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

ANNUAL PROGRESS REPORT 2016-17

Compiled and edited by

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ICAR- National Bureau of Agricultural Insect Resources
Bengaluru 560 024

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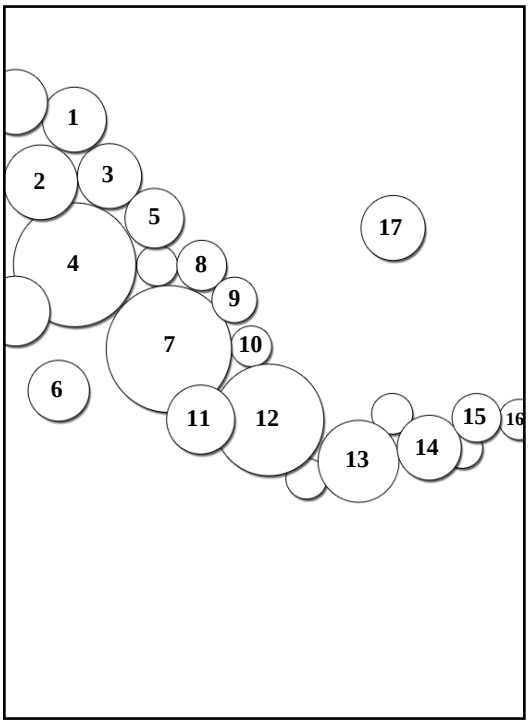

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Photo credits: Photographs 1 & 8 – OUAT; 2, 13 & 16 – AAU; 3 – GBPUAT; 4 – PAU; 5 – SKUAST; 6, 14 &15 – YSPUHF; 7 & 10 – TNAU; 9 – IGKV; 11 – KAU; 12 – DRYSRHU; 17 – Omaprakash Navik

Cover design: Sunil Joshi

Programme for 2016-17

1. Basic Research

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1.1.1 Biodiversity of oophagus parasitoids with special reference to Scelionidae (Hymenoptera).
1.1.2 Biosystematics of trichogrammatidae (Hymenoptera).
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EXPERIMENTAL RESULTS

1. Basic Research

1.1 National Bureau of Agricultural Insect Resources, Bengaluru

1.1.1 Biodiversity of oophagus parasitoids with special reference to Scelionidae (Hymenoptera)

The wasp genus *Oethecoctonus*, which consists of egg parasitoids of tree crickets (Orthoptera: Oecanthidae), was reported for the first time from the Oriental region. A new species *Oethecoctonus suryaseni* sp. n. was described and imaged. *Pardoteleia*, a monotypic genus was reported for the first time from India. A new species *Pardoteleia flava* sp. n. from India was described and imaged. The hitherto unknown male of this genus was also described and imaged for the first time. *Pardoteleia prater*, the type species was redescribed and imaged with intraspecific variations within the Indian specimens. Two new species of *Microthoron*, *viz*., *M. bloomsdalensis* sp. n. and *M. shompen* sp. n. were described. The male of *M. baeoides* Masner and its bizarre antenna were described. Both male and female *M. baeoides* and female *M. miricornis* Masner & Huggert were imaged. *Narendraniola* Rajmohana was treated as a junior synonym of *Microthoron.* The monotypic genus *Nyleta* was reported for the first time from India. A new species of *Nyleta, Nyleta onge* sp. n. was now described and imaged from the remote island of Little Andaman in the Andaman and Nicobar group of Islands in the Indian Ocean. Variants of the same species were also collected from Tamil Nadu. The images of the holotype of *N. striaticeps* were also provided for the first time.

1.1.2 Biosystematics of trichogrammatidae (Hymenoptera)

Insects were collected, processed from Assam, Rajasthan,Karnataka, Kerala and Tamil Nadu. Additional specimens of the new species of Trichogrammatoidea were obtained from Mudigere enabling its description as a new species. Hispidophila and Megaphragma were collected from Assam and are being reported from there for the first time. Periodic surveys for hymenopteran parasitoids were conducted in a ragi field in Karnataka at fortnightly intervals for a whole year. Seven thousand seven hundered eleven parasitoids belonging to 18 families were collected. Scelionidae were numerically the most abundant followed by Mymaridae, Encyrtidae, Ceraphronidae and Trichogrammatidae. Trichogrammatidae were fairly evenly distributed throughout the year with one peak in April. Scelionidae peaked in July while Mymaridae peaked in September. Further analysis, in progress, will reveal the implications of the occurrence of htese parasitoids. Identification services, especially for Trichogramma and Trichogrammatoidea were provided especially for a large consignment of over 600 specimens from Kerala.

1.1.3 Biodiversity of aphids, coccids and their natural enemies

A total of seven surveys were conducted for collection of aphids, coccids and their natural enemies at Udaipur, Yellagiri, Yercaud, Thandikudi and Thaditankudisai, Shimoga and Pune and 17, 21, 18, 12, 13 1nd 16 species of aphids/coccids were collected, respectively, from these places. A total of 527 species were identified by making 911 slides by processing 4484 specimens. A total of 75 identification services provided to different SAUs, ICAR institutes and Private Organisations and through which 105 species were

identified. Three species of mealybugs (*Heliococcus singularis* Avasthi and Shafee, *Dysmicoccus debregeasiae* (Green) and *Planococcus nilgiricus* Williams), one soft scale (*Macoccus watti* (Green)), one aphid (*Greenidea maculata* Noordam) and one eriococcid (*Gossypariella crematogastri* Kozár & Konczné Benedicty) were added as new to existing collection of aphids and coccids at ICAR – NBAIR museum. One aphid, *Schoutedenia emblica* Patel & Kulkarni and three species of mealybugs, *viz*., *Phenacoccus parvus* Morrison, *Phenacoccus madeirensis* Green, *Pseudococcus saccharicola* Takahashi were recorded for the first time from Udaipur, Rajasthan. Similarly, one armoured scale, *Semelaspidus artocarpi* (Green), one aphid *Imaptientinum impatiens* (Shinji) and one melaybug,*Heliococcus summervillei* Brookes were recorded for the first time from South India and two mealybugs and one aphid (*Antonina thaiensis* Takahashi *Exallomochlus hispidus* (Morrison) *Uroleucon pseudoambrosiae* (Olive) were collected for the first time from India. One species of soft scale, *viz*., *Pulvinaria urbicola* was re-described. Twenty two species of parasitoids on 39 species of different coccids were collected and got identified. No new host association or new records could me made this year. Thirteen species of mealybugs, *viz*., *Ferrisia malvastra, Formicoccus mangiferacola, Maconellicoccus hirsutus, Maconellicoccus hirsutus, Nipaecoccus viridis, Paracoccus marginatus, Phenacoccus solani, Phenacoccus solenopsis, Phenacoccus solenopsis, Phenacoccus parvus, Phenacoccus madeirensis, Planococcus citri, Planococcus lilacinus, Pseudococcus longispinus, Rastrococcus iceryoides, Rastrococcus invadens, Rastrococcus mangiferae* were deposited for molecular characterization. An identification guide to field and mounted characters of mealybug was developed. This guide includes 35 species of economically important mealybugs.

1.1.4 Taxonomy, diversity and host-parasitoid association of Ichneumonoidea with special reference to Braconinae, Doryctinae & Microgastrinae

In the studies of the world fauna of Microgastrinae (in total 269 species) a new species of *Cotesia* with similar shape of T1 (narrowing at midlength), together with diagnostic characters to separate it from *C. pistrinariae* from Africa was described. Further the generic placement of those two species, based on molecular and morphological analyses as well as parasitoid biology was ellaborated. To date, only two species of *Cotesia* are known to have a T1 narrowing at midlength. That represents less than 1% of all described species worldwide. In the neighbor-joining tree both species cluster more closely with other species, and in the Bayesian tree they are part of a large unresolved polytomy which provides no support for them being sister species, although it does not preclude that possibility either. However, the molecular data support the monophyly of *Cotesia*, including both *C. pistrinariae* and *C. trabalae*.

A new species, *Crinibracon chromusae* Gupta & van Achterberg parasitic on pupae of *Hasora chromus* (Cramer) (Hesperiidae) on *Millettia pinnata* (L.) Panigrahi (Fabaceae) was described from India and compared with *C. sinicus* (Yang, Chen & Liu, 2008) from China, the only other species known with a similar general appearance. For the first time biological information for the genus *Crinibracon* Quicke, 1988, is given. Three species of hyperparasitoids, *Philolema braconidis* (Ferrière) (Hymenoptera: Eurytomidae), *Nesolynx javanica* Ferrière (Hymenoptera: Eulophidae), and an *Eupelmus* sp. (Hymenoptera: Eupelmidae) emerged along with *C. chromusae* from pupae of *H. chromus*. The generic placement of this new species along with interesting parasitoid biology is discussed.

