	60.6	19.0	0.0	0	9.1
14	37.6	20.5	58.9	19.7	0.0	0	8.3
15	37.2	17.4	57.3	14	0.0	0	9.7
16	38.2	31.9	65.9	22.6	6.0	1	8.6
17	39.0	22.4	58.6	18.6	0.0	0	8.8
18	39.3	22.9	57.3	23	0.7	0	9.6
19	37.0	22.6	65.9	27.1	3.5	1	7.2
20	26.1	23.5	69.7	30.9	1.8	0	8.7
21	37.8	23.7	65.6	32.9	0.0	0	8.3
22	38	24	75.7	35	3.4	1	9.5
23	35.3	24.5	73.6	43.7	9.3	2	6.3
24	33.9	24.1	70.1	52.0	4.3	1	9.1
25	32.1	24.0	74.0	49.9	0.2	0	5.4
26	33.6	23.6	76.9	44.4	0.0	0	8.6
27	32.1	23.5	74.6	49.7	0.7	0	5.3
28	29.9	22.5	83.1	72.9	16.7	3	2.3
29	28.1	22.5	88.4	79.7	67.0	7	1.3
30	27.2	22.2	87.1	77.1	45.8	5	3.1
31	26.1	22.2	92.6	83	224.2	7	1.9
32	27.4	21.3	92.1	78.1	15.2	2	2.4
33	28.8	21.7	88.3	68.6	5.1	1	6.3
34	31.5	22.4	91.9	65.0	152.1	5	5.0
35	27.5	21.7	88.9	78.1	52.4	4	0.7
36	27.4	21.7	87.9	77.4	28.7	4	3.0
37	28.3	20.6	89	66.9	3.6	1	4.8
38	29.5	21.2	87.9	61.0	2.2	0	6.5
39	32.2	21.2	92.1	47.0	82.8	2	8.0
40	33.1	21.5	89.6	47.3	8.4	1	6.6
41	32.4	82.0	90.9	37.9	4.4	1	6.5
42	32.8	20.2	88.6	46.4	5.5	1	8.7
43	28.6	19.4	88.4	55.4	7.4	1	4.9
44	31.4	14.7	95.4	31.7	0.0	0	9.0
45	31.9	15.8	89.9	33.3	0.0	0	8.7
46	29.7	20.3	93.6	60.4	25.6	2	5.8
47	30.9	16.1	95.7	46.3	0.0	0	8.2
48	29.4	12.1	92.6	28.9	0.0	0	8.6
49	29.7	12.2	93.4	32.8	0.0	0	9.1
50	29.5	15.5	94.0	50.0	1.9	0	1.0
51	26.1	8.8	81	34	2.5	0	6.9
52	26.8	9.8	94.3	34.3	0.0	0	8.6
1	25.9	13.4	94	51	0.0	0	9.1
2	27.5	8.0	95	33	0.0	0	8.6
3	28.4	8.0	95	33	2.1	0	8.3
4	28.5	13.9	92	39	0.0	0	8.2
5	29.7	12.9	94	36	0.0	0	8.1
6	30.3	11.6	90	27	0.0	0	8.5
7	28.3	10.9	89	22	0.0	0	8.9
8	33.4	13.8	88	18	0.0	0	9.0
9	28.4	13.5	91	41	54.6	2	6.7
10	31.6	14.4	91	30	0.9	0	8.0
11	32.4	16.5	89	34	0.0	0	9.1

SKUAST, Srinagar

Date	Max. Temp.	Min. Temp.	Average Temp.	Rainfall	Max. Humidity	Min. humidity	Average Humidity
1-15 Jan	4.52	-1.7	1.4	4.7	87.8	83.3	85.5
16-31 Jan	4.6	-1.6	1.51	6.3	90.6	75.7	83.2
1-15 Feb	7.8	-0.7	3.5	2.3	90.2	64.6	77.4
16-29Feb	10.8	0.7	5.8	2.6	85.5	56.7	71.1
1-15 March	9.3	0.9	5.1	12.8	83.2	68.4	75.8
16-31March	12.7	5.0	8.9	5.3	86.6	64.6	75.6
1-15Apr	15.8	5.6	10.7	5.7	80	62.8	71.4
16-30Apr	19.7	6.7	13.2	2.5	76.9	59.2	68.1
1-15 May	22.3	9.1	15.7	2.9	92.2	57.8	75.0
16-31 May	23.8	8.6	16.2	1.5	77.8	53.7	65.8
1-15 June	29.4	9.6	19.5	0.9	68.1	44.6	56.3
16-30 June	29.0	13.2	21.1	0.6	76.3	44.2	60.3
1-15 July	29.6	15.5	22.5	3.7	76.8	47.3	62.1
16-31 July	31.2	18.0	24.6	1	80.7	51.1	65.9
1-15 Aug	31.8	16.7	24.2	0	75.8	47.2	61.5
16-30 Aug	26.5	12.9	19.7	5	83.6	58.5	71.0
1-15 Sep	22.1	10.2	16.2	13.6	91.2	77.3	84.3
16-31 Sep	27.5	9.8	18.6	0.4	84.3	54.5	69.4
1-15 Oct	23.4	8.1	15.7	1.3	91.9	62.0	77
16-31 Oct	19.1	5.0	12.1	0.2	92.6	71.5	82.0
1-15 Nov	14.9	1.7	8.3	1.3	87.4	64.8	76.1
16-30 Nov	12.5	-1.4	5.5	0	92.7	76.5	84.6
1-15 Dec	11.0	-3.2	3.8	0	89.9	65.2	77.5
16-31 Dec	9.1	-5.0	2.0	0	92.6	62.1	77.3

YSPUHF, Solan

Month	Av. Max. T (□ C)	Av. Min. T (□ C)	Relative Humidity (%)Max	Relative Humidity (%)Min	Total Rainfall (mm)	Total rainy days (days)
APRIL,2014	26.3	10.4	65	39	57.6	07
MAY, 2014	30.0	14.4	63	50	51.2	05
JUNE, 2014	32.6	17.8	66	50	101.8	12
JULY, 2014	28.1	19.2	81	70	361.0	14
AUG, 2014	28.8	18.6	79	64	83.8	06
SEPT, 2014	27.9	16.1	77	64	129.4	09
OCT,2014	25.7	10.3	67	52	15.7	04
NOV.2014	23.6	05.7	61	36	0.0	0
DEC.2014	19.7	02.4	67	50	75.6	04
JAN.2015	17.1	02.6	74	52	49.4	07
FEB.2015	19.6	05.7	73	44	67.0	07

UAS, Raichur

2014	Std Week	2014Max.T (°c)	2014Min.T (°c)	2014RF (mm)	R Day	RH I (%)	RH II (%)
May28-Jun3	22	38.9	24.8	31.8	2	76	35
Jun4-Jun10	23	39.5	25.2	1.4	0	68	30
Jun11-Jun17	24	37.8	24.4	38.2	1	73	32
Jun18-Jun24	25	36.2	24.0	0.0	0	73	41
Jun25-Jul01	26	37.0	24.9	4.0	1	69	33
Jul02-Jul08	27	37.1	24.0	73.0	3	73	42
Jul09-Jul15	28	32.8	22.4	31.7	2	86	70
Jul16-Jul22	29	32.1	23.1	3.8	0	85	49
Jul23-Jul29	30	33.3	22.6	10.6	2	83	65
Jul30-Aug05	31	32.5	22.6	8.8	1	83	51
Aug06-Aug12	32	34.3	23.6	0.0	0	79	46
Aug13-Aug19	33	34.1	23.1	7.9	1	78	49
Aug20-Aug26	34	33.7	22.3	187.0	3	89	67
Aug27-Sep02	35	28.0	21.6	189.4	6	93	83
Sep03-Sep09	36	30.0	21.7	19.8	2	87	68
Sep10-Sep16	37	32.2	22.5	20.2	2	83	57
Sep17-Sep23	38	29.8	22.3	45.8	2	90	78
Sep24-Sep30	39	32.4	23.7	0.0	0	83	55
Oct01-Oct07	40	34.2	22.4	35.4	1	75	46
Oct08-Oct14	41	31.7	21.8	0.6	0	83	60
Oct15-Oct21	42	32.9	22.7	0.0	0	75	51
Oct22-Oct28	43	29.9	20.7	14.6	1	81	61
Oct29-Nov04	44	30.5	16.2	0.0	0	76	41
Nov05-Nov11	45	31.6	17.7	4.4	1	68	46
Nov12-Nov18	46	30.3	19.8	7.6	1	83	59
Nov19-Nov25	47	31.3	18.4	0.0	0	84	49
Nov26-Dec02	48	30.1	14	0.0	0	82	34
Dec03-Dec09	49	30.1	14.3	0.0	0	81	32

CPCRI, Kayamkulam

Month	Temperature		Humidity (%)		Wind (km/h)	Sun shine (h/day)	Rain (mm)	No .of rainy days	Evaporation (mm)
	Max (°C)	Min (°C)	FN	AN					
March 2014	35.2	23.6	90	62	1.6	9.2	26.4	2	3.9
April	34.0	24.8	92	68	1.7	8.1	129.3	12	3.8
May	33.5	25.8	93	70	1.6	7.9	226.9	8	3.7
June	31.3	25.2	93	81	1.4	5.3	346.3	19	3.2
July	30.5	23.8	92	85	1.3	4.5	488.6	24	3.1
August	30.2	23.8	92	85	1.3	5.4	507.1	14	3.3
September	31.0	23.9	93	84	1.6	6.6	187.9	12	3.6
October	31.5	24.1	92	81	1.8	5.3	337.4	17	3.5
November	31.1	23.2	93	86	1.6	4.6	42.7	8	3.3
December	31.7	23.5	92	86	1.5	6.3	20.0	3	3.5
Jan. 2014	32.8	23.3	90	80	2.1	9.4	1.8	0	4.1
Feb. 2014	33.2	24.5	90	74	2.5	9.3	3.7	0	4.3

4.2. Visitors

AAU- Anand

1. Dr. B. Ramanujam, Principal Scientist, NBAIR, Bangalore visited on 19-22 Feb. 2015

AAU- Jorhat

1. Director of DBT Centre AAU, Jorhat visited Biological control laboratory, Department of Entomology, AAU, Jorhat on 10 08.2014
2. A group of vegetable farmers (12Nos) from Dangdhora village, Jorhat district visited the laboratory on 14.09.2014
3. Vice chancellor, Assam Agricultural University visited biological control laboratory on 12.03.2015
4. Research Monitoring Team, AAU, Jorhat visited biological control laboratory on 27.01.2015

KAU-Thrissur

1. Dr. Abraham Varghese, Director, NBAIR, Bangalore and Dr. P. Sivananda, Principal Scientist, IIHR, Bangalore visited the Scheme on 24-07-2014.

MPKV-Pune

1. ICAR Peer Review Committee visited Biocontrol Laboratory on 01/04/2014
2. Dr.R.M. Bhagat, Director Education, SKUAST, Jammu visited the Biocontrol laboratory on 21/04/2014.
3. Twenty five teachers of different Schools in Maharashtra working for Environment Service Scheme (ESS) visited Biocontrol Laboratory, Pune on 12.08.2014
4. Ms. Tanisha Thiara, Senior Advisor and her group from British High Commissioner visited the Agril. Entomology Section and Biocontrol Laboratory on 12.09.2014
5. Twenty two teachers trainees from Centre for Environment under Maharashtra Gene Bank Project supported by R.G. Science and Technology Commission, Govt. of Maharashtra visited the biocontrol laboratory on 18.10.2014. Education, Pune (CEE)
6. Shri. Tushar Pawar, Member, Executive Council, MPKV, Rahuri visited Biocontrol Laboratory on 28.10.2014.
7. Dr. B. S. Bhumanwar, Ex. Director, NBAIR, Bangalore visited the Biocontrol Lab. on 13/11/2014.
8. Dr. Chandish R. Ballal, Principal Scientist, Division of Insect Ecology, NBAIR, Bangalore visited the Biocontrol laboratory on 16th December, 2014 and taken the review of research programme.
9. Dr. Ashok Kumar Rao, Ex. Dean, MAU, Parbhani visited the Biocontrol Lab. On 31/12/2014.
10. Dr. M. S. Rao, Principal Scientist, IIHR, Bangalore visited Biocontrol Laboratory on 09/01/2015.
11. Dr. Abraham Verghese, Director, NBAIR and Network Project Coordinator, AICRP on Biocontrol visited the Biocontrol laboratory on 19th January 2015 and taken the review of the research work and field visit was carried out on 20th Jan. 2015 at BAIF, Urali Kanchan, Pune.

12. Dr. S. S. Aangadi, Professor and Head, Department of Agronomy, Agril. College Dharawad and the Dr. D. W. Thawal, Associated Dean, College of Agriculture, Pune visited the Biocontrol laboratory on 27/02/2015.
13. Dr. A. Krishna Murthy PS and PI . Borer Project., IIHR., Bangalore, T. N. Shivanada PS and Co- PI., Dr. P.V.R., Reddy, PS and PI. IIHR and Dr. N.Bakhtavatsalam, PS and PI, NBAIR, Bangalore visited the Biocontrol laboratory on 24/03/2015 and demonstrated the use of Sealer cum Healer at RFRS , Ganeshkhind, Pune on 24.3.2015 at Harsul Dist. Nasik under TSP on 25.3.2015 and CRS, MPKV., Rahuri on 26.3.2015
14. Dr. B.S. Mali and 30 students from Tuljaram Chutarchand College, Baramati visited the Biocontrol laboratory on 31/03/2015

PAU-Ludhiana

S. No.	Name	Date of visit
1.	Shri Suresh Kumar, Financial Commissioner Development, Govt. of Punjab	September 4, 2015
2.	Dr Abraham Verghese, Director, National Bureau of Agicultural Insects Resources, Bengaluru, India	October 10, 2014
3.	ICAR Team (ELP)	December 9, 2014
4	Delegation from Kenya	December 16, 2014

TNAU-Coimbatore

1. At regular intervals, students were hosted to the Laboratory from all over the country in partial fulfilment of their curriculum regarding biological control.
2. Dr.C.A.Reddy, Professor Emeritus, MSU, USA has visited the Biocontrol lab on 26.8.2014 and interacted with the TNAU scientists.
3. Dr.Abraham Verghese, Director, NBAII, Bengaluru visited on 7.11.2014. He inspected the brinjal field experiment at Arasur and also the exhibits of biological control in CODISSIA at Horti INTEX 2014.
4. Dr. B. Ramanujam, Principal Scientist and Dr. Shylesha Principal Scientist from NBAII, Bangalore visited the department on 16.3.2014 and 17.3.2014
5. 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:

NBAIR-Bangaluru

Dr. Chandish Ballal-Recognitions

- IMC member of NBAIM, Mau 2013-2016
- Councilor for Plant Protection Association of India, 2014-2016.

- Gave an interview on: Biocontrol approaches for pest management using parasitoids and predators and the article appeared in Bangalore Mirror "Scientists game insect parasite wasps to eliminate pests" – 19th September 2014.
- Received best oral paper award for Ph D student's presentation: Ghosh, E., Ballal, C. R. and Roopa, G. (2015) Developmental thresholds for two potential egg parasitoids Trichogramma chilonis (Ishii) and Trichogramma japonicum (Ashmead). pp. 358 – 359, In Proceedings of the International Conference on IIMASAE held at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu from 27th January to 30th January, 2015.
- Recognized guide for Doctoral Programme (Biotechnology) by Jain University
- Co-chaired the session IV on Bio-suppression of pests of fruit and vegetable crops, polyhouse crop pests, storage pests and weeds during the AICRP-BC Group Meet held at OUA&T, Bhubaneswar, and 27th to 28th June, 2014.
- Invited as resource person to give a talk on "Biological control of insect pests and diseases for Plant Health Management" during the Refresher Course in Environmental Science organized by Academic Staff College, Kannur University; 6th December 2014.
- Gave a lead talk on the new pest, *Tuta absoluta* during the District Level Workshop on tomato cultivation & interaction session with farmers organized by College of Horticulture, Kolar; 12th March 2015.
- Gave a presentation on the invasive pest Tuta absoluta during the one day meet organized by Directorate of Plant Protection Quarantine and Storage, at NBAIR on 21st February, 2015.

Patent: A patent has been filed on: METHOD FOR CONTINUOUS REARING OF AN ANTHOCORID PREDATOR BLAPTOSTETHUS PALLESCENS: Provisional patent number: 344/CHE/2015

Dr. K.Subhaharan-Honours

i. External examiner for Ph.D thesis by Ms. Kavitha in Agricultural Entomology at Tamil Nadu Agricultural University
ii. External examiner for M.Sc. thesis by Mr. Jeevan in Agricultural Entomology at Kerala Agricultural University.
iii. External Examiner for M.Sc. thesis by Mr.Ravikumar Patnala from PAJANCOA, Karikal.
iv. Interview panel member for selection of Assistant Professor in Nanotechnology at University of Horticultural Sciences, Bagalkot on 20.03.2015.
v. Interview panel member for selection of Juniour Research Fellow of Silk Board sponsored project on management of Uzi fly at ICAR – NBAIR.

- Best oral presentation for the invited lecture entitled "Behavioural manipulation methods in management of veterinary and agricultural pests " delivered in National Symposium on Entomology as a Science and IPM as a technology-the way forward held at College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh during November 13-15, 2014.

- Best oral presentation for the paper titled Efficacy of Entomopathogenic nematodes in combination with imidacloprid against *Leucopholis burmestrii* authored by Rajkumar, Jagdeesh Patil and Kesavan Subaharan in International Conference on Changing pest

scenario of pest problems in Agri- Horti-ecosystem and their management held from 27 -29 November, 2014 at Udaipur.

- Fellow of Society for Biocontrol Advancement. Conferred during the Annual General Body Meeting of SBA held at Bengaluru on 23, February, 2015.

- Best poster award for the paper titled "Cidal activity of Ajowan, Trachyspermum ammi essential oil and its component on housefly, *Musca domestica*" authored by M.Sowmya, Kesavan Subaharan and N.Bakthavatsalam presented in National Meeting on New/Safer Molecules and Biocontrol Technologies for Integrated Pest Management in Crops, held at Bangalore on 23.02.2015 .
- Best poster award for the paper titled "Behavioral responses of parasitoids of coconut black headed caterpillar to herbivore induced plant volatiles" authored by ADNT Kumara, Kesavan Subaharan and A.K.Chakravarthy presented in National Meeting on New/Safer Molecules and Biocontrol Technologies for Integrated Pest Management in Crops, held at Bangalore on 23.02.2015 .

Dr. Shivakumar

- Best Poster Presentation award: the paper entitled "Endosymbiotic bacteria, Bacillus pumilus and its role on fitness of *Amrasca biguttula biguttula* (Ishida) of cotton" by Surabhi Kumari, G. Sivakumar, R.Rangeshwaran, Chandish R. Ballal, Mahesh S. Yandigeri, M Mohan, A. Raghavendra and Abraham Verghese at Bengaluru during the National Meeting on "New/Safer Molecules and Biocontrol Technologies for IPM in crops" on 23 Feb 2015.

Patents developed:

Complete specification of patent titled "A composition and methods thereof" 5156/CHE/2013 was filed on 12.November 2014.

Technology commercialization: Technology entitled "Powder formulation (WP) of Bacillus megaterium strain NBAII 63 as a growth promoter (Phosphate solubilization)" was commercialized to Agribiocare, Kottayam and Ponalab, Bengaluru.

MPKV, Pune

1. Dr. R. V. Nakat, an authorised signatory to obtained the registration and licensing for commercialization of five biopesticides developed by MPKV., Rahuri from CIB and RC, DPPQ and S, Faridabad, New Delhi recognized by University Authority.
2. Dr. S.M. Galande, awarded Fellow of Society of Biocontrol Advancement (FSBA), NBAIR, Bangalore on 24.01.2015.
3. Dr. S.M. Galande, awarded Special award for best paper presentation in World Biodiversity Congress-2014 at Colombo, Srilanka on 26th November, 2014

CPCRI, Kayangulam

Chandrika Mohan

1. The paper entitled "Subduing red palm weevil attack on coconut through fine-tuned management approaches" and authored by *Josephrajkumar, A., Chandrika Mohan, Sunny Thomas, Namboothiri, C.G.N. and Shanavas, M.* was conferred the Best Poster Award during the *National Conference on Sustainability of coconut, arecanut and cocao farming-Technological Advances and Way forward*, held at CPCRI, Kasaragod, August 22-23, 2014.
2. The paper entitled '*Impact study on area-wide extension approach for bio-management of rhinoceros beetle in farmers' fields'* displayed as poster authored by Anithakumari.P, Muralidharan, K., Thejaswibhai and Chandrika Mohan was conferred Best Poster award during *International Symposium on Plantation Crops*, ICAR-Indian Institute of Spices Research, Kozhikode, Kerala. India, 10-12th December, 2014.

IIHR-Bangalore

Dr. A. Krishnamoorthy

Chief Editor, Journal of Horticultural Sciences, Society for Promotion of Horticulture, Bangalore
Vice- President, Society for Biocontrol Advancement, Bangalore
Appointed as Nodal officer to conduct ICAR UG and PG, SRF exams during in April 2014
Appointed as Nodal officer to conduct ARS /NET exams by ASRB in 2014

ii. Education and Training

AAU, A 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.

Sr. No.	Name of Teacher	Course No.	redits	PG Students	
				M. Sc.	Ph. D.
1.	Dr. D. M. Mehta	ENT-606	1+1	1	2
		ENT-612	2+0		
		Pl. Path. 514	1+1		
		ENT-507	1+1		
2.	Dr. P. H. Godhani	SST 511	1+1	1	0
		Ag. Ento – 2.2	1+1		
		ENT-507	1+1		

Advisory and Extension Services

Technical guidance on "Biological control" was provided to the farmers, extension officers, students and other visitors visited Biocontrol Research Laboratory

Sr. no	visitors	Total
1	VIPs	3
2	Govt. officers	17
3	Farmer	629
4	Student	213
	Total	**862**

Number of visitors visited the BCRL Anand during the year

- 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 Krushimela, 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:

Following talks were delivered to farmers /extension workers by Dr. D. M. Mehta in training programmes organized by various agencies.

Sr.No	Date	Topic	Trainee	Training organized
1	11-09-2014	Biological control of crop pests and visit of Biological Research Laboratory	Farmers	Extension Education institute, Anand
2	06-10-2014	Biological control of crop pests and visit of Biological Research Laboratory	Farmers	Extension Education institute, Anand
3	23-10-2014	Biological control of crop pests and visit of Biological Research Laboratory	Farmers	Extension Education institute, Anand
4	16-01-2015	Biological control of crop pests and visit of Biological Research Laboratory	Farmers	Extension Education institute, Anand
5	22-01-2014	Biological control of crop pests and visit of Biological Research Laboratory	Farmers	Dept. of Entomology, BACA, Anand
6	22-01-2014	Biological control of crop pests and visit of Biological Research Laboratory	Farmers	Dept. of Entomology, BACA, Anand
7	27-02-2014	Biological control of crop pests and visit of Biological Research Laboratory	Farmers	Extension Education institute, Anand
8	24-03-2015	Biological control of crop pests	Students	Dept. of Entomology, BACA, Anand

Following talks were delivered to farmers /extension workers by Dr. P. H. Godhani in training programmes organized by various agencies.

Sr. no	Date	Topic	Trainee	Training organized by
1	14-11-14	Biological control of crop pests	Students of BRS college	Dept. of Agronomy, BACA, Anand
2	19-11-14	Role of Bio-control agents in IPM & Exposure visit to bio-control lab, BACA, Anand	Officers of line depts./scientists of SAUs, SAMETI /ATMA/NGOs	Extension Education institute, Anand
3	21-11-14	Biological control of crop pests and visit of Biological Research Laboratory	Farmers	Dept. of Entomology, BACA, Anand
4	13-02-15	Biological control of crop pests	Students of BRS college	Polytechnic college, Anand

Details of Khedut Shibirs arranged during 2013-14

Sr. no	Date	Village &Taluka	No. of farmers attended
1	21/02/2015	Devghadhbariya	57

AAU-Jorhat

Teaching

1. Dr.D.K.Saikia, Principal Scientist conducted advance course of Biological Control (ENT 507), Classification of Insects (ENT 504) to P.G.Studies
2. Five M.Sc (Agri) student is being carried out P.G. research work under the guidance of Dr. D.K.Saikia,
3. Dr. D.K.Saikia is guiding two PhD student and title of the programme are (1) 'Evaluation of local varieties of Assam against yellow stem borer (*Scirpophaga incertulas*) and leaf folder (*Cnaphalocrosis medinalis*) and ecology of their trichogrammatid egg parasitoids' and (2)'Population dynamics of Sugarcane plassy borer, *Chilo tumidicostalis* (Lapidoptera: Pyralidae)
4. 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**
5. Dr. D.K.Saikia , Principal Scientist impart coaching to UG students for JRF examination
6. Dr. D.K.Saikia act as a Co- investigator in the Biopesticides programme under DBT –AAU, Centre
7. Dr.D.K.Saikia attended XXII Biological worker's group meeting held at OUAT, Bhubaneswar on 27th and 28th June, 2014.
8. R. N. Borakati, Jr. scientist, act as a course instructor in different UG courses like Insect Morphology and Taxonomy (Ent213), Pests of crops, stored grain and their management (Ent 323), and PG courses like Pest of Field Crops (Ent 510).
9. R. N. Borakati, Jr. scientist, act as a course instructor for experiential learning programme (Pesticides and plant protection equipments) offered to B.Sc. (Agri) student**s**

Training obtained

Sl. No.	Scientist attended	Organisation	Period		Details of Training
			From	To	
1	R. N. Borakati	NIPHM, Hyderabad	10.12.2014	30.12.2014	Ecological Engineering and Agro Ecosystem analysis for Pest Management

Training Imparted

Sl. No.	Programme	Place	Resource person	Date	Trainee
1.	Mass production of Trichogramma egg parasitoids	Department of Entomology, AAU, Jorhat	Dr.D.K.Saikia	14.08.14	2 nos of Progressive farmers, Arunachal Pradesh
2.	Role of Biopesticides and bio agents in Vegetable crops	Conference hall, DoEE, AAU	Dr.D.K.Saikia	18.08.14	SMSs, KVK (16 Nos)
3.	Bio-pesticides in organic agriculture	Sencuwa gaon, Dibrugarh	Dr. D.K.Saikia	1.11.14	Farmers. (40 Nos)
4	IPM of Horticultural crops	Grameen Vikash Bank, Jorhat	Dr.D.K.Saikia	10.11.14	Farmers (40Nos)
5	Farmers Scientist Interaction	Farmers Day,Rice Research Station, Titabar, AAU, Jorhat	Dr.D.K.Saikia	14.11.14	Farmers
6	IPM of Horticultural crops	At district level, Jorht	Dr.D.K.Saikia	19.12. 14	Farmers
7	ITK of Horticultural crops	At district level, Jorhat	Dr.D.K.Saikia	20.12. 14	Farmers (87Nos)
8	Biological control of important crop pests	Conference hall, DoEE, AAU	Dr. D.K.Saikia	14.03. 15	SMSs, KVK (12 Nos)
9	"2ND INTERNATIONAL AGRI-HORTI SHOW"	GUWAHATI	R. N. Borakati	11.02. 15	Farmers
10	MOTIVATIONAL PROGRAMME	NEIST, JORHAT	R. N. Borakati	18.02.2015	Students
11	Farmers Scientist Interaction	KACHUPOTHAR, GOLAGHAT UNDER TSP PROJECT	R. N. Borakati	24.02.2015	Farmers
12	Impact of climate change on Insect - pest	ATTAPAM, JORHAT	R. N. Borakati	30.03.2014	Farmers

Television/ Radio Programme

SL. NO.	TITLE	NAME OF RESOURCE PERSON	RECORDING DATE	BROADCASTING DATE
1	BIOLOGICAL CONTROL OF KHARIF VEGETABLE	Dr. D.K.Saikia	27.3.2015	4.4.2015
2	Jaibik Poddhatire Potango Niyantron	R. N. Borkakati	04.03.2015	10. 03.2015

F.8 TV PHONE IN PROGRAMME BY DD, NE

SL. NO.	TITLE	NAME OF RESOURCE PERSON	TELECAST TIME
1	Jaibik Poddhatire Potango Niyantron Byabosthapona	R. N. Borkakati	04.02.2015 (5.30 pm)

KAU

Extension
Mass production and sale of biocontrol agents
Arranging Exhibitions/ Demonstrations on Biocontrol to the visitors
Teaching: Handling U.G and P.G. classes on biocontrol and guiding P.G. students

Classes on biocontrol

Sl. No	Date of training	Venue	Beneficiaries
1	10-10-2014	Mannuthy	Agrl. Officers
2	09-01-2015	Vellanikkara	Farmers
3	21-01-2015	Cherpu	Farmers
4	12-02-2015	Vellanikkara	Farmers
5	07-03-2015	Kodungallur	Farmers

MPKV
i) Trainings

1. Shri. A. S. Dhane conducted the final practical examination of II year students of Argil. Polytechnic School, Baramati Dist, Pune from 28/04/2014 to 10/05/2014.
2. Shri. A. S. Dhane conducted the final Theory examination of students of Agril. Technology School, Bhor, Dist.: Pune from 11/05/2014 to 21/05/2014.
3. Dr. R.V. Nakat delivered lecture on Domestic Quarantine to thirty trainees of Govt. of Maharashtra on Nursery Management at National Horticulture Training Centre, Talegaon, Pune on 22/08/2014.
4. Dr. R. V. Nakat evaluated M.Sc. and Ph. D thesis of P.M. Sangale from B. A. College. of Agriculture, AAU, Anand, Gujrat on 1.9.2014.
5. Dr. R.V. Nakat, attended the Final Thesis viva of M.Sc students of Post Graduate students of MPKV, Rahuri on 17.9.2014.