Crinibracon chromusae

Tanostigma indica

Cotesia trabalae

***Trabala vishnou* parasitized caterpillar**

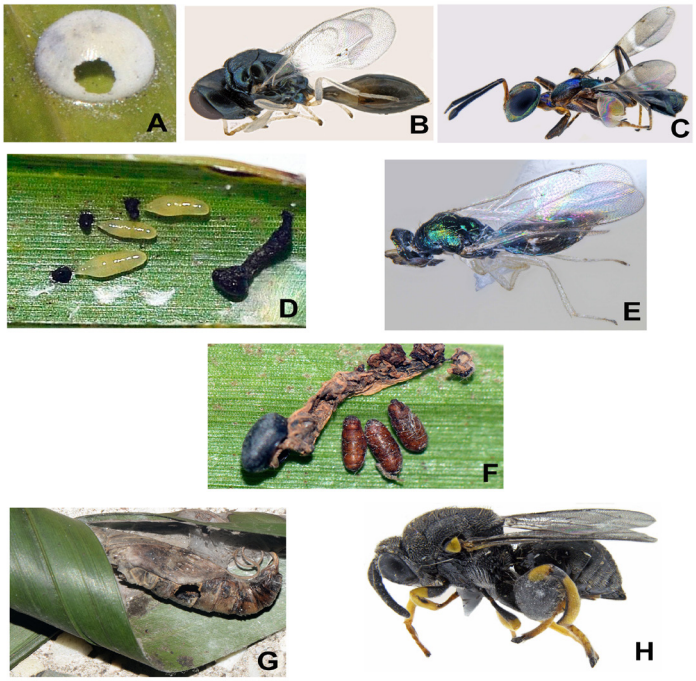


Plate 1. Parasitised life-cycle stages of *Gangara thyrsis* and their parasitoids. A, Parasitised egg; B, Female of *Agiommatus thyrsisae* ; C, Female of *Anastatus ramakrishnai*; D, Parasitised caterpillar with *Sympiesis thyrsisae* cocoons; E, Female of*Sympiesis thyrsisae*; F, Parasitised caterpillar with dipteran puparia; G, Parasitised pupa; H, Female of *Brachymeria lasus*

Recently, *Cotesia dictyoplocae* (Watanabe) (Hymenoptera: Braconidae) was fortuitously reared from *A. assamensis* in Assam, India, on the host plant *Persea bombycina* (King ex Hook. f.) Kosterm. (Lauraceae). This is the first report of *C. dictyoplocae* parasitizing larvae of *A. assamensis* in India. Previously, *C. dictyoplocae* was known from China, Japan, and Korea. *Cotesia dictyoplocae* is a gregarious larval parasitoid, and females lay on an average 30 eggs per host larva.

In rearing of *Gangara thyrsis* (Fabricius) (Lepidoptera: Hesperiidae) from Karnataka and Goa, India, six species of parasitoids were observed. One new species of parasitic wasp is described and illustrated: *Agiommatus thyrsisae* (Hymenoptera: Pteromalidae), a solitary parasitoid reared from the egg of *G. thyrsis* on the natural host plant *Dypsis lutescens* (H. Wendl.) Beentje & Dransf. Three additional species of parasitic wasps were also reared: *Anastatus ramakrishnai* (Mani, 1935) (Hymenoptera: Eupelmidae), a solitary hyperparasitoid of *A. thyrsisae*; *Sympiesis thyrsisae* Gupta, Gawas & Bhambure (Hymenoptera: Eulophidae), a gregarious parasitoid reared from the caterpillar of *G. thyrsis* on the host plant *Cocos nucifera* L., and *Brachymeria lasus* (Walker) reared from pupa of *G. thyrsis* on the host plant *D. lutescens*. Additionally, two species of tachinid flies were also reared from the pupae of *G. thyrsis*: *Exorista sorbillans* (Wiedemann, 1830) and an innominate species close to *Blepharella* spp. *Gangara thyrsis* is a new host record for the genus *Agiommatus* and for *A. ramakrishnai* and *B. lasus*. The mean percent parasitism in *G. thyrsis* eggs was 26.58% with an incubation period of 6-7 days. Amongst the egg parasitoids, 57.14–73.08% were females and 23.08% were males. Hyperparasitism ranged from 3.85 to 42.86%. *Dypsis lutescens*, a member of Arecaceae, is a new host plant record for *G. thyrsis*.

Tanaostigma Howard (Hymenoptera: Tanaostigmatidae) is recorded for the first time in the fauna of the Old World, with *T. indica* Gupta described and illustrated from southern India, reared from *Millettia pinnata* (Fabaceae).

The banana skipper *Erionota torus* Evans has recently emerged as a serious pest of banana. In the present study for the first time egg parasitism of *E. torus* by *Ooencyrtus pallidipes* (Ashmead), a gregarious parasitoid, is reported from India. The natural percent parasitism observed was 80−82% in the banana field located at Komanal, Shivamogga district, Karnataka. Since this parasitoid has served as an effective biological control agent for *E. torus* in Mauritius and Taiwan, possibilities are there that it can establish as a potential biological control agent in India as well.

Rearing data on parasitism of seven butterfly species in six genera belonging to three Lepidoptera families (Hesperiidae, Lycaenidae and Papilionidae) are presented for the first time from Kerala, India. Four species of parasitic wasps along with two possibly unnamed species, collectively from three Hymenoptera families (Braconidae, Chalcididae and Ichneumonidae), were discovered. *Dolichogenidea hasorae* (Wilkinson, 1928) **n. comb**. (Hymenoptera: Braconidae) is reassigned from the traditionally defined genus *Apanteles*. The following host associations are recorded: *Brachymeria lasus* (Walker) (Chalcididae) from pupa of *Hasora chromus* (Cramer) (Hesperiidae); *Casinaria ajanta* Maheshwary & Gupta (Ichneumonidae) from caterpillars of two hesperiid species − *Ampittia dioscorides* (Fabricius) (Hesperiidae) and *Parnara* sp. (Hesperiidae); *Dolichogenidea hasorae* (Wilkinson) **n. comb**. from caterpillar of *Hasora taminatus* (Hübner); *Glyptapanteles aristolochiae* (Wilkinson) from caterpillar of *Troides minos* (Cramer) (Papilionidae); *Apanteles* sp. (Braconidae) from caterpillar of *Telicota bambusae* (Moore) (Hesperiidae); and *Cotesia* sp. from caterpillar of *Udara akasa* (Horsfield) (Lycaenidae). The majority of these records are the first reports except *C. ajanta* from *Parnara* sp. Host range extension and varied host association of parasitoids are discussed based on newly acquired and

previously published data. Brief diagnosis of wasps and illustrations of wasps along with their respective hosts are provided.

Identified *Encarsia guadeloupae* Viggiani for the new invasive rugose spiraling whitefly (RSW) *Aleurodicus rugioperculatus* Martin which was found infesting coconut, banana and several ornamental plants in Tamil, Nadu, Andhra Pradesh and Kerala in India. During the survey, several natural enemies were recorded and maximum parasitism was recorded by *Encarsia guadeloupae* Viggiani. This communication is the first report of the rugose spiraling whitefly, its host plant range and associated natural enemies in India.

1.1.5 Biosystematics and diversity of entomogenous nematodes in India

Samples were collected randomly with a hand shovel. Each soil sample (approximately 500 g) was a composite of 5–7 random sub-samples taken at a depth of 0–15 cm in an area of approximately 25 m2. In total 189 soil samples were collected randomly from vegetables, banana, rubber, sugarcane, and forest land of Karnataka, Tamil Nadu, Kerala, Andhra Pradesh, Goa and Maharashtra. 20 *Steinernema* sp and 11 *Heterorhabidtis* sp were from these places.

First record of *Heterorhabditis pakistanense* (Nematoda: Heterorhabditidae) from India. A total of 11 soil samples were collected from the walnut and apple cultivated lands in Kargil district of Jammu and Kashmir. A soil sample drawn from walnut rhizosphere of Adul Gund of Kargil district and positive sample was anticipated with Heterorahbditis nematode, this nematode was identified as *H. pakistanense* through morphological and molecular characterization and named as Heterorhabditis pakistanense strain NBAIIH05. The genomic DNA of NBAIIH05 was extracted from single first generation hermaphrodite and successfully amplified using Internal Transcribed Spacer (ITS) region of rDNA gene by PCR amplification and then subjected to sequencing. The ITS region of rDNA of isolate *H. pakistanense* NBAIIH05 was successfully amplified and was found to have 816 base pairs. Sequence alignment of ITS region of *H. pakistanense* NBAIIH05 showed maximum identity with *H. pakistanense* Shahina et al. 2016 (99.0%) and formed a highly supported clade. The base sequence (1-795 bp) of this isolate has been deposited in GenBank, NCBI and accession number was obtained GenBank: KX954218.

Influence of soil texture and soil moisture on *Heterorhabditis pakistanense* (Rhabditida: Heterorhabditidae) activity. In this study we investigated the effect of soil texture (Sandy clay loam, Sandy clay and Clay soil) and soil moisture 1-20% (wt/wt) on activity of *H. pakistanense* infective juveniles (IJs). The horizontal soil column assay results revealed that, in sandy clay loam soil IJs migrated at a distance of 25cm in 5days and caused 100% mortality to *Galleria mellonella* larvae whereas, in sandy clay and clay soil mortality was 10% and 70%, respectively. At 45cm, *H. pakistanense* NBAII05 caused 60% mortality in only sand clay soil. In vertical soil column assay *H. pakistanense* NBAII05 caused 100% mortality in 45cm at 5days of after inoculation in sandy clay loam soil, but at 45cm we could not find mortality in sandy loam and clay soil. The effect of soil moisture on *H. pakistanense* NBAIIH05 infectivity indicated that, except 1% moisture in rest, 100% larval mortality was recorded. IJs penetration to *G. mellonella* larvae varied significantly with different soil types, depth and soil moisture. Based on this study we conclude that soil texture and moisture should be considered critical factor while using *H. pakistanense* NBAIIH05 in biological control programme.

The efficacy of two species of entomopathogenic nematodes (EPN), *Steinernema abbasi* and *Heterorhabditis indica*, against *H. consanguinea* was tested under laboratory and field conditions. In a laboratory assay, *H. indica* caused significantly greater mortality (25-100%) than *S. abbasi* (20-80%) against second instars and *H. indica* caused 17.5-82.5%

mortality in third-instar grub larvae, while *S. abbasi* caused (10-60%) mortality. These results revealed that second-instar grubs were more susceptible than third-instar grubs and efficacy of EPN against *H. consanguinea* varies with nematode species. The penetration and multiplication rate for *H. indica* was significantly higher than those of *S. abbasi*. Infective juveniles (IJ) of both nematode species and a commonly used insecticide (phorate) were tested against this insect in a field experiment. Field trail data showed that the percentage reduction in *H. consanguinea* grub population was significantly higher using *H. indica* at a dose of 2.5×10^9 IJ ha^{-1} than *S. abbasi* and phorate application. Phorate application was more efficient in reducing the grub population than both nematode species at the lower application rate (1.25×10^9 IJ ha^{-1}). Overall, these experiments suggest that *H. indica* may be a promising biocontrol agent against *H. consanguinea*.

1.1.6 Monitoring of invasive pests

In Karnataka, infestation papaya mealybug on 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. No sericulture farmer requested for parasitoids in the entire year showing the complete suppression of papaya mealybug in mulberry. Incidence of papaya mealybug was very low in almost all the locations surveyed in Karnataka. Damages in the score of 1 (1- 5 Scale) and below only were observed very sporadically in homesteads. Survey in about 65 orchards of papaya in Nelamangala, Devanahalli, Kunigal, Mandya, Bangalore, Kollegal, Maddur, Kanakapura, Mysore, Chamarajanagar, Kolar, Tumkur road, and Hassan revealed not a single tree with papaya mealybug. In the homesteds >85 % parasitization by *Acerophagus papayae* and also 15-25 per cent by *Pseudleptomastix mexicana* was found in all the places where ever papaya mealybug was observed. On request 18 shipments of Acerophagus papayae was received this year by papaya growers out of fear only and no orchard recorded severe incidence of papaya mealybug.

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*. Parasitism 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.

Erythrina Gall wasp *Quadrastichus erythrinae* was found in very low populations in Kolar, Mandya, and Ramnagar districts. *Aprostocetus gala* was found to be the major parasitoid of *Q. erythrinae*. 15-35% parasitization observed in field. It was clearly established that *Aprostocetus gala* was always found associated with *Q.erithrinae*.

Anagyrus amnestos was collected from parasitized nymph and adult Madeira mealybugs of both male(Nymphs) and female which collected from *Abutilon* plants during the survey.

Aleurocanthes bangalorensis was observed to be severe on jamun trees in and around Bangalore. The species identity was confirmed by Dr. Sundarraj of IWST. Two encyrtids and one eulophid parasitoid collected has been handed over for identification. *Acletoxenus indicus* Malloch a dipteran maggot was found feeding on the whitefly. Two encyrtids and one eulophid parasitoid collected has been handed over for identification.

Plate 2. *Aleurocanthes bangalorensis Eggs, Nymph and Acletoxenus indicus* larval to adult stages

At Gujarat, surveillance for alien invasive pests was carried out to record some of likely invasives such as *Brontispa longissima*, *Aleurodicus dugesii*, *Phenacoccus manihoti*, *Phenacoccus madeirensis*, alien invasive pests of fruits and vegetables in the market yards and *Tuta absoluta*. Periodic surveys revealed that none of the invasive pest listed above was recorded except *Tuta absoluta.*

At Himachal Pradesh, different vegetable and fruit ecosystems at Solan, Kandaghat, Nainatikkar, Deothi, Subathu, Sarahan, Una, Bilaspur,Ghumarwinn Rekongpeo, Ribba, Akpa, Moorang, Tabo, were surveyed for the collection of pests like*, Aleyrodicus digessi, Phenacoccus manihoti, Paracoccus marginatus*, *Phenacoccus madeirensis*and *Tuta absoluta* but only *Tuta absoluta* was recorded at Nauni, Dharja, Solan, Kandaghat, Nainatikkar, Deothi, Subathu, and Sarahan locations of the state. Under open conditions the leaf miner was recorded infesting tomato and potato, whereas, in a polyhouse the pest was found to infest tomato, brinjal and potato.

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

A field trial was conducted to evaluate the promising endophytic isolates of *Beauveria bassiana* (ICAR-NBAIR-Bb-5a, 23 and 45) through foliar applications of oil formulations against stem borer, *Chilo partellus* in maize (Var. Nithyashree) and sorghum (var. Maldandi M-35) at ICAR-NBAIR, Yelahanka Research Farm, Bengaluru, during kharif and rabi seasons of 2016-17. Two foliar sprays of the oil formulation of each isolate of *B. bassiana* ($1x0^8$ conidia/ml) were applied at 15 and 30 days after germination. Ten second instar larvae of *C. partellus* per plant were released in to the inner leaf whorl of the *B. bassiana* treated and untreated maize plants after 5 days of second spray. In maize field experiment, Bb-5a isolate showed significantly lower dead hearts (2.7 and 2.53 in kharif

and rabi, respectively), lowest no. of exit holes (3.38 and 2.05 /plant in kharif and rabi), lesser no. of galleries (1.98 and 1.40 /plant in kharif and rabi) and lower stem tunneling (6.73 and 3.38 cm/plant in kharif and rabi), as compared to untreated control which showed higher number of dead hearts (5.83 and 7.13), exit holes (6.78 and 6.65 /plant), galleries (3.05 and 3.40 no./plant) and stem tunneling (10.83 and 7.03 cm/plant) during kharif and rabi season respectively. Significantly higher cob yield was obtained in the plots treated with Bb-5a (11.8 and 13.0kg/10plants in kharif and rabi) compared to the lower yield of control plot (10.0 and 9.0 kg/10plants in kharif and rabi). In sorghum field trial, Bb-23 and Bb-5a isolates showed significantly lesser dead hearts of 6.78 and 9.33 % respectively, lowest exit holes of (0.38 and 0.73/plant) and stem tunneling (3.75 and 4.32 cm/plant) respectively as compared to untreated control, which recorded higher dead hearts of 19.78 %, exit holes 2.10/plant and stem tunneling of 10.18 cm/plant. The grain yield obtained in Bb-5a treated plot (151gm/10plants) and Bb-23 treated plot (147gm/10plants) were significantly higher compare to untreated control (105gm/10plants).

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

Analysis of cry gene diversity was determined for the three North-eastern states like Meghalaya, Tripura and Assam. Cry16 was most abundant accounting for 43% of the samples and it is dipteran specific. Cry10A accounted for 30% of the samples. Cry1 and cry2 was abundant and was present in 40% of the samples cry1 and cry2 occurred together. Cry1 is lepidopteran specific whereas cry2 is dipteran specific. Other cry genes included cry4 (dipteran) and cry12 (nematicidal) and were present in 23% of the samples. Cry3 the coleopteran toxin occurred in 16% of the samples. Since many of the cry genes occurred together the percentage calculation varied.

NBAIR-BtAN4 a new indigenous organism for control of both lepidopteran and coleopteran pests was identified. It expresses cry1, cry2, cry8 and vip3a toxins. Transcriptome analysis done to understand the range of toxins expressed by this organism.NBAIR-BtAN4 was initially identified as toxic to coleopteran pests since it carried the cry8 gene. However it was also found that it also carried cry1 and cry2 genes which are lepidopteran specific. The isolate was found toxic to the coleopteran pests like *Oryctes rhinoceros, Papillio* sp., *Callosobrochuschinensis*and *Sitophilus oryzae*. NBAIR-BtAN4 showed very high toxicity against *Callosobrochus chinensis* and was better than the standard exhibiting an LC_{50} of 6.8 µg/ml. Against *Sitophilus oryzae* same was gave least LC_{50} value (89.65 µg/ml) compared to the standard (85.26 µg/ml) and was the most toxic among the indigenous isolates tested.

NBAIR-BtAN4 was also tested against the important lepidopteran pests like *Helicoverpa armigera* and *Plutella xylostella*. It was found to be toxic to both and the LC_{50} was determined as 414.59 ng/ml for *H. armigera* and 545.15 ng/ml for *P.xylostella*. Liquid formulation of NBAIR-BtAN4 was prepared and sent to Dr. Chandrika Mohan, Principal Scientist, CPCRI, Kayangulam for evaluation against red palm weevil and *O. rhinoceros*.

1.1.9 Studies on insect viruses

Nucleo polyhedrosis viruses (NPVs) have been isolated from Bihar hairy caterpillar Spilosoma obliqua, semi looper Achaea janata, armyworms Spodoptera mauritia, Spodoptera litura and borer Helocverpa armigera. Under light microscopy, occlusion bodies of SlNPV, HaNPV, AjNPV and SpobNPV were appeared as irregular. Under Scanning Electron Micrscopy (SEM), occlusion bodies appeared as tetrahedral, rod, oval, and irregular in shape. SEM studies revealed that the polyhedral particles of size approximately

0.6-2.0 µm. Some OBS were having pits and protrusions. The LC_{50} values observed for second instar larvae were 2.5×10^4 OBs/ml for HaNPV, $3.5x10^4$ OBs/ml for SlNPV , 3.6×10^4 OBs/ml for AjNPV and 3.6×10^4 .OBs/ml for SpobNPV. The efficacy of SpobNPV was demonstrated on potato Bihar hairy caterpillar.

1.1.10 DNA barcoding and genomics studies on natural enemies

Forty parasitoids, predators and insect pests had been characterised using cytochrome oxidase I gene and ITS-2 region and GenBank accession numbers and DNA barcodes had been generated for the same. New invasive spiraling whitefly *Aleurodicus rugioperculatus* and its parasitoid *Encarsia guadeloupae* was characterized using CO1 and ITS-2 and barcode generated. Transcriptome analysis of DBM and validation of expression of insecticide resistant genes had been done using RT-PCR, Transcriptome sequencing of *Trichogramma chilonis* and *Chrysoperla zastrowi sillemi* had been done.

1.1.11 Diversity and predator-prey interactions in predatory mirids & geocorids

Surveys for mirids and geocorids were made from different places of Karnataka. There were more than 100 specimens were collected. Two species of predatory mirid, *Termatophylum* spp. from mango leaf web were collected from Kanakpura. Other mirid species collected is *Chimairacoris* sp. from *Ficus* from Bangalore. Among Geocorids, one species identified was *G.* sp. near to *jucundus*.