6. Dr. R. V. Nakat delivered the talk to 125 farmers on Biointensive Pest Management on Pomogranate Crop in Farmers rally at Akot Dist. Akola on 5.10.2014.
7. Dr. S. M. Galande worked Jr Supervisor at A.C. Baramati from 7.10.2014 to 12.10.2014
8. Dr. R. V. Nakat delivered the talk on Biointensive Pest Management of Important Horticultural Crops pomegranate and grapes to the 50 trainees of Kisan Call Center, Pune on 17 & 18th Nov. 2014.
9. Dr. R.V. Nakat delivered the talk to the management trainees of Deptt. of Extension organized by MANAGE Hyderabad in collaboration with MPKV, Rahuri at College of Agriculture, Pune on 21/11/2014.
10. Dr. R.V. Nakat, attended the qualifying viva of Ph. D Thesis viva of Post Graduate students of MPKV, Rahuri on 13/12/2014.
11. Dr. R. V. Nakat supervised and worked as Senior Supervisor for conducting the Semester end examination of I and II semester at College of Agriculture, Kolhapur from 3rd – 20th December 2014.
12. Dr. R.V. Nakat conducted final viva voce exam. of Mr. Nikhil Nisture , M.Sc. in Agril. Entomology on 9.1.2015.
13. Dr. R.V. Nakat, imparted the training to 21 trainees of Ecofriendly pest management with biopesticides and bioagents and delivered the talk on Mass production of *Trichogramma* and Registration of biopesticides during 3 - 5, March, 2015.
14. Dr. S. M. Galande delivered the talk on Conservation and augmentation of bioagents to the 21 trainees of Ecofriendly pest management with biopesticides and bioagents on 4th March, 2015.
15. Dr. S. M. Galande Conducted the Semester End Theory at A.C. Pune and Practical Examination of Jr. M.Sc. (Agri.) at A.C. Dhule on 3.3.2015 and at A. C. Pune on 07.3.2015.
16. Shri. N. D. Tamboli conducted the practical examination of Agril. Polytechnic at Madangaon Pharata Dist. Pune during 12th to 19th March, 2015

Extension development activities / Training Imparted: (MPKV, Pune)

1. 150*0 Cryptolaemus* beetles has been supplied to Mumbai Municipal Corporation, Mumbai on 27.5.2014 for release in the colonies of mealybugs on rain tree.
2. Ten farmers visited the Biocontrol laboratory on 29.5.2014 and registered the demand of bioagents and biopesticides.
3. Six farmers visited the Biocontrol laboratory on 20.6.2014 and registered the demand of bioagents.
4. Ten NGO farmers visited the Biocontrol laboratory on 30 /07/2014.
5. Trichocards and literature on bioagents as well as on IPM of African Giant Snails are supplied to the RAWE students of A.C.Pune.
6. Thirty five farmers has visited the AICRP on Biocontrol laboratory on 6.8.2014 and taken the advice regarding use of bioagents and its availability.
7. Five student of Dr. D. Y. Patil Institute of Pharmaceutical Science and Research, Pune visited Biocontrol laboratory and Insect Museum on 6.8.2014.
8. The bioagents were arranged in State level farmers exhibition Agro won Agri. Expo, 2014 at College of Agriculture, Pune on 17-21st November, 2014.
9. Eighteen trainees of Hi-Tech Floriculture Project have visited to Biocontrol Laboratory on 28/11/2014.
10. The bioagents were arranged in National level farmers exhibition KISAN 2014 at Moshi Pune on 12-16th December, 2014.

11. Organized one day training programme at Harsul, Nasik district and distributed the Biopesticides, Biofertilizers to 50 farmers under TSP on 6th Feb. 2015.
12. Three days training programme on Ecofriendly pest management with biopesticides and bioagents pertaining to production and use of bioagents to KVK's, NGO's and farmers was organized at MPKV, Rahuri during 3 to 5th March, 2015.
13. Organised the demonstration of the use of Sealer cum Healer for control of mango stem borer at RFRS , Ganeshkhind, Pune on 24.3.2015 at Harsul Dist. Nasik for tribal farmers under TSP on 25.3.2015 and CRS, MPKV., Rahuri on 26.3.2015.

Radio Talk

1. Galande S. M. delivered Radio Talk on Contribution of Dr. Karmaveer Bhaurao Patil in agriculture on 22/09/2014, AIR, Pune.
2. Galande S. M. delivered Radio Talk on Integrated management of root-knot nematodes in vegetables on 26/09/2014, AIR, Pune.

TV Programme

1. Dr. R.V.Nakat gave TV programme on Biological control of Insect Pests in *Kharif* crops telecasted on Sahyadri Channel of Doordarshan, Mumbai on 17.8.2014

PAU

Post/under graduate teaching:

Teacher	**No. of courses taught**	
	PG	**UG**
Dr K S Sangha	3	3
Dr Neelam Joshi	2	5
Dr Parminder Singh Shera	-	1
Dr Rabinder Kaur	1	1
Dr Sudhendu Sharma	-	-
	No. of PG Students Guiding/Guided	
	Ph. D.	**M.Sc.**
Dr K S Sangha	1	1
Dr Neelam Joshi	-	3
Dr Parminder Singh Shera	-	1
Dr Rabinder Kaur	-	1
Dr Sudhendu Sharma	-	-

Lectures delivered:

Title of Lectures	Event, Date and Venue
Dr Kamaldeep Singh Sangha	
Agroforestry Entomology - A New Paradigm In Insect Management	National Entomologist Meet organised by IINRG, held at Ranchi from February 5-7 , 2015 (Lead lecture)
Insect pest of tree species and their control measures	In training programme on watershed management to officials of rural development, Govt. Of Punjab on March 5,2015.
Dr Parminder Singh Shera	
Identification of insect pests and natural enemies in cotton	Training for scouts "Better production of cotton for economic growth, farm livelihoods and ecosystem health in Malwa region of Punjab" organized by Deptt. of Entomology and RGR Cell, PAU, Ludhiana on 26th March, 2014
Surveillance of insect pests and natural enemies in cotton	
Management of insect pests of *kharif* crops" during district training camp at Moga	District level training camp at Moga on April 4, 2014
Identification of insect pests and natural enemies in rice/ *basmati* rice (Practical)	Training for scouts on "Integrated productivity management of basmati based cropping system" held at PAU, Ludhiana on May 8, 2014
Surveillance of insect pests and natural enemies in rice/ *basmati* rice	

Trainings/ training camps organized

Programme	Dates
Training for scouts on "Integrated productivity management of basmati based cropping system" held at PAU, Ludhiana	8-9.5.2014
Two training camps on "Production and protection technology in rice crop" at villages Sarai Jatta and Tibba (Kapurthala) under NRTT project	9.6.14
Training camp on "Production and protection technology in rice crop" at village Sodha (Sri Muktsar Sahib) under NRTT project	24.6.14

PJTSAU

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.

TNAU

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

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	19.6.2014	District level training on biocontrol agents production and use	Farmers (50)	ADA, Karamadai, Dept. of Agriculture
2	7.7.2014	NADP Precision farming training	Farmers (45)	ADH, Dept. of Hort. Periyanaickenpalayam,
3	17.7.2014	Mass production and use of *Acerophagus* to check papaya mealybug in mulberry	Junior Inspectors from Dept. of Sericulture (50)	Dept. of Sericulture, Govt. of Tamil Nadu
4	20.8.2014	Special lecture on Agriculture in India	School students	Amirtha Vidyalaya, Ettimadai, Coimbatore
5	26.9.2014	Mass production of biocontrol agents	B.Sc (Botany) students (43)	St. Xavier college, Palayamkottai, Tamil Nadu
6	7.10.2014	Mass production of *Bracon brevicornis*	Extension official, Dept of Agriculture	Govt. of Goa
7	31.10.2014	Mass production of biocontrol agents	B.Sc (Agri.) students (34)	Birsa Agrl. University, Ranchi, Jharkand
8	14.10.2014	Mass production of biocontrol agents	B.Sc (Zoology) students (25)	Govt. Arts and Science college, Kozhikode, Kerala
9	2.12.2014	Environmental impact quotient in IPM	CAFT trainees	Dept.of Agrl.Etntomology, TNAU and ICAR
10	3.12.2014	Recent advances on integration of entomophages in pest management	CAFT trainees	Dept.of Agrl.Etntomology, TNAU and ICAR
11	4.2.2014	Biopesticides and use of pheromone traps	B.Sc (Agri.) students	Dept. of Agronomy, TNAU
12	6.2.2015	Mass production of biocontrol agents	Scientists	CAFT Training, Dept. of Agronomy, TNAU
13	5.3.2015	Mass production of biocontrol agents	I M.Sc (Agri. Entomology) students	ADAC&RI, TNAU, Trichy
14	10.3.2015	Mass production of biocontrol agents	B.Sc (Sericulture) students (20)	TNAU, Mettupalayam
15	10.3.2015	Mass production of biocontrol agents	B.Sc (Agri.) students (14)	College of Agriculture, Dhule, Maharastra

iv. Extension / Out reach programmes participated

Sl.No	Date	Title of the Program	Beneficiary / Participants	Organisers
1	18.7.14 to 21.7.14	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	6.11.14 to 9.11.14	HORTI INTEX 2014 - Exhibition Exhibited the various biocontrol agents and explained its application and use in pest management	Farmers and students	CODISSIA and TNAU and Govt. of Tamil Nadu
3	6.1.2015 to 9.1.2015	Exhibition – Regional Agricultural Fair and Farmer's Day 2015 Exhibited the various biocontrol agents and explained its application and use in pest management	Farmers	ICAR, Govt. of Tamil Nadu and TNAU
4	23.1.2015	Exhibition – Doubling of food output within a decade	Stake holders	Govt. of Tamil Nadu and TNAU
5	7.7.2014	TV programme Papaya mealybug and its parasitoids	Farmers and Public	Puthiya Thalaimurai
6	7.7.2014	TV programme Banana pseudostem borer and pseudostem injector developed by Dr.S.Sridharan	Farmers and Public	Puthiya Thalaimurai
7	30.3.2015	Papaya mealybug and its parasitoids	Farmers	Times of India - Daily

YSPUHF

Lectures delivered in various trainings/Workshops:

S.N	Title of Lecture	Training	Date	Delivered by
1.	Insect Pests of flower crops and their management under controlled conditions	Advances in Protected Cultivation and Plant Protection. Organized by Directorate of Extension Education at Nauni for Scientists of KVKs of UHF Nauni and HPKV,Palampur	22.05.2014	Dr Usha Chauhan
1	Insect pest management of	Seven days training on cultivation of ornamental	19/07/2014	Dr Usha Chauhan

	flower crops.	plants for farmers of Chamba district		
2	-do-	Five days training for the farmers of Una District w.e.f.29thDec. 2014 to 2nd Jan. 2015 2.2015	2.01.2015	Dr Usha Chauhan
3	-do-	Five days training for the farmers of Una District w.e.f.5-9th Jan.2015	9.01.2015	Dr Usha Chauhan
4	-do-	Five days training on flower production w.e.f.19-23rdJan.2015	20.01.2015	Dr Usha Chauhan
4	Biological control of insect pests of vegetable and flower crops	Farmers training on Floriculture and vegetable cultivation	21-8-2014	PL sharma
5	Sabjion mein jaivik keet pravandhan	Farmers training on sabjion ke vaigyanik kheti	3-9-2014	PL sharma
6	Madhumakhi palan evam ekikrit keet pravandhan	Farmars training on Adharboot madhumakhi palan	17-10-2014	PL sharma
7	Protection of life forms in soil	Training for technical staff of Organic centre Hissar	18-11-2014	PL sharma
8	Laboratory visit of technical staff of Organic centre Hissar	Training for technical staff of Organic centre Hissar	19-11-2014	PL Sharma
9	Integrated Pest Management in winter vegetables	Farmers training camp	5-12-2014	PL Sharma
10	Scope and Potential of Biological Control	Training programme for scientists of KVKs of Himachal Pradesh	6-1-2015	PL Sharma
11	Insect pests of medicinal plants and their management	Farmers training programme	7-1-2015	PL Sharma

Academics

1. Evaluated thesis and conducted viva of M.sc. student, Mr Pradeep Kumar (H-2011-40-M) of Deptt of Food Science and Technology, UHF Naunui8 on 9th December, 2014 (DR Usha Chauhan).
2. Acted as internal Examiner of final Practical Exam of M.Sc. Applied Zoology Course XI in HP University Shimla -5 on 31.12.2014(Usha Chauhan)
3. Evaluated thesis and Conducted M.Sc. thesis viva of Ms Shakshi Sharma (A-2012-30-017) of Entomology Deptt at CSK Himachal Pradesh Krishi Vishvavidyalaya,College of Agriculture, Palampur by Dr Usha Chauhan.on 5/2/2015.(Usha Chauhan)
4. Acted as Dean Nominee for conducting Viva Voce of M.Sc students during 2014-15(Dr Usha Chauhan and Dr PL Sharma)

UG/PG courses taught by Dr Usha Chauhan and Dr PL Sharma during the Year 2014-2015:

ENT 505: Insect Ecology
ENT 507: Biological control of crop pests and weeds
ENT606: Recent trends in biological control
ENT602: Immature stages of insects
ENT 604: Advanced Insect Ecology
ENT 609: Advanced Host Plant Resistance

Students guided for M.Sc and Ph D. degree:

S.No	Student Name	Degree	Title of thesis	Guided By
1	Suman sanjta (H-2012-04-M)	M.Sc	Studies on thrips fauna and their associated natural enemies on different crops under mid hill conditions of Himachal Pradesh	Dr.Usha Chauhan
2.	Vijay Singh (H-2010-06-D)	Ph.D.	Phytophagous mites and their natural enemies in different horticultural ecosystems of Himachal Pradesh.	Dr Usha Chauhan
3	Gavkare Omkar	PhD	Studies on Zoophytophagy of *Nesidiocoris tenuis on tomato*	Dr PL Sharma
4	Anamika Saini	M Sc	To be decided	Dr PL Sharma
5	Sarawati Negi	Ph D	To be decided	Dr PL Sharma

Demonstration cum training programmes for the management of apple root borer, *Dorysthenes hugelii* and other crop pests organized at different places/orchards during 2014-15

SN	date	Topic	Place(s)	No of Orchards/No of farmers
1	22-3-14 to 25-3-14	Management of apple root borer	Kotkhai, Jubbal and Rohru of Shimla district	3 orchards
2	6-8-14 to 9-8-14	Do	Bajaura and Kullu of Kullu district	2 orchards
3	15-9-14 to 19-9-14	Management of apple and vegetable pests (under TSP)	Rogi, Kalpa and Duni villages of Kinnaur district	130 farmers(Under TSP)
4	2-11-14 to 5-11-14	Management of apple root borer	Bajaura and Kullu of Kullu district	3 orchards
5	21-11-14 to 23-11-14	Do	Chopal and Nerwa of Shimla district	2 orchards

iii. Participation of Scientists in conference, meetings, seminars, workshops, symposia, training extension etc. In India and abroad

AAU-A

1. Attended XXIII Biocontrol Workers Group meeting to be held are Project Directorate of Biological Control (ICAR), QUAT, Bhubaneswar during June 27-28, 2014.
2. State level seminar on "Plant Protection in Mari Masalana Pakoma Pak Saurakshan" organized by PPAG, College of Horticulture, SDAU, Sardarkrushinagar during October 11, 2014.
3. Attended International conference on "Changing scenario of pest problems in Agri-Horti Ecosystem and their management" held at Department of Entomology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur during 27-29th November
4. Attended training on "Functional Insect Pest Management" from 02-12-2014 to 22-12-2014 conducted by Department of Agricultural Entomology, Centre of Advanced Faculty Training, Tamil Nadu Agricultural University, Coimbatore, India.

KAU -Thrissur

1. Dr. K. R. Lyla, Professor and Smt. Vidya C.V., Asst. Professor attended XXIII Biocontrol Workers Group Meeting held on 27-28th June, 2014 at Orissa University of Agriculture and Technology, Bhubaneswar.

MPKV-Pune

1. Attended the State level meeting at Director of Agriculture, Inputs & Quality Control at Central Building, Pune for finalizing the rates of bio pesticides on 07/05/2014.
2. Dr. R.V. Nakat and Dr. S. M. Galande, attended the seminar on "Weather change and its impact on Agriculture – Fulfilling Meteorology's vision on 29.05.2014.
3. Dr. R.V. Nakat attended meeting for Mango-net at Director of Extension, Govt. of Maharashtra, Sakhar Sankul, Pune on 9.6.2014.
4. Dr. R.V. Nakat and Dr. S. M. Galande, attended the XXIII Biocontrol Workshop of AICRP on Biological Control of Crop Pests and Weeds held at OUAT,Bhubaneshwar, Orissa on June 27-28, 2014 and presented the report. The Tribal Sub Plan of Rs. 1.92 lakhs is sanctioned for the year 2014-15.
5. Dr. R.V. Nakat, attended meeting on Pesticide poisoning at Sakhar Sankul, Pune on 04.07.2014.
6. Dr. R.V. Nakat visited Center of Insecticide Board and Registration Committee (CIB & RC) during 24 to 29 August, 2014 and got the permission for registration for 3 biopesticides namely Phule *Verticillium lecanii,* Phule *Beauveria bassiana* and Phule *Metarhizium anisopliae* developed by MPKV, Rahuri in CIB & RC 350th meeting held on 29.08.2014. He has also discussed the matter of registration of rejected *Trichoderma viride* file with Chairman, CIB & RC, ADG (PP) and two members of CIB & RC Dr. Chatopadhaya, Director, NCIPM and Dr. K. K. Sharma, Network Coordinator of AICRP on Pesticide Residues Project, New Delhi.
7. Dr. R.V. Nakat attended the meeting on Registration of biopestcicides with Director of Inputs and Quality Control, Dept. of Agriculture, Govt. of Maharashtra at Central building Pune on 15.09.2014

8. Dr. R.V. Nakat attended the meeting with Director of Research, MPKV, Rahuri on 19.09.2014 regarding common registration of biopesticides of four SAUs under common license of Agril. Department, Govt. of Maharashtra.
9. Dr. R.V. Nakat attended awareness Workshop on Key Issues of GM crops organized by BCIL, New Delhi and MPKV., Rahuri at YASHDA, Pune on 17.10.2015.
10. Dr. R.V. Nakat attended the State Level Meeting to finalize technical Specification for purchase of Lab. equipments for Govt. Maharashtra on 27.10.2014.
11. Dr. S. M. Galande attended World Biodiversity Congress-2014 at Colombo, Sri Lanka on 24-27 Nov. 2014.
12. Dr. R.V. Nakat attended meeting on Effect of Neonicotinoids on Honey bee at Agril. Commissioner, Pune on 27.11.2014.
13. Dr. S. B. Kharbade and Shri. N. D. Tamboli attended one day Seminar on "Impact analysis for Agril.-Technologies in research, education and extension" organized by the Director of Research, MPKV, Rahuri on 6th Feb. 2015.
14. Dr. R. V. Nakat, attended National Symposium on IPM for Sustainable Crop Protection on 24-25, Feb. 2015 at Division of Entomology, IARI, and New Delhi in Collaboration Association of Botanical Led Enterprises, Agril. Focus Group, India.
15. Dr. R.V. Nakat Visited the CIB & RC, Director of Plant Protection Quarantine and Storage and obtained the commercial registration for production of Phule *Trichoderma* and Phule *Beauveria* on 24th and 26th Feb. 2015.

Research meetings:

1. Dr. S. M. Galande attended the Recommendation Committee Meeting on 10/04/2014.
2. Dr. S. M. Galande attended the Research Finding Release Committee Meeting on 8/05/2014 and submitted the proposal of recommendation for Joint Agresco meeting
3. Dr. R.V. Nakat and Dr. S. M. Galande, attended synopsis of M.Sc. (Agri.) students of Entomology on 27.5.2014.
4. Dr. R. V. Nakat attended the Final Research Recommendation Release Committee Meeting on 25/04/2014
5. Dr. R.V. Nakat and Dr. S. M. Galande, attended the 22nd Board of studies meeting of Agril. Meteorology, AC. Pune on 29.5.2014 .
6. Dr. R.V. Nakat attended synopsis of M.Sc. (Agri.) students of Entomology, Department of Entomology, MPKV, Rahuri on 31.5.2014.
7. Dr. R.V. Nakat attended the qualifying viva of Ph. D and M. Sc. Thesis viva of Post Graduate students of MPKV, Rahuri on 30/07/2014
8. Dr. R.V. Nakat and Dr. S. M. Galande, A.S. Dhane attended Research Review Committee Meeting at MPKV., Rahuri on 5 and 6th January, 2015.
9. Dr. R.V. Nakat attended the internal action research plan meeting at KVK, Baramati For planning of extension research programme for implementation during 2015-16

PAU-Ludhiana

1. Drs J S Virk, K S Sangha, Neelam Joshi, Parminder Singh Shera and Rabinder Kaur participated in Research and Extension Specialist's Workshop for Vegetables, Floriculture, Post-harvest Management, Farm Power and Machinery, Food Technology and Agricultural Economics on May 22-23, 2014 at PAU, Ludhiana.
2. Drs J S Virk, Neelam Joshi, Neelam Joshi, Parminder Singh Shera and Rabinder Kaur participated in XXIII Biocontrol Workshop group meeting held on 27.6.2014 & 28.6.2014 at OUAT, Bhubaneswar.

3. Drs J S Virk, K S Sangha, Neelam Joshi, Neelam Joshi, Parminder Singh Shera, Rabinder Kaur and Sudhendu Sharma participated in Research and Extension Specialists Workshop for *Rabi* crops on August 12-13, 2014 at PAU, Ludhiana.
4. Drs Parminder Singh Shera and Rabinder Kaur participated in Launch-cum-orientation workshop of Network Project on "Conservation of Lac Insect genetic resources" held at Institute of Natural Resins and Gums on August 27-28, 2014 at IINRG, Ranchi.
5. Drs J S Virk, K S Sangha, Neelam Joshi, Neelam Joshi, Parminder Singh Shera and Rabinder Kaur and Sudhendu Sharma participated in *Kisan Mela* held on September 12-13, 2014 and March 20-21, 2015 at PAU, Ludhiana.
6. Dr K S Sangha participated in National seminar on "Augmenting *processing and shelf life of perishable food products*" held at PAU Ludhiana on 26.09.2014 by the Productivity council, New Delhi.
7. Dr K S Sangha participated in National symposium on Crop improvement for inclusive sustainable development, Nov 7-9, 2014 Ludhiana
8. Dr Parminder Singh Shera participated in National Symposium on "Entomology as a Science & IPM as a Technique-The Way Forward" held on 14-15 November, 2014 at Central Agricultural University, Pasighat.
9. Dr K S Sangha participated in National Symposium on "*Agriculture Diversification, for Sustainable Livelihood and Environmental Security"* at Punjab Agricultural University, Ludhiana from November 18–20, 2014
10. Drs Neelam Joshi and Rabinder Kaur participated in International Conference: Changing Scenario of Pest Problems in Agri-horti Ecosystem and their Management held on 27-28 November, 2014 at Rajasthan College of Agriculture, MPUAT, Udaipur.
11. Drs J S Virk, K S Sangha, Neelam Joshi, Neelam Joshi, Parminder Singh Shera and Rabinder Kaur and Sudhendu Sharma participated in Research & Extension Specialists' Workshop for fruits, mushroom, agro forestry along with post harvest management, farm power & machinery, food technology and agri. economics and flower crops held on 22-23 January, 2015 at PAU, Ludhiana.
12. Drs K S Sangha and Parminder Singh Shera participated in National Entomologists' Meet held on 5-7 February, 2015 at IINRG, Ranchi.
13. Drs K S Sangha, Neelam Joshi and Sudhendu Sharma participated in Research and Extension Specialists Workshop for *Kharif* crops on February 16-17, 2014 at PAU, Ludhiana.
14. Dr K S Sangha participated in National Meeting on New/Safer Molecules and Biocontrol Technologies for Integrated Pest Management in Crops, February 23, 2015, NBAIR, Bangalore.
15. Drs K S Sangha and Rabinder Kaur participated in Annual review meeting of Network Project on Conservation of Lac Insect Genetic Resources held on March 10, 2015 at KFRI, Thrissur.

SKUAST

Dr. Jamal Ahmad

1. Participated in 3rd Jammu & Kashmir Agricultural Science Congress on Organic Agriculture Prospects in Jammu & Kashmir, from May 12-14, 2014.
2. Participated in State level symposium on " Prospects and Challenges of domestication and commercialization of Non- timber Forest Products (NTFPs) including bamboo in Jammu & Kashmir, from 19-20th March' 2015.
3. Attended 49th Research Council Meeting of SKUAST – Kashmir on 26.5.2014.
4. Attended Review meeting on AICRP projects with Director Research, SKUAST-K on 14.8.2014.

5. Attended meeting with Commissioner Secretary, Agriculture Production Department regarding review of externally funded projects, on 5.11.2014.
6. Attended first Board of Studies for faculty of Horticulture on 22.11.2014.
7. Attended meeting with Director Research, SKUAST-K regarding review of ongoing/ new programmes under Organic Farming Research, on 5.3.2015.

Dr. Sajjad Mohiuddin

1. Participated in XXIII Biocontrol Workers Group Meeting On Biological Control of Crop Pests and Weed at OUAT, Bhubaneswar on 27- 28th June' 2014.
2. Attended Counselling Programme on Human behaviour and Personality development at convocation Hall, SKUAST-K, Shalimar campus, Srinagar, on 1.12.2014.
3. Participated on 21 days' ICAR sponsored winter school on "Recent advances in Insect Pest Management at ICAR- National Research Centre for integrated pest management, New3 Delhi from 26th Feb- 18th March' 2015.

CPCRI
Dr. Chandrika Mohan

1. Deputed to Dhaka, Bangladesh for Participation as Focal point expert from India in the Regional Expert consultation workshop on mite management of coconut in SAARC member countries held at Dhaka, Bangladesh during 10-11 August 2014. Presented the status paper from India entitled "Current status of coconut eriophyid mite management in India".
2. Participated in the 'National Review Meeting cum consultation meet on Date palm' held at Date Palm Research Station, Mundra, Gujarat on 21st June 2014.
3. Attended the "23rd AICRP workshop on "Biocontrol of crop pests and weeds" held at OUAT, Bhuvaneshwar during 27-28 June 2014 and presented the work on Biocontrol of coconut pests.
4. Participated in the 23rd Annual Meeting of AICRP (Palms) during 26-28 July 2014 held at DOR, Hyderabad and co -chaired the session on Pest Management.
5. Participated in the 'Brain Storming session on Fine-tuning of management package for root (wilt) disease of coconut for plant health and improved productivity" held at CPCRI, RS, Kayamkulam on 05-08-2014.
6. Participated in the "National Conference on Sustainability of coconut, arecanut and cocao farming- Technological Advances and Way forward' held at CPCRI, Kasaragod during August 22-23, 2014
7. Participated in :International Symposium on Plantation Crops' held at Kozhikode, Kerala during 10-12 December 2014
8. Participated in the National Conference on "Advances in Entomological Research *ADVENTOR 2015*" held at University of Calicut during 19-20 March 2015.

iv. List of publications

1. Research Papers

NBAIR

1. Ankita Gupta, R. Khot & S. Chorge 2014. A new species of Parapanteles Ashmead, 1900 (Hymenoptera: Braconidae: Microgastrinae) parasitic onCharaxes athamas (Drury) (Lepidoptera: Nymphalidae) in India. Systematic Parasitology 88:273–279