A protocol to rear *Geocoris ochropterus* was standardized. *G. ochropterus* was reared on beans and *Sitotroga cerealella* eggs. One oviposition container (500 ml) can accommodate 6 pairs. A female on an average lays 176 eggs with 68% hatchability. So from one container 714 newly emerged nymphs can be harvested. They can be multiplied in same container till 3rd instar. After that they can be separated to other containers as more space is required with growing size. Approximately 83% nymphs develop into adults. So from one container with 6 pairs nearly 593 adults can be harvested in 32-35 days. It was found that *S. cerealella* eggs can be effectively utilized for continuous rearing of *G. ochropterus*.

Functional response of *Geocoris ochropterus* was studied against different densities of *Helicoverpa* eggs and it was found that it almost follow type II functional response model i.e. the rate of *Helicoverpa* eggs consumption by *G. ochropterus* rises as egg density increases, but eventually levels off at a plateau at which the rate of consumption remains constant regardless of increases in egg density. Attack rate and handing time has to calculate.

Feeding potential of *G. ochropterus* on *S. cerealella* eggs was studied. The total number of eggs fed was about 586 during the nymphal period. Total feeding by one female was 3372 eggs and feeding per day was 51.25 eggs. Adult male fed upon 2306.5 eggs and mean feeding per day was 50 eggs.

Biology of the geocorid predator, *G. superbus* was studied under laboratory conditions using UV irradiated eggs of alternate host, *S. cerealella*. The mean incubation period was ten days. A total of five nymphal instars were recorded and the total developmental period was 41.2 days with a nymphal period of 31.2 days. Longevity of adult male and female was 24.8 and 30.0 days, respectively. Mean fecundity per female was 29.4 eggs.

Geocoris ochropterus fertility table was studied in laboratory on *Sitotroga cerealella* eggs. The net reproductive rate was 28.60, The approximate duration of a generation, Net generation time of the predator when reared on *S. cerealella* were 51.9 and 56.77,

respectively, finite rate of increase, Hypothetical F2s and Weekly multiplication rate were 1.06, 817.96 and 1.50, respectively when reared on *S. Cerealella.*

Laboratory studies were conducted to check the feeding preference of geocorid predator, *Geocoris ochropterus* for unparasitized eggs of *Corcyra cephalonica* (Stainton) and *Helicoverpa armigera* (Hubner) and those parasitized by *Trichogramma chilonis* Ishii. In a no-choice situation, *G. ochropterus* nymph and adult devoured 64 and 91 per cent of the unparasitized *Helicoverpa* eggs provided and both nymph and adult fed only 3.3 and 1.3 percent, parasitized eggs respectively. Given a choice of parasitized and unparasitized *H. armigera* eggs, nymphs and adults of this species preferred to feed on unparasitised eggs. Same result obtained with *Corcyra cephalonica.* It indicates that it may be possible to integrate releases of geocorids and trichogrammatids for biololgical control of lepidopteran pests in different crop ecosystems.

1.2 Biodiversity of biocontrol agents from various agro-ecological zones

1.2.1 Indian Institute of Rice Research, Hyderabad

1.2.1.1 Survey and collection of natural enemies of rice pests

Survey and collection of natural enemies of rice was done at Navsari, Danti, Vyara, Nawagam and Derol (Gujarat), Kota (Rajasthan), Pattambi (Kerala) and Indian Institute of Rice Research, Hyderabad. The biodiversity of Odonata was quite high in the fields of Navsari and Nawagam of Gujarat and Kerala. Some of the dragonfly species observed was *Brachythemis contaminata*, *Crocothemis servilia*, *Tramea basilaris, Trithemis aurora, Orthetrum sabina, Diplacodes trivialis, Pantala flavescens, Neurothemis tulli, N fulvia, Trithemis pallidinervis, Neurothemis intermedia.* The damselflies observed were *Agriocnemis pygmaea Pseudagrion microcephalum, Ceriagrion cerinorubellum, C rubiae, C coromandelianum, Ischnura aurora, Copera sp., Aciagrion sp.* and the open wing *Lestes sp.* The diversity was highest in Pattambi, Kerala. The nymphs and adults of the spiny soldier bug *Andrallus spinidens* was found in plenty in the upland rice fields of Derol, Gujarat. Grasshoppers, *Heiroglyphus banyan* and *Oxya* sp., were also more prevalent in this area.

In addition, under the IIRR coordinated trial on monitoring of pest species and their natural enemies, data on stem borer species composition and its egg parasitoids were collected from 20 centres. The stem borer species composition and the egg parasitoids observed were reported from 9 centres. Four species of stem borer were observed *viz*., yellow stemborer (YSB), *Scirpophaga incertulas*, pink stemborer (PSB), *Sesamia inferens* and White stem borer (*WSB) Scirpophaga fusciflua* and the dark headed borer *Chilo polychrysus*.

1.2.1.2 Stem borer species composition

During *Kharif* 2016, YSB was observed as the dominant species in eight locations *viz*., Karaikal, Karjat, Navsari, Nawagam, Ragolu, Rajendranagar, Ranchi and Raipur accounting for 58.13 -100 per cent of the stem borer population, followed by PSB was observed as a second species accounting for 5.32 – 18.82 per cent in Ragolu, Raipur and Rajendranagar and Navsari. The white stem borer was reported from Ranchi and Malan. The Mean egg mass parasitization ranged from 53.2-92.5% by *Trichogramma* species. During Rabi 2016, the stem borer species composition was reported from Coimbatore, Chinsurah, Moncompu and Pattambi. At Coimbatore two species YSB and PSB were observed over four observations. YSB was the only species observed on three dates while pink stem borer occurred up to 36.89 % during the reproductive phase of the crop. At

Moncompu and Pattambi three species were observed – YSB, WSB and PSB. At Moncompu YSB dominated in all phases of crop growth ranging from 60.0-90.0%, followed by WSB (13.33%) and PSB (8.10%). At Pattambi, YSB dominated in the vegetative phase of crop growth, ranging from 55.17 - 55.09 %, while PSB was more abundant in the reproductive phase accounting for 83.50%. The average relative composition across all stages was YSB (41.97%), followed by WSB (30.20%) and PSB (27.83%). YSB was the only species observed at Chinsurah in the Boro rice season.

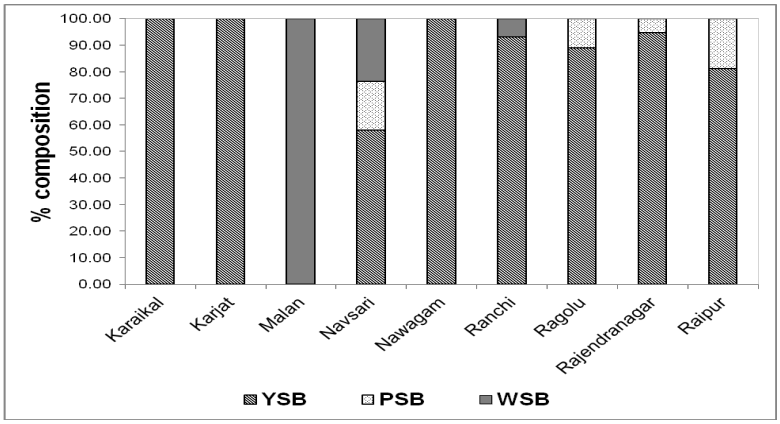


Fig. 1. Stem borer species composition at various centres, MPNE, *kharif* 2016

Egg parasitoids of stem borer

Seven centres reported on the egg parasitoids of stem borer species. The egg mass parasitisation ranged from 14.58-90.00% while the egg parasitisation varied from 11.69 to 44.14 % at various locations (Fig.1). The mean egg mass parasitisation was 44.04 and mean egg parasitisation 31.82 across all locations. The mean egg mass parasitisation was highest at Rajendranagar (90.00%) while the lowest was observed at Nawagam (14.58%). The egg parasitisation was the lowest at Raipur (11.69%) and highest at Rajendranagar (44.14%) followed by Nawagam (43.86%). Three species of parasitoids were recorded across locations and all three species were observed in three locations (Fig. 2). *Trichogramma* species was observed at Pusa and Ranchi, Only *Tetrastichus* sp. was observed at Nawagam. *Trichogramma* sp. was dominant at four locations accounting for 42.49-100 per cent of the parasitoid population on stemborer egg masses. *Telenomus* sp. was the dominant parasitoid at only one location – Raipur accounting for 48.56%. The average composition of the three parasitoids across locations was *Tetrastichus* (36.47%), *Telenomus* (23.41%) and *Trichogramma* (52.08%).