2. Ankita Gupta & José L. Fernández-Triana 2014. Diversity, host association, and cocoon variability of reared Indian Microgastrinae (Hymenoptera: Braconidae) Zootaxa 3800 (1): 001–101.
3. Ankita Gupta & C. V. Achterberg 2014. A new species of PhanerotomaWesmael (Hymenoptera: Braconidae: Cheloninae) from the Andaman Islands, India. Zootaxa 3856 (4): 595–600.
4. Ankita Gupta, P. V. Churi, A. Sengupta & S. Mhatre 2014. Lycaenidae parasitoids from peninsular India with description of four new species of microgastrine wasps (Hymenoptera: Braconidae) along with new insights on host relationships. Zootaxa 3827 (4): 439–470.
5. Ankita Gupta & P.M. Sureshan (2014). A new pteromalid species of the genus Anisopteromalus Ruschka (Hymenoptera) from India. Oriental Insects 48:1-2, 67-72
6. Archana, M., D'Souza, P. E., Jalali, S. K., Renukaprasad, C. and Ojha, R. 2015. DNA barcoding of commonly prevalent Culicoides midges in South India. Indian Journal of Animal Sciences 85: 37–39.
7. Arvind Kumar Yadav, Mahesh S. Yandigeri, ShachiVardhan, Sivakumar G., Rangeshwaran, R. and C. P. M. Tripathi (2014) Streptomyces sp. S160: a potential antagonist against chickpea charcoal root rot caused by Macrophominaphaseolina (Tassi) Goid, Annals of Microbiology, 64(3):1113–1122 (DOI 10.1007/s13213-013-0750-6).
8. Babu RV, Vemuri S, Padmavathy C, Mohan M, Balachandran S, 2014. Toxicity of *Bacillus thuringiensis* crystal toxins to field populations of rice leaf folder, Cnaphalocrocis medinalis (Guenee) and establishment of baseline susceptibility to Cry1Ab. J. Agrl. Sci & Technol. A3: 617-621.
9. Babu RV, Vemuri S, Padmavathy C, Mohan M, Balachandran S, Ramesh B, 2014. Carboxylesterase abd glutathione-S-transferase (GST's) induced resistance to *Bacillus thuringiensis* toxin Cry1Ab in rice leaf folder, Cnaphalocrocis medinalis (Guenee) populations. J. Agrl. Sci & Technol. A3: 53-59.
10. B. Ramanujam, S. Sriram, R. Rangeshwaran and H. Basha 2015. Biocontrol efficacy of fungal and bacterial antagonists against early blight of tomato caused by Alternaria solani. Accepted for publication in March 2015 issue of Indian Journal of Horticulture 76 (1)
11. B. Ramanujam, R. Rangeshwaran G. Sivakumar, M. Mohan and Mahesh S. Yandigeri 2014. Management of insect pests by microorganisms. Proceedings of the Indian National Science Academy 80 (2): 475-471.
12. B.Ramanujam, Rangeshwaran, R., Sivakmar, G., Mohan, M. and Yandigeri, M. S. 2014. Management of Insect Pests by Microorganisms, Proceedings of Indian National Science Academy , 80(2): 455-471.
13. Chaubey, B.K., Srinivasa Murthy, K. Jalali, S.K. and Venkatesan, T. 2014. Determination of host parasitoid ratio for Diamond backs moth Plutella xylostella (Linnaeus) and its parasitoid Cotesia vestalis Haliday. International Journal of Current Research, 6(11):42-45. (NAAS rating 8.0)
14. Chaubey, B.K., Srinivasa Murthy, K. Jalali, S.K. and Venkatesan, T 2014. Standardisation of host –parasitoid ratio of Plutella xylostella and Trichogramma bactrae Nagaraja.Journal of Biological Control , 28 (3): (Accepted) (NAAS rating 3.9)
15. Chaubey, B.K., Srinivasa Murthy, K. Jalali, S.K. and Venkatesan, T 2014. Standardisation of host –parasitoid ratio of Plutellaxylostella and TrichogrammabactraeNagaraja.Journal of Biological Control , 28 (3): (Accepted)
16. Chaubey, B.K., Srinivasa Murthy, K. Jalali, S.K. and Venkatesan, T. 2014. Determination of host parasitoid ratio for Diamond backs moth Plutellaxylostella (Linnaeus) and its parasitoidCotesiavestalisHaliday. International Journal of Current Research, 6(11):42-45.
17. David, K. J., Shakti Kumar Singh and Ramani, S. 2014. New species and records of Trypetinae (Diptera: Tephritidae) from India. Zootaxa, 3795(2): 126-134

18. David, K. J., Hancock, D. L. and Ramani, S. 2014. Two new species of Acroceratitis Hendel (Diptera: Tephritidae) and an updated key for the species from India. Zootaxa, 3895 (3): 411-418
19. David, K. J. and Shakti Kumar Singh. 2015. Two new species of Euphranta Loew (Diptera: Tephritidae: Trypetinae) and an updated key for the species from India. Zootaxa, 3914 (1): 064–070
20. Dheemanth, L., Srinivasa Murthy, K. and ChandishBallal, R. 2014. Molecular characterization of common predatory anthocorids. Journal of Biological Control, 28 (4): (Accepted)
21. Dheemanth, L., Srinivasa Murthy, K. and Chandish Ballal, R. 2014. Molecular characterisation of common predatory anthocorids. Journal of Biological Control, 28 (4): (Accepted) (NAAS rating: 3.9).
22. Guruprasad, N. M., Harish, B. M., Jalali, S. K. and Puttaraju, H. P. 2014. In-silico modelling of Wolbachia and its potentials in combating mosquito borne diseases chikungunya and dengue. International Journal of Mosquito Research, 1: 61-68.
23. Guruprasad, N. M., Jalali, S. K. and Puttaraju, H.P. 2014. Wolbachia – a foe for mosquitoes. Asian Pacific Journal of Tropical Disease, 4: 78-81.
24. Hayat, M., Veenakumari, K, Badruddin, S.M.A 2014. Description of a new species of Aphelinus Dalman (Hymenoptera: Calcidoidea: Aphelinidae) from India, with some records. PROMMALIA, II, 120-129.
25. Hayat, M., and Veenakumari, K. 2014. Further records of Encyrtidae (Hymenoptera: Chalcidoidea) from Andaman & Nicobar Islands, with description of a new species of Ooencyrtus Ashmead. PROMMALIA, II, 23-36.
26. Hayat, M., and Veenakumari, K. 2013. Encyrtidae (Hymenoptera: Chalcidoidea) from Andaman & Nicobar Islands, with description of a new genus and two new species. PROMMALIA I, 98-113.
27. Honnur Basha. T and Ramanujam. B. 2015. Growth promotion effect of Pichia guilliermondii in chilli and biocontrol potential of Hanseniaspora uvarum against Colletotrichum capsici causing fruit rot. Biocontrol Science & Technology 25 (2): 185-206.
28. Honnur Basha and B. Ramanujam.2014. Growth promoting potential of native Bacillus megaterium strain EXB-53 in some vegetable crops in commercial nursery. Journal of Pure and Applied Microbiology 8 (5): 3653-3665
29. Jalali, S .K., Y. Lalitha, Ojha, R., Kumar, P., Sulaikhabeevi, S. B., Sharma, R., Nair, R., Kadanur, R. C., Kamath, S. P. and K. S. Mohan. 2014. Baseline sensitivity of maize borers in India to the Bacillus thuringiensis insecticidal proteins Cry1A.105 and Cry2Ab2. Pest Management Science, (wileyonlinelibrary.com) 2014 Aug 20. doi: 10.1002/ps.3888.
30. Kharbanda, N., Jalali, S. K., Ojha, R. and Bhatnagar, R. K. 2015. Temporal expression profiling of novel Spodoptera litura nucleopolyhedrovirus encoded microRNAs upon infection of Sf21 cell line. Journal of General Virology, 96: 688–700.
31. Lalitha, Y. and Ballal, C. R. (2015) Influence of seasons and inoculum dosages on the production efficiency of Corcyra cephalonica Stainton. Journal of Biological Control (In Press).
32. Mani M. and Shylesha A.N. 2015. Invasive insect pests and their management in India Past, present and future. Lead paper in International conference on innovative insect management approaches for sustainable agro eco system January 27-30th 2015. TNAU Madurai Agricollege and research institute Pp: 569-584
33. Mohan M, Venkatesan T, Sivakumar G, Mahesh Y, Verghese A. 2015. Fighting Pesticide Resistance in Arthropods. Westville Publishers, New Delhi (Under Press)

34. Mohan M, Rangeswaran, R, Sivakumar G, Verghese A, 2014. Relative toxicity of subspecies of *Bacillus thuringiensis* against lepidopterous insect pests of agricultural importance. J. Biol. Control 28(4): 119-125.
35. M. Pratheepa, Y G Prasad, P Jeyakumar, S Vennila, M Prabhakar, Niranjan Singh, U P Barkhede, A N Sharma and J Cruz Antony. 2014. Decision tree induction model for forecasting the pest Gesonia gemma on soybean based on abiotic factors. Indian Journal of Plant Protection. Vol. 42(4):343-348.JFJGG (NAAS rating : 4.9)
36. Nityanand Malviya, Mahesh S. Yandigeri, Arvind Kumar Yadav, Manoj Kumar Solanki and Dilip K. Arora (2014) Isolation and characterization of novel alkali-halophilic actinomycetes from the Chilika brackish water lake, India. Annals of Microbiology, 64:1829–1838. DOI 10.1007/s13213-014-0831-1.
37. Nagesh, M., SaleemJaveed, Ramanujam, B. and Rangeswaran, R. 2013. Suitability of soil types for Paecilomyceslilacinus and Pochonia chlamydosporiaand their performance against root-knot nematode, Meloidogyne incognita on Lycopersiconesculentumin glass house. Indian Journal of Agricultural Sciences, 83(8): 828-833.
38. Ojha, R., Jalali, S. K., Mushtak Ali, T. M., Venkatesan, T., Prosser, S. W. and Krishna Kumar, N. K. 2014. DNA barcoding of Indian ant species based on cox1 gene. Indian Journal of Biotechnology, 13: 165-171.
39. Patil J., Rajkumar and Subharan, K. (2014). Virulence of Steinernema carpocapsae and Heterorhabditis indica against coconut Rhinoceros Beetle, Oryctes rhinoceros L. (Scarabaeidae: Coleoptera). Indian Journal of Nematology, 44: 73-81. (NAAS rating 4.56).
40. Patil, J and Gaur, H.S. (2014). Effect of root-knot nematode, Meloidogyne graminicola, on the quality and vigour of rice seed. Nematology, 16: 555-564. (NAAS rating 7.25).
41. Patil, J and Gaur, H.S. (2014). Relationship between population density of root-knot nematode, Meloidogyne graminicola and the growth and nutrient uptake of rice plant. Vegetos, 27: 130-138. (NAAS rating 6.04).
42. Prabhulinga, T., Thyagaraj, N. E., Kalavathi, K. K. and Jalali, S. K. 2014. Comparison of biological parameters among arrhenotokous & thelytokous forms of Trichogramma pretiosum Riley (Hymenoptera: Trichogrammatidae). Green Farming, 5: 1101-1104.
43. Prabhulinga, T., Thyagaraj, N. E., Kalavathi, K. K. and Jalali, S. K. 2015. Life-table characteristics of arrhenotokous and thelytokous T. pretiosum Riley on eggs of Corcyra cephalonica Stainton. Green Farming, 6: 137-139.
44. Prashanth Mohanraj and K. Veenakumari. A new species of Mymaromma Girault Mymarommatoidea: Mymarommatidae) from India. Entomological News (Accepted)
45. Ramanujam B, Rangeshwaran R, Sivakumar G, Mohan M, Yandigeri M, 2014. Management of insect pests by microorganisms. PINSA, 80: 455-471.
46. Rajmohana, K. and Veenakumari,K.2014. Chakra, a new genus of Scelioninae (Hymenoptera: Platygastridae) from India, along with description of a new species. Zootaxa. 285-290.
47. Ramya, S.L., Venkatesan, T., Murthy, K.S. and Jalali, S.K. 2015. Detection of carboxylesterase and esterase activity in culturable gut bacterial flora isolated from diamondback moth, Plutella xylostella from India and its possible role in indoxacarb degradation. Brazilian Journal of Microbiology (Accepted) (NAAS rating: 6.45)
48. Rangeshwaran, R., Gorky, A., Velavan, V., Ashwitha, K., Sivakumar, G. and Mohan, M. 2014. Plasmid profiling of native Bacillus thuringiensisisolatesharboring insecticidal cry genes. Journal of Biological Control 28(4): (in press).
49. Shakti Kumar Singh and David, K. J. 2015. A new species of Magnimyiolia Shiraki (Diptera: Tephritidae: Trypetinae) and new records of Acanthonevrini from India. Zootaxa, 3949 (1): 129-134

50. Shashank, P.R., Ojha, R., Venkatesan, T., Jalali, S.K. and Bhanu, K.R. M. 2015. Molecular characterization of brinjal shoot and fruit borer, Leucinodes orbonalis(Guenée) (Lepidoptera: Crambidae) based on mitochondrial marker cytochrome oxidase I and their phylogenetic relationship. Indian Journal of Experimental Biology, 52: pp. 51-55.
51. Sivakumar G, Mahesh Yandigeri, Rangeshwaran R, Mohan M, Yalashetti S, Venkatesan T, Raveendran P, Krishnakumar NK and Abraham Verghese. Diversity of gut bacteria associated with the field populations of Amrasca biguttula biguttula (Ishida) of cotton of India. Bioscan (in press).
52. Sivakumar G, Rangeshwaran R, Sriram S and Raveendran P. 2014. Bacillus megaterium strain NBAII 63 a potential biocontrol agent for the management of bacterial wilt of tomato caused by Ralstonia solanacearum, Indian Journal of Agricultural Sciences.84(10):1288-92 (NASS rate 6.0)
53. Sivakumar G, Mahesh Yandigeri, Rangeshwaran R, Mohan M, Yalashetti S, Venkatesan T, Raveendran P, Krishnakumar NK and Abraham Verghese. Diversity of gut bacteria associated with the field populations of Amrasca biguttula biguttula (Ishida) of cotton of India" is accepted for publishing in "The Bioscan" journal (NAAS rate 4.5)
54. Shylesha A.N. 2015. Insect management approaches for sustainable agro eco system. Lead paper in International conference on innovative insect management approaches for sustainable agro eco system January 27-30th 2015. TNAU Madurai Agricollege and research institute Pp: 701-715
55. Srinivasa Murthy, K., Ramya, S.L, Venkatesan, T., Jalali, S.K. and Abraham verghese. 2014. Biochemical basis of insecticide resistance and determination of esterase enzyme patterns in field collected populations of Cotesia vestalis (Haliday) (Hymenoptera: Braconidae) from India. Annals of Biological Research, 5 (11):7-15 (NAAS rating 8.1).
56. Srinivasa Murthy, K., Rajeshwari, R., Ramya,S.L., Venkatesan, T. Jalali, S.K. and Abraham Verghese. 2015. Genetic diversity among Indian termites based on mitochondrial 12S rRNA gene. European Journal of Zoological Research,4 (1):1-6 (equivalent NAAS rating 7.9)
57. Srinivasa Murthy, K., Venkatesan, T. Ramya , S L, Jalali S.K. and Abraham Verghese . Insecticide degradation by gut bacteria in Cotesia vestalis Haliday, a potential parasitoid of Diamond back moth, Plutella xylostella (Linnaeus) .Journal of Agricultural Science and Technology (Under review) (NAAS rating 7.1)
58. Veenakumari, K. Rajmohana, K. and Prashanth Mohanraj. 2013. A new species of Trimorus (Neotrimorus) (Hymenoptera: Platygastridae) from Andaman Islands, India. Journal of Biological control. 27(4):243-246
59. Veenakumari, P. N. Buhl, Prashanth Mohanraj and F.R. Khan. 2014. Four new species of Platygastridae (Hymenoptera: Platygastroidea) from India .Entomologists monthly magazine:150: 49-59.
60. Veenakumari, K. and Prashanth Mohanraj 2014. Five new species of Phanuromyia (Hymenoptera: Platygastridae) from India. Entomologists monthly magazine 150: 135-147.
61. V.V. Pashte, A.N. Shylesha and N.S. Bhat 2014. Effectiveness of Attractants and Scents in enticement of Apis cerana on Sesamum crop. Environment and Ecology, 33(4):1504-1507.M.Pratheepa, Chandish R. Ballal, Abraham Verghese, A.Robinson Silvester and Y. Lalitha. 2014. Arthropod Germplasm Information System in India. International Journal of Engineering Research & Technology (IJERT). Vol. 3(9):276-282. (Impact factor 1.76)
62. Y K Sharma, K Kant, S Sriram & B Ramanujam. 2014. Efficacy of indigenous Trichoderma isolates for the management of cumin wilt (Fusarium oxysporum f. sp. cumini) in Rajasthan. Journal of Spices and Aromatic Crops 23 (2): 268–271.

AAU-Anand

1. Solanki,C. G.;Dhobi, C. B.; Patel, M. V.; and Mehta, D. M.(2015). Seasonal incidence of tobacco capsule borer, *Helicoverpa armigera* (hubner) hardwick on bidi tobacco (seed crop) in middle Gujarat. *Life Sciences Leaflets.* 59: 108 –113.
2. Patel, M. V.; Mehta, D. M.; Patel, S. R.; Parmar, V. R.; Tathod, D. M. And Gohel, V. R. (2014). Chemical management of the papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink. *Trends in Bioscience*, **7**(24): 4386-4391

GBPUAT-Panthnagar

1. Shukla, N., Awasthi, R.P., Rawat, L., and Kumar, J. 2015. Seed biopriming with drought tolerant isolates of *Trichoderma harzianum* promote growth and drought tolerance in *Triticum aestivum* L. Annals of Applied Biology166: 171–182.
2. Deepika Saxena, A.K.Tewari and Dinesh Rai (2014). *In-vitro* antagonistic assessment of *T. harzianum* PBT 23 against plant pathogenic fungi. *Journal of Microbiology and Biotechnology Research.* 4 (3): 59-65.
3. Deepika Saxena, A.K.Tewari and Dinesh Rai (2014). The *in-vitro* effect of some commonly used fungicides, insecticides and herbicides for their compatibility with *Trichoderma harzianum* PBT23. *World Applied Sciences Journal.* 31 (4): 444-448,
4. Vinod Kumar, C.S. Mathela, A.K. Tewari and K.S. Bisht (2014). *In- vitro* inhibition activity of essential oils from some Lamiaceae species against phytopathogenic fungi. *Pesticide Biochemistry and Physiology.* 114: 67–71.

PAU

1. Kumar V, Dhawan A K and Shera P S (2014) Field efficacy of insect growth regulator, pyriproxyfen against sucking insect pests and predatory complex on Bt cotton. *Pesticide Research Journal* 26: 12-19.
2. Sarao P S and Shera P S (2014) Field efficacy of Mortar 75 SG (cartap hydrochloride) against stem borers and leaf folder on rice/*basmati* rice. *Indian Journal of Plant Protection* 24: 131-134.
3. Shera P S, Sohu R S, Gill B S, Sekhon P S and Sarlach, R S (2014) Relative performance of different Bt cotton cultivars expressing single and dual toxin for pest infestation, yield and fibre quality parameters. *Vegetos* 27 (3): 237-243.
4. Shera P S, Arora R and Singh P (2015) Comparative susceptibility of transgenic Bt cotton hybrids to *Earias* spp. and other non-target insects. *Crop Protection* 71: 51-59.
5. Sarao P S, Shera P S and Singh P (2015) Impact of multiple insect-pest incidence on yield in basmati rice. *Cereal Research Communications* DOI 10.1556/CRC.2014.0034.
6. S. Sharma and Aggarwal N (2014). Comparing efficacy of biopesticides for the management of insect pests in aromatic rice under organic farming system. *Journal of Biological Control* 28 (2): 87-92.
7. S Sharma and Aggarwal N (2015). Time-linked dosage appraisal of Trichogrammatids against *Cnaphalocrocis medinalis* (Guenée) and *Scirpophaga incertulas* (Walker) in organic aromatic rice. *Ecology, Environment and Conservation* 20 (Suppl.): 111-118.
8. Kaur A and Joshi N (2014) Conidial production of *Beauveria bassiana* on agricultural products and effect of storage temperature on its formulation .*African Journal of Microbiological Research* 8 : 3164-170
9. Kumar Ashok, Sangha K S and G P S Dhillon (2014) Screening of 19 genotypes of *Eucalyptus* spp. against gall wasp (*Leptocybe invasa*) in north-western India. *Journal Forestry Research* (Springer publication) (Accepted)

10. Dhillon G P S, Kumar Ashok and K S Sangha (2014) Selection and conservation of superior germplasm of *Eucalyptus tereticornis* Sm. In: National symposium on Crop improvement for inclusive sustainable development, Nov 7-9, 2014 Ludhiana pp. 971-973.

TNAU-Coimbatore

1. Sridharan. S, K. Chandra Shekhar & N. Ramakrishnan. 2015. 'Bioefficacy, Phytotoxicity and Bio safety of Mineral Oil on Management of Whitefly in Okra' International Journal of Vegetable Science DOI: 10.1080/19315260.2013.818607 pages 28-35
2. Ramakrishnan.N, S. Sridharan & S. Chandrasekaran 2014. 'Insecticide Usage Patterns on Curry Leaf' International Journal of Vegetable Science DOI: 10.1080/19315260.2013.876566
3. Ramakrishnan, N. and S. Sridharan 2014. 'Pesticide Usage Pattern of Curry Leaf, *Murraya koeinigii* (L.) Sprengel in Coimbatore District of Tamil Nadu' Trends in Biosciences 7(24) PP 4407-4411.
4. Ramakrishnan, N. and S. Sridharan 2014.' Eco-friendly Pesticides to manage major Pests of Curry Leaf, Murraya koeinigii (L.) Sprengel' The Ecoscan – Special Issue (V) PP 277-283.

YSPUHF

1. Kanwar, Reecha and Chauhan, Usha.2012.Record of parasitoids of greenhouse whitefly, *Trialeurodes vaporariorum* in mid hill regions of Himachal Pradesh. Ann.Entomol.30(1): 47-53.
2. Sharma, Ajay and Chauhan, Usha 2014. Standardization of rearing technique for *Neoseiulus*(=*Amblyseius*) *longispinosus*(Acari Phytoseiidae) in mid hill region of Himachal Pradesh.*Indian Journal of Plant Protection* (In Press)
3. Singh,Vijay and Chauhan,Usha.2014.Diversity of mite (Acari) fauna associated with vegetables and ornamental plants in mid-hill conditions of Himachal Pradesh, India.Journal of Biocontrol .28(2) : 18-23
4. Sharma P.L., Chauhan Usha and Sharma K.C. 2014. Studies on the diversity of predatory coccinellid beetles (coleoptera) in different agro-climatic zones of Himachal Pradesh.*The Bioscan* (in press)
5. GavkareOmkar andSharmaP. L. .2014. New record of *Nesidiocoris tenuis* (Reuter) (Hemiptera: Miridae) associated with *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae) on tomato from Maharashtra, India. *Journal of Biological Control*, 28(2): 117–118

MPUAT

1. B.S. Rana and Dinesh Kachhawa 2014. Study of bio-efficacy of Entomopathogenic fungi for suppression of termite incidence in Maize. *International Journal of Plant Protection*; 7 : 377.
2. B.S. Ranawat, B.S. Rana, O.P. Ameta, S.K. Jat and M.K. Jat 2014. Relative efficacy of entomo-pathogens and botanicals against major insect pests of soybean. *Indian Journal of Applied Entomology*; 28(1) : 10-14.
3. M.K. Jat, B.S. Rana, O.P. Ameta, S.K. Jat and A. Murdia 2014. Relative efficacy of bio-pesticides against major insect-pests of cabbage. *Indian Journal of Applied Entomology*; 28(1) : 20-25.

CPCRI

1. Josephrajkumar, A. and Chandrika Mohan (2014) Beware of pests (Agro-clinic) *Kerala Karshakan e-journal* **1**(9): 25-33.
2. Josephrajkumar, A., Sunny Thomas, Shanavas, M. and Chandrika Mohan (2014) Managing the hidden villain in coconut garden. *Kerala karshakan e-journal* (September issue) **2**(4): 21-27.

IIVR

1. A.B.Rai and Debjani Dey. 2015. Occurrence of *Phenacoccus solenopsis* (Tinsley) in vegetable ecosystem and host-mediated effects on its dominant parasitoid,*Aenasius bambawalei* Hayat. *Vegetable Science* (Communicated).

2. Papers presented in symposia/seminar/workshops

NBAIR

1. ADNT Kumara, Kesavan Subaharan A.K.Chakravarthy and Vibina Venugopal. 2014. Electrophysiological response of coconut black headed caterpillar, *Opisina arenosella* to coconut leaf volatiles. Oral presentation in SLCARP International Agricultural Research Symposium held at Colombo 11 -12 August, 2014.
2. ADNT Kumara, Kesavan Subaharan and A.K.Chakravarthy. (2015). Behavioral responses of parasitoids of coconut black headed caterpillar to herbivore induced plant volatiles. In book of abstracts of National Meeting on New/Safer Molecules and Biocontrol Technologies for Integrated Pest Management in Crops . (Eds) Kesavan Subaharan, Shivakumar,G, Ankita Gupta, Mohan.M., Pratheepa.M, Gandhi Gracy and Abraham Verghese. Society for Biocontrol Advancement at Bengaluru , February 23,2015.p39.
3. B.K.Chaubey and .Srinivasa Murthy, K. 2015. Cold storage to enhance shelf life of *Cotesia vestalis* Haliday, a potential parasitoid of Diamond back moth *Plutella xylostella* Linnaeus. *Poster presented at National Meeting on New/ Safer Molecules and Biocontrol Technologies for Integrated Pest Management in crop. 23rd February 2015*. Organised by Society for Biocontrol Advancement and NBAIR, Bangalore
4. Ballal, C. R. and Yamada, K. (2014) Diversity of Indian Anthocoridae. p. 89 In *World Biodiversity Congress – 2014.* November 24th to 27th 2014, Colombo, Sri Lanka, 212 pp.
5. Ballal, C. R. 2015. Insect ecology interfacing biological control" during the "Ecology and Ecological Engineering Methods session". pp. 54 - 72. In Proceedings of the International Conference on INNOVATIVE INSECT MANAGEMENT APPROACHES FOR SUSTAINABLE AGRO ECO – SYSTEM (IIMASAE) held at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu from 27th January to 30th January, 2015, 815 pp.
6. B. Ramanujam, B. Poornesha and K.R. Yatish.2014. Evaluation of virulence of different isolates of *Metarhizium anisopliae* (Metchnikoff) Sorokin on maize stem borer *Chilo partellus* (Swinhoe) by laboratory bioassay. Paper presented at "Innovative Insect Management Approaches for Sustainable Agro Ecosystem (IIMASAE)" held at Agriculture College & Research Institute, Madurai, Tamil Nadu during 27-30th of January 2015. Abstract. p369.
7. Chaubey, B. K. and .Srinivasa Murthy, K. 2015. Cold storage to enhance shelf life of *Cotesia vestalis* Haliday, a potential parasitoid of Diamond back moth *Plutellaxylostella* Linnaeus. Poster presented at National Meeting on New/ Safer Molecules and Biocontrol

Technologies for Integrated Pest Management in crop. 23rd February 2015. Organised by Society for Biocontrol Advancement and NBAIR, Bangalore.

8. Djeddour, D., Tanner, R. A., Ballal, C. R. (2014) International collaboration facilitates research into the natural control of two highly invasive plant species. P. 49 In *World Biodiversity Congress – 2014.* November 24th to 27th 2014, Colombo, Sri Lanka, 212 pp.

9. Ghosh, E., Ballal, C. R. and Roopa, G. 2015. Developmental thresholds for two potential egg parasitoids *Trichogramma chilonis* (Ishii) and *Trichogramma japonicum* (Ashmead). pp. 358 – 359, In Proceedings of the International Conference on INNOVATIVE INSECT MANAGEMENT APPROACHES FOR SUSTAINABLE AGRO ECO – SYSTEM (IIMASAE) held at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu from 27th January to 30th January, 2015, 815 pp. Won the Best Oral presentation award.

10. Gupta, T. and Ballal, C. R. 2015. Biology and feeding potential of *Xylocoris flavipes* (Reuter) predating on eggs of different moth pests infesting stored grains. pp. 348 – 350, In Proceedings of the International Conference on IIMASAE held at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu from 27th January to 30th January, 2015, 815 pp.

11. Jagadeesh, Patil. (2015). Use of entomopathogenic nematodes for the management of insect pests. In: Nematode taxonomy training at Aligarh Muslim University, Aligarh, India.

12. Jagadeesh, Patil. (2015). Effect of root nitrogen supply form on the invasion of rice roots by the root-knot nematode, *Meloidogyne graminicola.* In*:* Brain storming session on "Emergence of new nematode diseases of Karnataka with special reference to rice root knot nematode, *Meloidogyne graminicola*" held on 29th and 30th April 2014 at University of agricultural and horticultural sciences, Shivamoga, India.

13. Kesavan Subaharan (2015). Advances in chemoecological methods in veterinary and agriculture pest management. Invited paper presented at International conference - Innovative Insect Management Approaches for Sustainable Agro Eco System (IIMASAE) held Agriculture College and Research Institute, Madurai 27-30 January 2015 Srinivasan *et al.* (Eds) Book of Abstracts p 587-589.

14. Kesavan Subaharan (2014). Behavioural manipulation methods in management of veterinary and agricultural pests. In: *National Symposium on Entomology as a Science and IPM as a technology-the way forward (compilation of invited lectures)* V.V. Ramamurthy and Subramanian (Eds.), Entomological Society of India, New Delhi pp. 155-166.