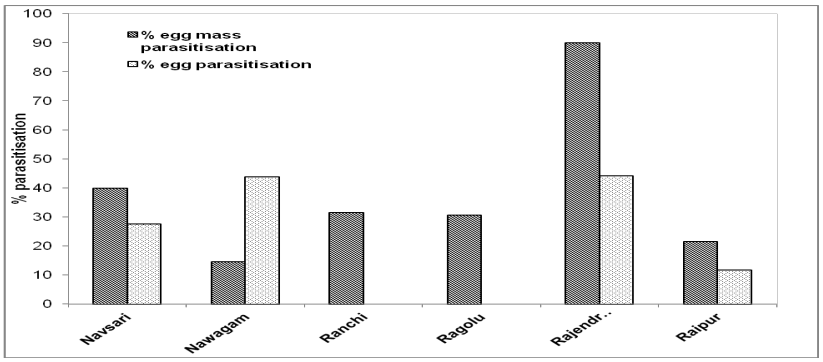


Fig. 2 .Parasitisation of stem borer eggs at various centres, *kharif* 2016

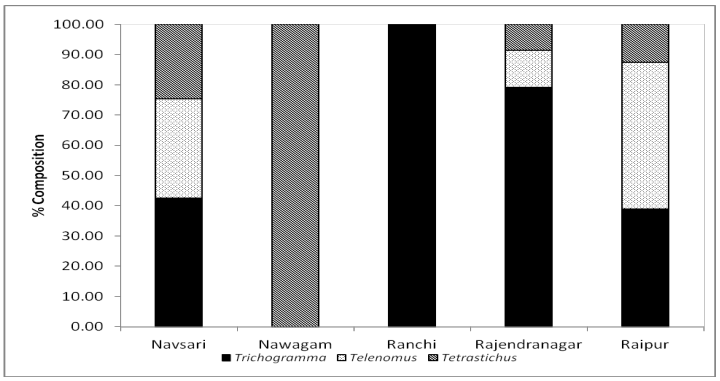


Fig. 3. Relative composition of stem borer parasitoids at different locations, *kharif* 2016

At Coimbatore, Chinsurah, Moncompu and Pattambi during *rabi* season, the egg mass parasitization ranged from 25 - 54.17%, 48-76 %, 19.675% and 8.33-36.00% over the crop period with a mean egg mass parasitsation of 39.58%, 60.78%, 8.01% and 11.08%. For Coimbatore and Chinsurah, egg parasitisation per cent was 34.66 and 34.5. In all the four locations, *Trichogramma japonicum* was dominant followed by *Telenomus* spp. and *T. schoenobii.*

Hoppers

Six centres, *viz*., Karaikal, Maruteru, Navsari, Nawagam, New Delhi and Pusa reported on the status of hoppers and their natural enemies. Four centres *viz*., Maruteru, Navsari, Nawagam and New Delhi reported on presence of population of both BPH and WBPH populations. The highest population of planthoppers was observed at New Delhi (14.01/ hill). At Maruteru a mixed population of BPH (5.39/hill) and WBPH (0.36/hill) occurred while at Nawagam the WBPH population (2.24/hill) was more than that of BPH (1.1/hill). During *rabi* 2015-16 at Coimbatore BPH, WBPH and GLH were observed in low levels at an average of 1.7, 3.0 and 14.75 per 10 hills. The predators observed were green mirids (5.85/10hills) and spiders (6.9/10hills). At Maruteru, BPH and WBPH were observed with a mean of 24.42 and 2.69 per hill, respectively and reached upto a maximum of 500 per hill in April. The predators observed were green mirids (28.68/10hills) and spiders (6.12/10hills). Drynid parasites were also recorded at 5.55 per ten hills. The data shows that the predator and parasitoid population did not increase as much as the pest population.

Natural enemies

In general, observations on hopper natural enemies were reported from six locations. The egg parasitoids of hoppers were recorded at Navasari and Nawagam. At *Navsari* the total egg parasitisation was 10.38 %, with *Anagrus, Oligosita and Gonatocerus* accounting for 45, 25 and 30 per cent respectively. 12.47 per cent of hopper eggs were found parasitized at Nawagam and *Anagrus* was the only parasitoid observed.

Malan centre reported parasitisation ranged from 36-100 per cent by *Chrysonotomyia* sp. (Eulopidae: Hymenoptera) on hispa, *Dicladispa armigera* grubs and pupa under field conditions.

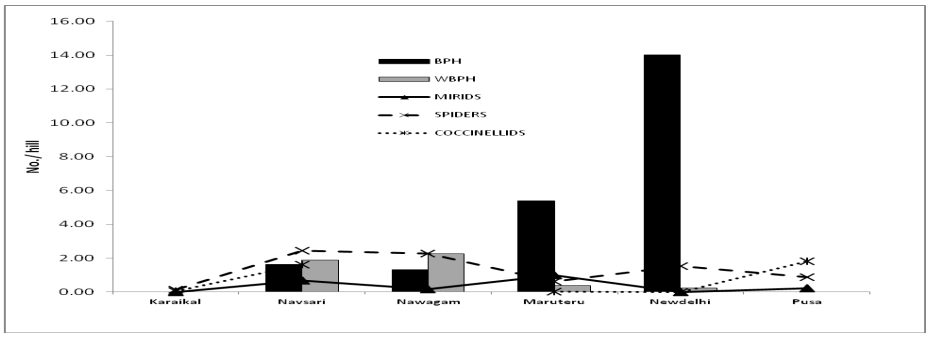


Fig. 4. Planthopper population and their predators across locations, *kharif* 2016

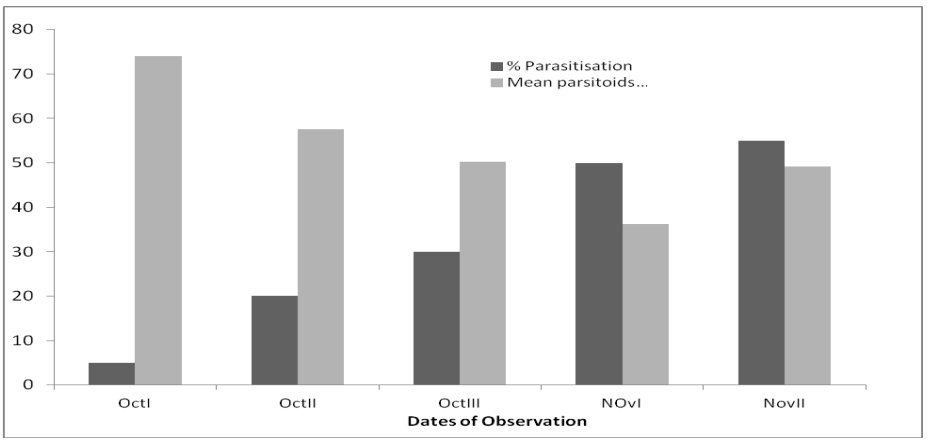


Fig. 5 . Gall midge parasitisation at Chiplima, *kharif* 2016

Gall midge parasitisation by *Platygaster oryzae* was observed at Chiplima and Moncompu, with 84.55 % parasitisation was recorded at Moncompu during *rabi*.

1.2.2 Biodiversity of biocontrol agents from various agro ecological zones (AAU, Anand; ANGRAU, Anakapalle; CISH, Lucknow; IGKV, Raipur; IIHR, Bangalore; IIVR, Varanasi; MPKV, Pune; OUAT, Bhubaneswar; PJTSAU, Hyderabad; SKUAST, Srinagar; TNAU, Coimbatore; UAS, Raichur; YSPUHF, Solan)

1.2.2.1 AAU, Anand

The activity of biocontrol agents were monitored during *kharif* and *rabi* seasons in different crops, with a view to know the activity of egg-parasitoid, *i.e., Trichogramma* species, sentinel cards with eggs of *Corcyra cephalonica* were placed in various crops, *i.e*., tomato, groundnut, maize, cotton, castor, okra and observed for egg parasitism. Besides, the diversity of *Chrysoperla*, coccinellids, spiders, antagonistic bacteria-*Bt*, entomopathogenic nematodes (EPN) was studied.

The egg parasitoid, *Trichogramma* sp. was collected from tomato, castor, groundnut, cotton, maize and okra, of which it was more frequently recorded from cotton, okra and tomato crops on sentinel cards. The parasitism ranged from 0.0 to 3.0%.

Green lacewing *Chrysoperla zastrowi sillemi* was found throughout the year and cotton was most preferred crop on which it was most frequently recorded. Diversity of coccinellids from various crop ecosystem of the region was also studied. The natural population of *C. montrouzieri* was observed. Total 23 spider specimens were collected from cotton

ecosystem and preserved as per the standard methodology. Regular surveys were carried out for anthocorid predators on thrips and mites infested plants. No predators were recorded.

Soil samples were collected from different geographical locations (Panchmahal and Dahod Districts) and *Bacillus thuringiensis* isolates were isolated paddy, pearl millet, sorghum, cotton, pigeon pea and maize crops.

The soil samples collected for the isolation of *B. thuringiensis* were screened for the entomopathogenic nematodes (EPNs) using *Corcyra* larvae as host. Only two soil samples were found positive for the presence of EPNs.

1.2.2.2 ANGRAU, Anakapalle

In sugarcane ecosystem, *Chilo infuscatellus* as early shoot borer and two species of internode borer, i.e., *Chilo infuscatellus* and *Chilo sacchariphagus indicus* were observed. Natural parasitization of *Trichogramma* by using sentenal cards showed variation in sugarcane, maize and rice ecosystems. The maximum parasitization was recorded during last week of July, 2016 (10.8%); August, 2016 (18.6%) and in Munagapaka village (6.1%). In paddy, parasitism of 5.23% was recorded, while in *rabi* maize (1.15%) parasitism ws recorded. Abundance of Coccinellid predators and spiders observed high in *rabi* maize crop.

Other natural enemies recorded in sugarcane crop were *Euborellia annulipes, Pharascymnus horni*, *Chilochorus nigritis*, *Chrysoperla z. sillemi*, *Microspis discolor* and spiders. On paddy natural enemies recorded were *Tetrastichus* spp*., Telenomous* spp. and few spiders.

1.2.2.3 CISH, Lucknow

Population of coccinellid predators were recorded which feeds on mango hopper and mealybugs during 11^{th} to 17^{th} SMW, and the highest number of beetles (2.5/panicle) recorded at 13^{th} SMW. The most abundant species was *Coccinella septempunctata.* Reduviid predator was observed in mango orchard during 39^{th} SMW, eggmass & neonates also found during 40^{th}- 43^{rd} SMW.

1.2.2.4 IGKV, Raipur

Sentinel cards were placed in various ago-ecosystems of Chhattisgarh plain areas to collect the *Trichogramma* species. Collected specimens were sent to NBAIR for identification. Different parasitoids like *Goniozus* sp. from sapota, *Elasmus* sp. from rice fields and Bracon spp. from cabbage crop were collected. The bio-diversity of mealy bugs associated with a wide range of vegetables, fruits, pulses, ornamentals and weeds. The mealybugs identified were *Phenacoccus solenopsis* (from different vegetable crops), *Rastrococcus iceryoides*, *Nipaecoccus viridis*, *Paracoccus marginatus* and *Ferrisia virgata* (from cotton, fruit crops, ornamentals, medicinal and legume crops) and *Phenacoccus solenopsis* (from weeds).

1.2.4.5 IIHR, Bangalore

In annona, continuously monitoring for predators and parasitoids of mealybugs showed presence of three major predators. The predominant predator was predatory gall midge *Triommata coccidivora,* followed by lycaenid butterfly *Saplgis epius* and lady bird beetle *Cryptolaemus montrouzieri*. In a fixed plot surveys for predators and parasitoids were carried out at IIHR, Bengaluru, during 2016-17, a predatory gall midges, *Tirommata*

coccidivora was identified as one of the potential predators of mealybugs. These gall midges predate on all mealybug species, *viz.*, *Maconellicoccus hirsutus, Ferrisia virgata, Rastrococcus iceryoides, and Planococcus citri*. Other natural enemies complex associated were *Anagyrus* sp., *Aneasius advena*, *Spalgis epius*, *Cryptoleamus montrouzieri* and *Acerophagous papaya*e.

1.2.4.6 IIVR, Varanasi

Extensive surveys were conducted in and around Varanasi revealed the occurrence of two mealybug species, *viz*., *Phenacoccus solenopsis* and *Centrococcus insolitus* infesting major vegetables during April, 2016 to March, 2017. One prominent nymphal, endoparasitoid, *viz., Aenasius arizonensis* of *Phenacoccus solenopsis* was recorded. Tritrophic interaction (Host plant – *P. solenopsis* – parasitoids) was observed during the recovery of the parasitoids from different hosts. Highest cumulative recovery was obtained from tomato (27.6%) followed by okra (19.3%) whereas lowest recovery (7.8%) was in case of brinjal.

1.2.4.7 KAU, Thrissur

Surveys for natural enemies of banana pseudostem weevil and banana aphid were conducted in four districts, namely, Thrissur, Ernakulam, Calicut and Wayanad districts. Three different species of earwigs were collected from banana plants infested by pseudostem weevils at Kannara and Vellanikkara. They were identified as *Auchenemus hinksi*, *Paralabis dohrini* and *Euborellia shabi* by comparing with identified specimens available at the centre. Survey for the natural enemies of pepper root mealy bug *Formicoccus polysperes* was conducted at both Ambalavayal in Wayanad District as well as Ramanattukara in Calicut District. No natural enemies could be collected from either location.

1.2.4.8 MPKV, Pune

The natural enemies fauna consisted of coccinellids (*Coccinella septempunctata*, *Menochilus sexmaculata*, *Scymnus* sp.), *Dipha aphidivora*, *Micromus igorotus* and syrphid *Eupeodes confrater* and parasitoid *Encarsia flavoscuttellum* were recorded on SWA in sugarcane, *Coccinella transversalis* F., *Menochilus sexmaculata* F*., Brumoides suturalis* (F.), *Scymnus coccivora, Triomata coccidivora* and *B. suturalis* in mealybug colonies on custard apple, *Acerophagus papayae*, *Mallada boninensis* and *Spalgis epius* on papaya mealybugs. The natural parasitism of *Trichogramma* was not recorded in the crops like cotton, maize, soybean, sugarcane, tomato and brinjal in Pune region. The chrysopid, *Chrysoperla zastrowi sillemi* was observed in cotton, maize, bean, jawar, okra and brinjal and *Mallada boninensis* on cotton, beans, mango, papaya and hibiscus. *Cryptolaemus* adults were recovered from custard apple and papaya orchards and hibiscus on mealybugs. The cadavers of *S. litura* and *H. armigera* infected with *Nomuraea rileyi, Metarhizium anisopliae, Sl*NPV, *Ha*NPV were collected from soybean, jawar, maize, cabbage, pigeon pea and tomato crops in farmers' fields. The papaya mealybug, *Paracoccus marginatus* observed in papaya orchards along with encyrtid parasitoid, *A. papayae* and *S. epius* in Dhule and Pune region.

1.2.4.9 OUAT, Bhubaneswar

Survey was made in the agro ecosystem in and around Bhubaneswar during *kharif* and *rabi* 2016-17 for the host range and bio control agents of *Phenacoccus solenopsis*. The natural enemies recorded were spiders, *Aenasius bambawalei*, *Chelomones sexmaculatus* and *Cryptolaemus montrouzieri*.

1.2.4.10 PJTSAU, Hyderabad

Regular collections were made from important crops of Telangana state to know the natural occurrence of the parasitoids and predators in different crop ecosystems. The crops from where collections were made included rice, maize, cotton, castor, pigeon pea, sunflower, cabbage, chilli, bitter gourd and brinjal. The results of the pooled data in *Kharif* & *Rabi*, 2016-17, revealed that *Trichogramma* parasitization ranged from Nil in chilli to a maximum of 9.3 per cent in rice. Rice crop recorded maximum of 9.3 per cent while in maize it was 5.7 percent and in cabbage it was as low as 0.8 per cent. The abundance studies pertaining to *Chrysoperla* suggested that *Kharif* recorded more predatory presence than in *Rabi*. In *Kharif,* Bitter gourd recorded maximum population (12.0) and minimum was recorded in Red gram (2.0). *Chrysoperla* population in *Rabi* was maximum (9.0) in brinjal while it was least (5.0) in bitter gourd.

1.2.4.11 SKUAST, Srinagar

A total of twenty three species of parasitoids and predators belonging to the orders Hymenoptera and Coleoptera were collected from different fruit crops in Kashmir during 2016-17. Two coccinellid predators, *viz*., *Aiolocaria hexaspilota*, *Serangium* sp. (?) and three pteromalid parasitoids, *viz*., *Cheiropachus* sp., *Macromesus* sp. and *Raphitelus* sp. were reported first time. Among parasitoids, *Aphelinus mali* and *Encarsia perniciosi* on an average parasitized uo to 23.0 and 16.0% woolly apple aphids and San Jose scale, respectively. Hyper parasitism by *Marietta* sp. and *Azotus* sp. was noticed during July-August, which displayed an upward swing during September 2016. Parasitism by *Cheiropachus* sp*., Macromesus* sp. and *Raphitelus* sp. in xylophagus grubs infesting almonds was observed from September to December 2016.

1.2.3.12 TNAU, Coimbatore

In coconut, the occurrence of rugose whitefly *Aleurodicus rugioperculatus* was observed from second week of August 2016 in Anamalai and Pollachi block of Coimbatore district. The natural enemies observed were *Encarsia* sp, *Mallada* sp, *Cryptolaemus montrouzieri* and *Chrysoperla zastrowi sillemi*. The monitoring and record of incidence of papaya mealy bug and its natural enemies on papaya and other alternate hosts showed the infestation of *Paracoccus marginatus* in crops like papaya, tapioca, mulberry, guava, cocoa, Coccinea, brinjal, cotton, tomato and hibiscus crops. The incidence of papaya mealybug was recorded in Coimbatore, Erode, Tiruppur, Salem, Karur, Theni, Vellore, Dindigul, Perambalur, Tiruvannamalai, Villupuram, Namakkal, Nagapattinam, Trichy, Cuddalore districts of Tamil Nadu. The prevalence was high in Erode, Tiruppur and Coimbatore. In all the places of occurrence of *Paracoccus marginatus* the parasitoid *Acerophagus papayee*, *Anagyrus lockii* and predator *Cryptolaemus montrouzieri*, *Spalgius* and *Mallada* were noted. Monitoring the invasive South American tomato pinworm, *Tuta absoluta* in Coimbatore district recorded maximum moth collection of pinworm in October (3-23),

November (5-25) and December (3-17 adult moths trap) as compared to rest of the cropping period. The leaf damage and fruit damage observed in the field was also high in October, November and December 2016 which coincides with the maximum adult catches.

1.2.4.13 UAS, Raichur

The incidence of mealybug was noticed on cotton during second week of October (0.08 mealybugs per 10 cm apical shoot length) and continued till harvest of the crop. The peak activity was noticed first fortnight of January (82.25 mealy bugs per 10 cm apical shoot length) and the associated natural enemies population was also more with the incidence of mealybug. The primary parasitoid, *Anesius arizonesis* was high at second week of February (20.75 cocoons/ 10cm apical shoot length) and it has successfully suppressed the mealybug population. Similarly, the peak activity of *Anagyrus dactylopi* was noticed during first week of January and thereafter decline in population was noticed. Coccinellid activity was coincided with the peak activity of mealybugs. The peak activity of mirid bug was noticed during second fortnight of October (3.00 mirid bugs /plant) and thereafter the decline in population was noticed. The incidence of mired bug was noticed on second fortnight of September and continued till second fortnight of November. The predatory populations, *viz*., coccinellids, chrysoperla and spiders activity had no direct effect on the activity of mirid bug population.

1.2.4.14 YSPUHF, Solan

Diversity of bio-control agents from various agro-ecological zones was recorded. The coccinellids recorded were *Adalia tetraspilota, Coccinella septempunctata, Hippodamia varigieta, Cheilomenes sexmaculata, Propylea lutiopustulata, Chilocorus infernalis, Stethorus* sp., *Priscibrumus uropygialis, Platynaspis saundersii, Harmonia eucharis* and *Oenopea sauzetii* from apple, apricot, cole crops and wild flora. In and around Solan on vegetable and flowering plants, *Oenopia kirbyi, Illeis* spp*., Coelophora bisselata, Pharoscymnus flexibilis Scymnus posticalis*, *Stethorus* sp. and *Harmonia dimidiate* were additional records. The syphids recorded were *Episyrphus balteatus*, *Eupeodes frequens*, *Melanostoma univitatum*, *Betasyrphus serarius, Sphaerophoria indiana, Ischiodon scutellarisMetasyrphus corollae* and *Scaeva pyrastri* and mirids recorded were *Nesidiocoris tenuis* and *Neochrysocharis formosa*. Besides above mentioned natural enemies *Cotesia glomerata* parasitizing *Pieris brassicae* in cauliflower and *Campoletis chloridae* parasitizing *Helicoverpa armigera* in tomato were also collected from Nauni.