15. Lalitha, Y. and Ballal, C. R. 2015. Mass rearing of an arboreal species *Trichogramma embryophagum* Hartig on eggs of Eri silkworm *Samia cynthia* Drury for inundative releases. pp. 391 – 393, In Proceedings of the International Conference on IIMASAE held at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu from 27th January to 30th January, 2015, 815 pp.

16. Malathi, V.M., Jalali, S.K., Didde Gowda, D.K., Mohan, M. and Venkatesan, T. 2015. Susceptibility of field populations of *Nilaparvatha lugens* from south India to various insecticides. Oral presentation at International conference on Innovative Insect Pest Management approaches for sustainable agro-ecosystem held at TNAU, Madurai during Jan 27-30, 2015.

17. Mani, M., Venkatesan, T. and Pratheepa, 2014. Insecticide resistance and its management in mealybugs. Presented at Brainstorming session on Insecticide Resistance Management" held at IIHR, Bangalore on 30th August 2014.

18. M.Sowmya, Kesavan Subaharan and N.Bakthavatsalam. (2015). Cidal activity of Ajowan, *Trachyspermum ammi* essential oil and its component on housefly, *Musca domestica*. Paper presented. In book of abstracts of National Meeting on New/Safer Molecules and Biocontrol Technologies for Integrated Pest Management in Crops . (Eds)

Kesavan Subaharan, Shivakumar,G, Ankita Gupta, Mohan.M., Pratheepa.M, Gandhi Gracy and Abraham Verghese. Society for Biocontrol Advancement at Bengaluru , February 23,2015.p39.
19. Prathibha P.S., Subaharan, K. and Kumar, A.R.V. (2014) Epizootics and natural enemies of palm white grub *Leucopholis* spp. *In: Book of Abstracts National Conference on Sustainability of coconut, arecanut and cocoa farming Technological Advances and Way forward.(Eds.)* Muralidharan, K., Rajesh M.K., Muralikrishna K.S., Jesmi Vijayan, Jeyasekhar, S., CPCRI, Kasaragod, August 22-23, 2014, p 94.
20. Rajkumar., Patil, J and Subharan, K. (2014). Efficacy of entomopathogenic nematode in combination of imidacloprid against whitegrub (*Leucopholis burmesterie*) management in arecanut. In: International conference on "Changing scenario of pest problem in Agri-horti ecosystem and their management" held from 27-29 November 2014 Udaipur, India.
21. Rajkumar., Patil, J and Subharan, K. (2014). Compatibility of entomopathogenic nematode, *steinernema carpocapsae* with chloropriphos insecticide. In: International conference on "Innovative insect management approaches for sustainable agroecosystem (IIMASAE)" held from 27-30 January 2015.
22. Rajkumar, Jagadeesh Patil and Kesavan Subaharan (2014) Efficacy of entomopathogenic nematode in combination with imidacloprid against root grub (*Leucopholis burmesteri*) in arecanut *In: International conference on 'Changing scenario of pest problems in Agri-Horti ecosystem and their management'*, held at MPUA&T, Udaipur, Rajasthan during 27-29 November, 2014. p.199.
23. Rajkumar, Jagdeesh Patil, Subaharan, K. and Sujithra M. (2015). Compatibility of Entomopathohgenic Nematode *Steinernema carpocapsae* with chlorpyrifos insecticide. Paper presented at International conference - Innovative Insect Management Approaches for Sustainable Agro Eco System (IIMASAE) held at Agriculture College and Research Institute, Madurai 27-30 January 2015 Srinivasan *et al.* (Eds) Book of Abstracts p 357
24. Rangeshwaran, R., Frenita M. Lewis, G. Shivakumar, M. Mohan and Satendra Kumar. 2014. Cloning and expression of VIP3A gene for broad spectrum insecticidal activity. Presented during the National Meeting on New/Safer Molecules and Biocontrol Technologies for Integrated Pest Management in Crops, 23 February 2015, Bengaluru
25. Ramya, S.L., Venkatesan, T., Murthy K.S. and Jalali, S.K. 2014. Molecular diversity analysis of culturable bacterial flora of Diamondback moth, *Plutellaxylostella* from India and its possible role in degradation of Indoxocarb. Presented at IXth International Conference on Bacteriology and applied Microbiology" held during July 27th-August 1st, 2014, at Montreal, Canada.
26. Ramya, S.L., Venkatesan, T., Murthy K.S. and Jalali, S.K. 2014. Molecular ecology of *Bacillus cereus* isolated from diamondback moth, *Plutella xylostella* (Linnaeus) a notorious pest of cruciferous crops from India and its role on acephate degradation at EMBL - Conference on Experimental Approaches to ecology and evolution of yeast and other model organisms held during October 12th - 15th, 2014, at Heidelberg, Germany.
27. Ramya, S.L., Venkatesan, T., Jalali, S.K. Srinivasa Murthy, K. 2014. Biochemical mechanism of insecticide resistance in field populations of Diamondback moth, *Plutellaxylostella*. In 2nd International Conference on Agricultural and Horticultural Sciences, at Hyderabad during 03-05 Nov. 2014.
28. SurabhiKumari., Sivakumar, G., Rangeshwaran, R., Chandish R. Ballal., Mahesh S. Yandigeri., Mohan, M. and Abraham Verghese. 2014. Endosymbiotic bacterium, *Bacillus pumilus* and its role on fitness of *Amrasca biguttula biguttula* (Ishida) of cotton. Presented during the National Meeting on New/Safer Molecules and Biocontrol Technologies for Integrated Pest Management in Crops, 23 February 2015, Bengaluru

29. T. Ramasubramanian, N. Geetha, B. Ramanujam and G. Santhalakshmi. 2014. Endophytic-*Beauveria bassiana:* An ideal candidate for managing internode borer of sugarcane. Paper presented at 73rd Annual Convention of Sugar Technologists' Association of India held in Bangalore during 9-11 September, 2014.
30. Venkatesan, T., Ramya, S.L., Murthy, K.S., Jalali, S.K. and Verghese, A. 2014. Investigations on field-evolved insecticide resistance in diamondback moth, *Plutellaxylostella* (L) in India. Presented at Brainstorming session on Insecticide Resistance Management" held at IIHR, Bangalore on 30th August 2014.
31. Venkatesan, T. 2015. Commercialization of NBAIR-technologies, presented at One-day workshop on IPR and Technology Management, held at University of Agricultural Sciences, GKVK, Bengaluru on 30th January 2015.
32. Venkatesan, T. and Jalali, S.K. 2015. "DNA Barcoding & its application in identification of species" at XVIII National Training Programme on "Advanced techniques for detection and control of parasitic diseases at Centre of Advanced Faculty Training in Veterinary Parasitology, KVS, FSU, Bengaluru on 28th November 2014.
33. Venkatesan, T. 2015. Presented Technical Programme of the project on "Insecticide resistance in mealybugs" under the Network Project "Out Reach Programme on Management of Sucking Pests in Horticultural Crops" under XIIth Plan on 3rd Nov. 2014 at IIHR, Bengaluru.
34. Venkatesan, T. 2015. Presented "Network Project on Agricultural Bioinformatics (Insect Bioinformatics**)- at** Steering Committee, Centre for Agricultural Bioinformatics (CAB in), IASRI, New Delhi during 12-14th March 2015.
35. Venkatesan, T. 2014. Delivered a talk on "Commercialization of biocontrol agents during the training programme on Production & quality control of Organic inputs**,** held organized by Regional Centre of Organic Farming, Bengaluru on 21st August 2014.
36. Vibina Venugopal and Kesavan Subaharan.2014. Electrophysiological and behavioural response of coconut red palm weevil, *Rhynchophorous ferrugineus* to host volatiles. Oral presentation in SLCARP International Agricultural Research Symposium held at Colombo 11 -12 August, 2014.

AAU-Anand

1. Godhani, P. H.; Patel, H. M.; Jani, J. J.; Patel, A. J.; Rathod, N. K.; Patel, N. B.; Dhobi, C. B.; Korat, D. M. and Mehta, D. M. (2014). Evaluation of bio-intensive pest management (BIPM) practices against pod borer and wilt disease in chickpea. International conference on "Changing scenario of pest problems in Agri-Horti Ecosystem and their management" held at Department of Entomology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur during 27-29th November, 2014: 108.
(Awarded as best oral presentation)
2. Godhani, P. H.; Patel, N. B.; Patel, H. M.; Dhobi, C. B.; Korat, D. M. and Mehta, D. M. (2014). Evaluation of bio-intensive pest management (BIPM) practices against major insect pests infecting Kharif okra. International conference on "Changing scenario of pest problems in Agri-Horti Ecosystem and their management" held at Department of Entomology, Rajasthan College of Agriculture, MaharanaPratap University of Agriculture and Technology, Udaipur during 27-29th November, 2014: 116.

AAU-Jorhat

1. Buragohain, P, D. K. Saikia and A. Devi (2014). Indigenous insect pest management in traditional farming of Assam. UGC sponsored national seminar on Science, technology and their impact on society with special reference to north east India. PP: 53
2. Devee, A., M. Borah, D.K. Saikia, P. Dutta and K. C. Pujari (2015). Biological weed management in Assam. Organized by "European Weed Research Society" on "Optimising Herbicide use in an Integrate weed management (IWM) context" in Crete, Greece on 5th to 7th March 2015. Pp-27.

KAU-Thrissur

1. Dr. K. R. Lyla, Professor and Smt. Vidya C.V., Asst. Professor attended XXIII Biocontrol Workers Group Meeting held on 27-28th June, 2014 at Orissa University of Agriculture and Technology, Bhubaneswar.

MPKV-Pune

1. Attended the State level meeting at Director of Agriculture, Inputs & Quality Control at Central Building, Pune for finalizing the rates of bio pesticides on 07/05/2014.
2. Dr. R.V. Nakat and Dr. S. M. Galande, attended the seminar on "Weather change and its impact on Agriculture – Fulfilling Meteorology's vision on 29.05.2014.
3. Dr. R.V. Nakat attended meeting for Mango-net at Director of Extension, Govt. of Maharashtra, Sakhar Sankul, Pune on 9.6.2014.
4. Dr. R.V. Nakat and Dr. S. M. Galande, attended the XXIII Biocontrol Workshop of AICRP on Biological Control of Crop Pests and Weeds held at OUAT, Bhubaneshwar, and Orissa on June 27-28, 2014 and presented the report. The Tribal Sub Plan of Rs. 1.92 lakhs is sanctioned for the year 2014-15.
5. Dr. R.V. Nakat, attended meeting on Pesticide poisoning at Sakhar Sankul, Pune on 04.07.2014.
6. Dr. R.V. Nakat visited Center of Insecticide Board and Registration Committee (CIB & RC) during 24 to 29 August, 2014 and got the permission for registration for 3 biopesticides namely Phule *Verticillium lecanii*, Phule *Beauveria bassiana* and Phule *Metarhizium anisopliae* developed by MPKV, Rahuri in CIB & RC 350th meeting held on 29.08.2014. He has also discussed the matter of registration of rejected *Trichoderma viride* file with Chairman, CIB & RC, ADG (PP) and two members of CIB & RC Dr. Chatopadhaya, Director, NCIPM and Dr. K. K. Sharma, Network Coordinator of AICRP on Pesticide Residues Project, New Delhi.
7. Dr. R.V. Nakat attended the meeting on Registration of biopestcicides with Director of Inputs and Quality Control, Dept. of Agriculture, Govt. of Maharashtra at Central building Pune on 15.09.2014
8. Dr. R.V. Nakat attended the meeting with Director of Research, MPKV, Rahuri on 19.09.2014 regarding common registration of biopesticides of four SAUs under common license of Agril. Department, Govt. of Maharashtra.
9. Dr. R.V. Nakat attended awareness Workshop on Key Issues of GM crops organized by BCIL, New Delhi and MPKV. Rahuri at YASHDA, Pune on 17.10.2015.
10. Dr. R.V. Nakat attended the State Level Meeting to finalize technical Specification for purchase of Lab. equipments for Govt. Maharashtra on 27.10.2014.
11. Dr. S. M. Galande attended World Biodiversity Congress-2014 at Colombo, Sri Lanka on 24-27 Nov. 2014.

12. Dr. R.V. Nakat attended meeting on Effect of Neonicotinoids on Honey bee at Agril. Commissioner, Pune on 27.11.2014.
13. Dr. S. B. Kharbade and Shri. N. D. Tamboli attended one day Seminar on "Impact analysis for Agril.-Technologies in research, education and extension" organized by the Director of Research, MPKV, Rahuri on 6th Feb. 2015.
14. Dr. R. V. Nakat, attended National Symposium on IPM for Sustainable Crop Protection on 24-25, Feb. 2015 at Division of Entomology, IARI, New Delhi in Collaboration Association of Botanical Led Enterprises, Agril. Focus Group, India.
15. Dr. R.V. Nakat Visited the CIB & RC, Director of Plant Protection Quarantine and Storage and obtained the commercial registration for production of Phule *Trichoderma* and Phule *Beauveria* on 24th and 26th Feb. 2015.