1.3 Outbreak of insect pests

Heavy incidence of tailed mealybug *F. virgata* was recorded in Guava and Custard apple in Kanakapura district. About 12 ha of guava were severely affected by the pest. Custard apple in Ramnagar areas was highly attacked by the pest and advocated release of *Cryptolaemus* beetles @10 per plant.

Heavy incidence upto 85% was recorded in Kadur, Arasikere, Hassan, Maddur, Kollegal, Mysore, Mandya and Chennarayapattana taluks. Low level of parasitization by *Goniozus nephantidis* was recorded (less than 10%). *Bracon* was found to the tune of 25-30% in Maddur and Kollegal areas. *Parena* sp., a Carabid beetle was recorded in Maddur and one reduviid bug was also recorded feeding on larvae in addition to anthocorid bugs.

Location specific and timely advisories based on scientific observations will help in judicious use of biological and chemical pesticides and thereby, reducing the pesticide load.

Based on regular surveys with weather data leads to development of forewarning system for appropriate use in IPM strategy. Identification of major and emerging pest scenario under changing climatic situation will also be addressed from time to time. The efforts to generate information on pest scenario were initiated by this bureau recently. The status of pests across different crop was monitored through **Surveillance for pest outbreak and alien invasive pests - Crop Pest Outbreak Report (CPOR)** on monthly basis by different AICRP-BC centres. The status of CROP reported by the centres between November 2016 and January 2017 are presented hereunder.

November 2016

Pest Survey undertaken during November 2016 for the crops like rice, sugarcane, brinjal and redgram at Gondupalem, Gullepalli, Suredupalli Villages in K Kotapadu Mandal and A. Kotahpalli Village in Devarapalli Mandal of Visakhapatnam District, Andhra Pradesh, by ANGRAU, Anakapalle centre revealed that the popular rice varieties RGL 2537, BPT 5204, MTU 7029, RGL 11414 at panicle initiation stage were affected severely by Panicle mite, BPH and stem borer. Severe incidence of diseases like sheath blight, brown spot and narrow brown spot and sheath rot was also observed. Sugarcane cultivated in this region was severely affected by ring spot disease. Moderate incidence of inter node borer and mealy bug was also recorded. Low infestation by whiteflies and leaf crinkle virus were reported for brinjal crop grown in this region. Redgram were infested by low incidence of *Maruca*, aphids and cowbugs.

Survey undertaken by AAU, Anand centre, during November 2016 for pest incidence in cotton and tomato crop at Gujarat revealed that, low to moderate incidence of *Tuta absoluta* and early blight diseases in tomato at Kashipura village in Bodeli taluk of Chhota Udepur district. Cotton crop at Karena village in Karjan taluk of Vadodara district were infested by pink bollworm, *Pectinophora gossypiella*. The level of infestation was between low and moderate.

December 2016

For the month of December 2016, pest report has been received for the crops like apple, and sugarcane, cotton from the centres YSUHF, Solan and MPKV, Pune respectively. As a result of good parasitisation by *Aphelinus mali,* low to moderate incidence of Apple woolly aphid (*Eriosoma lanigerum*) was observed at Kinnaur district, Himachal Pradesh. Pink boll worm incidence was reported from Dhule, Sangli and Kohlapur districts of Maharashtra causing 2 to 10 per cent damage in *Bt* cotton. Sugarcane grown in Satara, Sangli and Kohlapur districts were witnessed low to moderate infestation of sugarcane woolly aphid (*Ceratovacuna lanigera).* The predators observed, *Micromus igorotus* (5 to 6 larva/leaf) and *Dipha aphidivora*, (1 to 2 larva / leaf) played a key role in preventing this pest build-up further

January 2017

A massive outbreak of army worm was reported during this period from Kuttanad and Moncompu districts of Kerala. Rice varieties uma and jyothi at maximum tillering stage witnessed a severe damage tune to a complete loss of >2000 ha.

2. Biological control of plant disease using antagonistic organisms

***Trichoderma/ Pseudomonas/ Bacillus* isolates used in the present investigation**

Trichoderma / Pseudomonas isolates
TCMS-36 (*T. asperelleum*) *Trichoderma* from copper mining soils
TCMS-43 (*T. harzianum*) *Trichoderma* from copper mining soils
TCMS-9 (*Hypocrea lixii*) *Trichoderma* from copper mining soils
Th-14 (*T. harzianum*)
PBAT-3 - Pant Bio- control agent(*T. harzianum* + *Pseudomonas fluorescence*)
Bacillus N 18
Psf-2 (*Pseudomonas fluorescence*) from wheat rhizosphere
Psf-173 (*Pseudomonas fluorescence*) from wheat rhizosphere

2.1.1 Field evaluation of promising *Trichoderma / Pseudomonas/Bacillus* isolates for the management of soil-borne diseases and improved crop growth of Rice, chickpea and lentil

2.2.1.1 Rice (var. Pant Dhan-4)

A field experiment was conducted at Crop Research Centre, Pantnagar to evaluate nine potential bio-agents and one fungicide Carbendazim as standard check on rice (var. Pant-4) to improve crop vigour and reduce soil borne diseases borne diseases of rice. These bio-agents were applied as soil application (10 g formulation with 1 kg vermicompost), seed bio-priming (10g or 10 ml/kg seed), seedling root dip treatment (10g or 10ml/l) and as three foliar sprays (10 g or 10ml/l) at 45, 70 and 95 DAT. The experiment was laid in a randomized block design in three replications with a plot size of 2 m x 3m.


Seed bio-priming (48 hr)


Seedlings dip treatments (30 min.)



Nursery view **Field view**

Significantly minimum sheath blight disease incidence was recorded with carbendazim (8.16%). Among bioagents Th-14 (11.18%) and TCMS-36 (13.10%) showed minimum incidence and were on par as compared to the control (32.33%). Minimum brown spot disease incidence was recorded in carbendazim (7.15%) which was at par with Psf-2

(8.33%) and TCMS-36 (8.7%) but significantly better than other treatments and control (17.26%) (Table 1).

Table 1. Efficacy of promising bio-agents against brown spot and sheath blight disease of rice (variety Pant Dhan-4)

Treatment	Brown spot		Sheath blight	
	Disease incidence*	Disease reduction	Disease incidence*	Disease reduction
	(%)	(%)		(%)
TCMS-43	11.00 (19.35)	36.26	16.02 (23.56)	50.55
TCMS-36	8.70 (17.14)a	49.59	13.10 (21.20)b	59.48
TCMS-9	12.45 (20.63)	27.88	22.97 (28.62)	28.95
Th-14	10.82 (19.18)	37.29	11.18 (19.51)b	65.42
PBAT-3	10.41 (18.80)	39.68	14.49 (22.37)	55.17
Psf-173	11.37 (19.69)	34.12	24.00 (29.32)	25.78
Psf-2	8.33 (16.73)a	51.71	26.52 (30.99)	17.96
Bacillus N 18	11.37 (19.68)	34.12	15.20 (22.93)	53.0
Carbendazim	7.15 (15.41)a	58.57	8.16 (16.59)a	74.77
Control	17.26 (24.54)	-	32.33 (34.64)	-
CD (0.05)	2.42 (2.37)	-	2.57 (1.81)	-
CV (%)	13.03 (7.2)	-	8.16 (4.24)	-

Among various potential bio-agents significantly maximum number of tillers/plant was observed in TCMS-36 (8.13 tillers/plant), however other treatments were at par with control (6.40 tillers/plant). Maximum plant height was observed in PBAT 3 (113.40 cm) followed by *Bacillus* sp. (112.80 cm) and TCMS-36 (112.26 cm) and were at par with each other but significantly better than other treatments and control (106.67 cm) which were at par with each other (Table 2).

All the treatments gave significantly higher yield than control. Maximum yield was obtained with Th-14 (87.22 q/ha) followed by PBAT-3 (82.78q/ha) and Carbendazim (81.67 q/ha) as compared to control (65.0 q/ha). Maximum 1000 grain weight was observed with Th-14 (30.63g) followed by carbendazim (29.64g), Psf-2 (29.57g) and were at par with each other but significantly better than control (26.66g) (Table 2).

The cfu counts of all bio-agents were found significantly higher in rhizosphere and rhizoplane as compared to control and carbendazim during post treatment Increased CFU count in bio-agents treated plots were observed at 45 days after transplantation (DAT) and decreased CFU count was observed at 90 DAT. At 45 DAT maximum population of bio-agents was observed in PBAT-3 (*Pseudomonas*-$38.67x10^4$ & $32.33x10^4$ and *Trichoderma*-$23.33x10^4$ & $37.67x10^4$ CFU/g) followed by *Bacillus* ($35.0x10^4$ & $26.0x10^4$ CFU/g) respectively as compared to control (*Pseudomonas*- $3.33x10^4$ & $3.0x10^4$, *Trichoderma*-2.0 $x10^4$ & $1.67x10^4$ and *Bacillus* $2.67x10^4$ & $2.0x10^4$ CFU/g) in rhizosphere and rhizoplane respectively. At 90 DAT maximum population of bio-agents in rhizosphere and rhizoplane was observed in PBAT-3 (*Pseudomonas*-$31.33x10^4$ & $31.33x10^4$ CFU/g and *Trichoderma*-$10.67x10^4$ & $23.67x10^4$ CFU/g) followed by *Bacillus* ($27x10^4$ & $21x10^4$ CFU/g) respectively (Table 3). Of various bio-agents Th-14, PBAT-3 and TCMS-36 were found most promising in reducing diseases, and in increasing yield.