PAU-Ludhiana

1. Shera P S and Sarao P S 2014. Impact of IPM practices in paddy on insect pest incidence and grain yield, pp 173-174. In: Ramamurthy, V.V. and Subramanian, S. (eds), Extended Abstracts, *National Symposium on Entomology as Science and IPM as a technology-the Way Forward*, November 14-15, 2014, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh.
2. Shera P S and Sarao P S 2014. Efficacy of newer insecticides against insect pests in rice (Abstract), pp. 22-23. *International Conference: Changing Scenario of pest Problems in Agri-Horti Ecosystem and their Management*, November 27-29, 2014, Maharana Pratap University of Agriculture and Technology, Udaipur.
3. Shera P S, Sharma S and Kaur R 2015. Tri-trophic interactions between Bt cotton, sucking insect pests and the predator *Chrysoperla zastrowi sillemi* (Esben-Petersen). Oral presentation in the National Entomologists' Meet, February 5-7, 2015 IINRG, Ranchi.
4. Kaur R, Shera P S, Sharma S, Joshi, N and Sangha K S 2015. Successful adoption of potential bio-control based IPM technologies in Punjab. In : Subaharan K, Sivakumar G, Gupta A, Mohan M, Pratheepa M, Gracy G and Verghese A (eds.) Abstracts, *National Meeting on New/Safer Molecules and Biocontrol Technologies for Integrated Pest Management in Crops*, February 23, 2015, NBAIR, Bangalore.
5. Joshi N, Virk J S and Shera P S 2015. *Bacillus thuringiensis* formulations for the management of cabbage butterfly, *Pieris brassicae* on cauliflower. In : Subaharan K, Sivakumar G, Gupta A, Mohan M, Pratheepa M, Gracy G and Verghese A (eds.) Abstracts, *National Meeting on New/Safer Molecules and Biocontrol Technologies for Integrated Pest Management in Crops*, February 23, 2015, NBAIR, Bangalore.
6. Joshi N and Arora A (2014) Fungal antagonists for the management of foot rot in Kinnow in International Conference: on "Changing Scenario of pest problems in Agri-horti Ecosystem and their management" held on 27-29th November 2014 at Maharana Partap University of Agriculture and Technology, Udaipur. pp 194.
7. Kaur Kirandeep and Kaur R (2014) Predation Efficacy of *Blaptostethus pallescens* Poppius on Two-Spotted Spider Mite, *Tetranychus urticae* Koch on Brinjal. In: International Conference: on "Changing Scenario of pest problems in Agri-horti Ecosystem and their management" held on 27-29th November 2014 at Maharana Partap University of Agriculture and Technology, Udaipur. pp 50-51.
8. Saini M K and Sangha K.S. (2014) Field efficacy of different insecticides against plant hopper, *Pyrilla purpusila* Walker (Lophopidae: Homoptera) in Sugarcane crop In: National Symposium on "*Agriculture Diversification, for Sustainable Livelihood and Environmental Security" at Punjab Agricultural University, Ludhiana* from November 18–20, 2014

9. K S Sangha & Rajinder Kumar (2015) Management of Early Shoot Borer *Chilo infuscatellus* Snellen in sugarcane with Chlorantraniliprole 18.5% SC. In : Subaharan K, Sivakumar G, Gupta A, Mohan M, Pratheepa M, Gracy G and Verghese A (eds.) Abstracts, National Meeting on new/safe molecules and biocontrol technologies for integrated pest management in crops" at NBAIR Bangalore on February 23, 2015 pp : 9.

TNAU Coimbatore

1. Nikita S. Awasthi and S. Sridharan. 2015 , 'Biology of Pentalonia nigronervosa Coquerel in Banana' Paper Presented in International Conference on Innovative Insect Management Approaches for Sustainable Agro Eco System (IIMASAE) .PP 24-26 January 27-30 2015 Department of Agricultural Entomology, AC&RI, Madurai.
2. Sridharan, S. P.A.Saravanan, P.Karuppuchamy and .Kalyanasundaram.2015. 'Diversity of Mealybugs on major horticultural crops in Western districts of Tamil Nadu' Paper Presented in International Conference on Innovative Insect Management Approaches for Sustainable Agro Eco System (IIMASAE) .PP 47-48January 27-30 2015 Department of Agricultural Entomology, AC&RI, Madurai.
3. Amol Chaudhari and S.Sridharan. 2015 'Survey on relative importance of the pests infesting Mango under ultra high density planting in Tamil Nadu and Andhra pradesh'. Paper Presented in International Conference on Innovative Insect Management Approaches for Sustainable Agro Eco System (IIMASAE) .PP 102-104 January 27-30 2015 Department of Agricultural Entomology, AC&RI, Madurai.
4. Ramakrishnan, N. and S. Sridharan.2015 'Eco-safe biopesticides to manage Psyllids, *Diaphorina citri* Kuwyama in Curry leaf, *Murraya koenigii* (L.) Sprengel'. Paper Presented in International Conference on Innovative Insect Management Approaches for Sustainable Agro Eco System (IIMASAE) .PP *181-182* January 27-30 2015Department of Agricultural Entomology, AC&RI, Madurai.
5. Nikita S. Awasthi, S. Sridharan and P. A. Saravanan. 2015 'Reactions of Banana germplasm to Pseudostem borer damage'. Paper Presented in International Conference on Innovative Insect Management Approaches for Sustainable Agro Eco System (IIMASAE) .PP *296-297*January 27-30 2015 Department of Agricultural Entomology, AC&RI, Madurai.
6. Saravanan, P.A., S.Sridharan, M.Kalyanasundaram and P.Karuppuchamy.2015. **'**Biological control of Brinjal mealybug *Coccidohystrix insolita* Green'. Paper Presented in International Conference on Innovative Insect Management Approaches for Sustainable Agro Eco System (IIMASAE) .PP *346-347*January 27-30 2015 Department of Agricultural Entomology, AC&RI, Madurai.
7. Shanmuga Prema, M and S. Sridharan 2015 'Management of rice leaf folder with a novel Phenyl Pyrrozole pesticide - Fipronil 80 WG' Paper Presented in International Conference on Innovative Insect Management Approaches for Sustainable Agro Eco System (IIMASAE) .PP 461-462 January 27-30 2015 Department of Agricultural Entomology, AC&RI, Madurai.
8. Shanmuga Prema, M and S. Sridharan 2015 'Fipronil 80 WG – A promising Phenyl Pyrozole insecticide to check Thrips damage in Grapes' Paper Presented in International Conference on Innovative Insect Management Approaches for Sustainable Agro Eco System (IIMASAE) .PP *463-464* January 27-30 2015 Department of Agricultural Entomology, AC&RI, Madurai.
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v. Biocontrol Agents Maintained

AAU- Jorhat
i. *Trichogramma japonicum*
ii. *T. chilonis*
iii. *T. mwanzai*
iv. *T. pieridis*
v. *Blaptostethus pallescens*
*vi.Trichogramma sp(*unidentified)recovered from castor
telenomus sp)recovered from tea
vii. 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.

PAU

Activities of Biocontrol Group at PAU Centre

1. Establishment of State of the Art Laboratories (Biocontrol) at Entomological Research Farm, Punjab Agricultural University, Ludhiana.
2. Establishment of Biocontrol museum in State-of-Art Laboratories (Biocontrol) at Entomological Research Farm, Punjab Agricultural University, Ludhiana.
3. Collaboration with two new sugar mills, one co-operative and one private (Gurdaspur and Buttar Sevian, respectively) for technical guidance, provision of nucleus culture and large scale demonstration of bioagents for the management of sugarcane borers.

MPKV-Pune

1. Maintenance of cultures of natural enemies and their mass production

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
Trichogrammatoidea bactrae Nagaraja
Trichogramma brassicae Mot.
Chelonus blackburni Blanchard
Acerophagus papayae Noyes & Schauff

Predators: *Cryptolaemus montrouzieri* Mulsant
Scymnus coccivora Ayyar
Chrysoperla zastrowi sillemi (Esben-Petersen)
Blaptostethus pallescens Poppius
Xylocoris flavipes (Reuter)

Microbial: agents *Nomuraea rileyi*
Metarhizium anisopliae
Beauveria bassiana
Lecacilium 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)	700	45	2,250
2. *Chelonus blackburni*	4,000	-	-
3. *Cryptolaemus montrouzieri*	15,000	1400	2800 Demonstration
4. *Metarhizium anisopliae*	100 kg	-	- Demonstration
5. *Nomuraea rileyi*	150 kg	-	- Demonstration

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, teaching and training to P.G.students, farmers, FCLAs, extension workers etc.

1. *Trichogramma brassicae* (from PDBC)
2. *T. chlionis* (-do-)
3. *T. cacoeciae* (-do-)
4. *T. embryophagum* (-do-)
5. *Blaptostethus pallescens* (-do-)
6. *Coccinella septempunctata* (Local strain)
7. *Coccinella undecimpunctata* (Local strain)
8. *Chrysoperla* sp. (Local strain)
9. *Quadraspidiotus perniciosus* (Local strain)
10. *Corcyra cephalonica* (Local strain)

Almost entire culture of the above mentioned bio agents was lost, being unattended for more than a fortnight because of devastating flood in Kashmir during August' 2014.

vi. Technology Assessed and Transferred

AAU-Johrat

Technology assessed

1. Spray of *Beauveria bassiana*, six releases of *Trichogramma japonicum* @ 1,00,000/ha from 30 days after transplanting, application of botanicals (Neem oil/NSKE) and erection of Bird perches @ 15/ha could effectively reduce the dead heart and WEH caused by *Scirpophaga* spp. and leaves damage by Cpnaphalocrosis sp. and contributing higher yield in BIPM package.
2. *Bt* formulation (delfin) @ 1kg/ha effective against brinjal shoot and fruit borer, *Leucinodes orbonalis*– two sprays.
3. Six releases of *Trichogramma pieridae* @ 1 lakh/ha/week could effectively suppressed cabbage butterfly.
4. Recommended *Acerophagus papaya* for the management of papaya mealybug. Recommended 11 releases of *Trichogramma chilonis* @ 50,000/ha/week against sugarcane plassy borer, *Chilo tumidicostalis*

KAU-Thrissur

Technology transferred

Bio control of papaya mealybug *Paracoccus marginatus* by the parasitoid *Acerophagus papayae*

MPKV-Pune

1. Enrichment of sorghum grain with *Nomuraea rileyi* :

In Maharashtra, the area under soybean crop is around 16,000 ha. which is very difficult to cover large area by using biopesticides *Nomuraea rileyi* for the management of Spodoptera litura and semiloopers. Therefore, 100 g. sorghum grains inoculated with culture of *N. rileyi* mixed with 2 kg cooked sorghum grain after three days sporulation broadcasted the inoculated grains in 0.40 ha area of soybean crop var. JS 9305 at Research Farm Botany Section, A.C. Pune during last week of August when the climatic condition was congenial for sporulation (humidity above 90 % and drizzling rains). *N. rileyi* sporulated on larvae. The MPKV strain of *N. rileyi* showed average 3.23 surviving larval population of *S. litura*

per meter row length 53 % mortality due to fungal infection and gave 19.50 q/ha soybean yield.

The 100 g. sorghum grains inoculated with culture of *N. rileyi* was supplied to the farmers. The farmers cooked 2 kg sorghum grain in cooker at their home and mixed the inoculated culture of *N. rileyi.* On farmers field, there was 50 to 60 percent decrease in the pest population and 15 to 20 % increase in yield.

2. Enrichment of FYM with *Metarhizium anisopliae*:

Mass production of *Metarhizium anisopliae* was carried out on solid media (rice + soybean). About 1 kg of inoculated rice grain with *M. anisopliae* are mixed with well décomposed FYM and after adding little water to moist, covered with plasic for 5 days for enrichment. The enriched FYM with *M. anisopliae* is broadcasted in 0.40 ha area of soybean var. JS 9305 at Research Farm Botany Section, A.C. Pune on 19.9.2014. The larval population of *S. litura* per meter row length was decreased from 5.7 to 3.26 and recorded 41 % mortality due to fugal infection and gave 17.32 q/ha soybean yield. The application of enriched FYM with *M. anisopliae* is a easy method for the management of *Spodoptera litura a*nd semiloopers in soybean crop. This method can cover large area and substitute for spraying the crop during rainy season which is very difficult due to crop canopy.

PJTSAU

Technology Assessed and disseminated:

1. Sequential application of bioagents, Bt-Ha NPV-endo-Bt in pigeon pea against *Helicoverpa.*
2. Bio intensive management of pod borer complex through *Ha* NPV-NSKE alternation in pigeon pea.
3. Release technology of *T.chilonis* @ 1, 50,000/ha/week through distribution @ 200 strips/ha in cotton.
4. BIPM module consisting of alternate methods for management *Helicoverpa* in cotton ecosystem.
5. Effective *Bt* formulations such Biobit & Dipel for managing DBM in cabbage.
6. Combination of *T.pretiosum* @ 50,000/ha-5 times and NPV @250 LE/ha –3 times to manage *Helicovera* in tomato.
7. Application of NPV @ 250 LE/ha in pigeon pea – 4 rounds for *H.armigera*.
8. Dipel @ 0.5 kg/ha effective against castor semi looper.
9. Standardization of host distance for better parasitization by *T.chilonis*-1 meter (Optimum) 4 meter (Maximum).
10. *Bt* @ 1 kg/ha is very effective against *Adisura atkinsoni* on Dolichos bean recording lesser pod damage and good yield .
11. Pigeon pea bordered with two rows of sorghum and intercropped with sunflower (9:1) gave better yields recording lesser population of pests due to higher biological control activity by natural enemy population compared to the sole crop.
12. The Anthocorid bug *Xylocoris flavipes* performed better than *Blaptostethus pallescens* in controlling the moth *Corcyra cephalonica* in stored rice grain. Lesser moths of Corcyra emerged from the bin where the grain was treated with *Xylocoris flavipes.*

vii. Recommendations included in the package of practices:

MPKV, Pune

The following recommendations were approved in Research Review Committee Meeting of MPKV, Rahuri for the year 2014-15 are given below. The recommendations are based on the field trials conducted on various crops as per the Technical Programme of "All India Co-ordinated Research Project on Biological Control of Crop Pests and Weeds, MPKV, College of Agriculture, Pune- Centre" during 2010-11 to 2013-14.

1. Spraying of *Metarhizium anisopliae* 1.15% WP (1 x 10^8 conidia/g) @ 50 g + sunflower oil 10 ml and liquid soap 1 ml /10 litres of water before flowering (December) followed by need based two to four sprays at weekly interval during flowering is recommended for the control of mango hopper.

2. Three sprays of *Metarhizium anisopliae* 1.15% WP (1 x 10^8 conidia/g) @ 50 g + sunflower oil 10 ml + liquid soap 1 ml /10 litre water at 15 days interval after the pest incidence are recommended for the control of thrips on onion in *Rabi* season.

3. Three sprays of *Metarhizium anisopliae* 1.15% WP (1 x 10^8 conidia/g) @ 50 g + sunflower oil 10 ml + liquid soap 1 ml /10 litres of water at fortnightly interval starting from the appearance of the pest incidence are recommended for the control of aphids on safflower.

4. Three sprays of *Bacillus thuringiensis* (NBAII *Bt* strain) @ 20 ml/10 lit of water at 15 days interval starting from initiation of flowering are recommended for the control of legume pod borer, *Maruca testulalis* and pod borer, *Helicoverpa armigera* on pigeon pea.

5. Three sprays of *Sl*NPV 250 LE/ha (10^9 POBs/ ml) @ 10 ml or *Nomuraea rileyi* (10^8 conidia/g) @ 50 g/10 litre water at 15 days interval starting from the appearance of pest are recommended for the control of *Spodoptera litura* on soybean.

5. ACRONYMS

AAU-A	Anand Agricultural University, Anand
AAU-J	Assam Agricultural University, Jorhat
CPCRI	Central Plantation Crops Research Institute, Kayangulam
CTRI	Central Tobacco Research Institute, Hunsur
CAU	Cental Agricultural University, Pasighat
CISH	Central Institute of Sub-Tropical Horticulture
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. Rice Res	Directorate of Rice Research, Hyderabad
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
IIHR	Indian Institute of Horticultural Research, Bangalore
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