Table 2. Efficacy of promising bio-agents on plant growth and yield of rice (variety Pant Dhan-4)

Treatments	Plant vigour		Yield			
	Plant height	Tiller/hill (90DAT)	Yield /plot (6 m^2)	Yield	Increase in yield	1000 grain wt
	(cm)	(no.)	(kg)	(q/ha)	(%)	(g)
TCMS-43	108.85	7.47a	4.53	75.56	16.23	26.92
TCMS-36	112.26	8.13a	4.80	80.00	23.07	29.46
TCMS-9	108.67	7.00a	4.67	77.77	19.65	29.07
Th-14	109.20	7.73a	5.23	87.22	34.18	30.63
PBAT-3	113.40	7.67a	4.97	82.78	27.35	30.32
Psf-173	108.00	6.87a	4.63	77.72	18.80	27.94
Psf-2	110.53	7.13a	4.83	80.55	23.93	29.57
Bacillus N 18	112.80	7.47a	4.70	78.33	20.51	28.38
Carbendazim	107.47	6.67a	4.90	81.67	25.64	29.64
Control	106.67	6.40	3.90	65.00	-	26.66
CD (0.05)	2.73	1.60	0.71	-	-	2.85
CV (%)	1.44	12.90	8.79	-	-	5.76

Table 3. Population dynamics of potential bio-agents in rhizosphere and rhizoplane of Rice

Treatment	Observed population	Population dynamics					
		Rhizosphere (x10^4 cfu/g)			Rhizoplane (x10^4 cfu/g)		
		0 DAT	45 DAT	90 DAT	0 DAT	45 DAT	90 DAT
TCMS-43	*Trichoderma*	4.67	16.67	15.00	1.00	11.67	9.33
TCMS-36	*Trichoderma*	5.67	22.67	16.67	7.67	13.67	10.33
TCMS9	*Trichoderma*	5.33	12.67	11.33	3.00	8.33	5.67
Th-14	*Trichoderma*	9.33	22.00	16.00	8.67	22.00	15.67
PBAT 3	*Trichoderma*	3.33	23.33	10.67	1.33	32.33	23.67
	Pseudomonas	13.00	38.67	31.33	13.33	37.67	31.33
Psf-173	*Pseudomonas*	13.67	32.00	25.33	13.00	10.00	10.67
Psf-2	*Pseudomonas*	10.00	16.33	12.67	10.67	11.33	5.67
Bacillus N 18	*Bacillus*	6.67	35.00	27.00	1.00	26.00	21.00
carbendazim	*Trichoderma*	2.67	1.00	0.67	0.67	1.67	1.33
	Pseudomonas	2.33	2.33	1.33	1.33	3.67	3.00
	Bacillus	3.33	2.67	1.33	2.00	3.33	3.00
Control	*Trichoderma*	2.33	2.00	2.00	1.00	1.67	1.33
	Pseudomonas	3.00	3.33	3.00	2.00	3.00	2.00
	Bacillus	2.33	2.67	2.33	2.33	2.00	1.67
CD (0.05)		2.04	3.17	2.20	1.57	2.18	1.78
CV (%)		20.88	12.19	11.18	20.51	13.40	10.97

2.2.1.2 Chickpea (Var. PG-186)

A field experiment was conducted at Crop Research Centre, GBPUA&T, and Pantnagar during Rabi 2016-17 to evaluate the efficacy of bio-agents 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^2. Bio-agents were applied as soil application (10 g

formulation with 1 kg vermicompost), seed bio-priming (10g or 10 ml/kg seed) and as three foliar sprays (10 g or 10ml/l) while carbendazim (1g/ml) at 45, 70 and 95 DAS.

During the crop season seedling and young plant mortality was observed. Significantly minimum seed mortality was observed with PBAT-3 (20.46%) followed by Psf-2 (21.67%) and Psf-173 (23.75%) as compared to carbendazim (34.08%) and control (39.63%) (Table 4).

Significantly minimum plant mortality (30-70 DAS) was observed with *Bacillus* (2.54%), followed by TCMS-43 (4.53%), PBAT-3 (5.34%) and Psf-173 (5.46) as compared to Carbendazim (12.45%) and control (17.12%) (Table 4). Of different isolates PBAT-3, Psf-173 and *Bacillus* were found very promising in reducing pre and post emergence seed and plant mortality in field**.**

Table 4. Efficacy of promising bio-agents against seed and seedling mortality of chickpea in field

Treatment	Plant Stand (30 DAS)	Seed mortality	Plant stand (70 DAS)	Plant mortality (30-70DAS)
	No.	(%)	No.	(%)
TCMS-43	544.67	31.92	520.00	4.53
TCMS-36	567.33	29.08	499.00	12.04
TCMS-9	545.00	31.88	486.67	10.70
Th-14	587.00	26.63	517.67	11.81
PBAT-3	636.33	20.46	602.33	5.34
Psf-173	610.00	23.75	576.67	5.46
Psf-2	626.67	21.67	568.33	9.31
Bacillus N 18	565.33	29.33	551.00	2.54
Carbendazim	527.33	34.08	461.67	12.45
Control	483.00	39.63	400.33	17.12
CD (0.05)	76.05	-	61.46	-
CV (%)	7.9	-	6.91	-

*800 counted seeds were sown in each plot

2.2.1.3 Lentil (variety PL-7)

A field experiment was conducted at Crop Research Centre, GBPUA&T, and Pantnagar during Rabi 2016-17 to evaluate the efficacy of bio-agents 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^2. Bio-agents were applied as soil application (10 g formulation with 1 kg vermicompost), seed bio-priming (10g or 10 ml/kg seed) and as three foliar sprays (10 g or 10ml/l) while Carbendazim (1g/ml) 1st at 45, 2nd at 70 and 3rd at 95 DAS.

Significantly minimum seed mortality was observed with PBAT-3 (19.20%) followed by Psf-173 (21.02%), TCMS-36 (23.70%) and Th-14 (23.95%) as compared to carbendazim (32.98%) and control (34.92%). Significantly minimum plant mortality (30-70

DAS) was observed with PBAT-3 (3.86%) followed by *Bacillus* (4.28%) and Psf-2 (5.97%) as compared to Carbendazim (10.40%) and control (11.06%) (Table 5).

Of all the isolates PBAT-3, Psf-173, and *Bacillus* were found very promising in reducing pre and post emergence seed and plant mortality in field**.**

Table 5. Efficacy of promising bio-agents against seed and seedling mortality of lentil in field

Treatment	Plant Stand (30 DAS)	Seed mortality	Plant stand (70 DAS)	Plant mortality (30-70DAS)
	No.	(%)	No.	(%)
TCMS-43	1369.67	31.52	1239.00	9.54
TCMS-36	1526.00	23.70	1408.00	7.73
TCMS-9	1443.33	27.83	1301.00	9.86
Th-14	1521.00	23.95	1429.67	6.00
PBAT-3	1616.00	19.20	1553.67	3.86
Psf-173	1579.67	21.02	1494.67	7.53
Psf-2	1379.33	31.03	1297.00	5.97
Bacillus N18	1473.33	26.33	1410.33	4.28
Carbendazim	1340.33	32.98	1201.00	10.40
Control	1301.67	34.92	1157.67	11.06
CD(0.05)	169.9	-	125.47	-
CV (%)	6.81	-	5.42	-

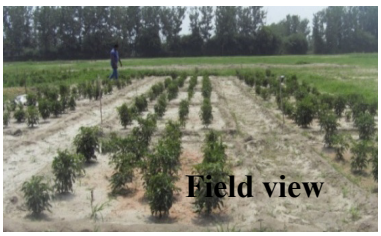
*2000 counted seeds were sown in each plot

2.1.2 Field evaluation of promising biological control agents chilli anthracnose disease (GBPUAT, Pantnagar; AAU, Anand; PAU, Ludhiana)

2.1.2.1 GBPUAT, Pantnagar

Methods of application: i) seed treatment: Soaked the seeds in suspension for 5 min. then dried under shade before sowing in nursery beds, a**.** Bio-agents @ 10 g or 10 ml formulation in 100 ml water/kg seed; b. Carbendazim @ 1g/kg seed. ii) seedling dip treatment: dipped the seedlings in bio-agent suspension as above for 5 min and iii) foliar sprays: 10 g or 10 ml formulation in 1lit.water.

A field experiment was conducted at Vegetable Research Centre, GBPUA&T, and Pantnagar during Rabi 2016 to evaluate the efficacy of different biological control agents viz. *Trichoderma harzianum* (Th-3), *Pichiaguillier mondii* (Y-12) and *Hanseniaspora uvarum*(Y-73) received from NBAIR, Bangalore and carbendazim (standard check) were used against Chili anthracnose. The experiment was laid in a randomized block design in three replications with a plot size of 3x2 m. The data on healthy and diseases fruit, disease incidence and yield are indicated in (Table 6).


Field view


Diseased fruits

Significantly maximum number of healthy fruits were obtained with carbendazim (2558.3) followed by Y-12 (2353.3), Th-3 (2265.0) as compared to control

(1525.0). Significantly minimum number of diseased fruits was observed with carbendazim (100.0) followed by Th-3 (126.6) as compared to control (166.6). Minimum fruit rot incidence was found with carbendazim (3.9%) followed by Th-3 (5.5%) and Y-12 (6.3%) as compared to control (10.9%). Maximum fresh weight of healthy fruits was observed with carbendazim (1275 g) followed by Y-12 (1190 g) and Th-3 (1128 g) and was at par but significantly different from control (916 g). Significantly maximum fruit yield was observed with carbendazim (21.2 q/ha) followed by Y-12 (19.8 q/ha) and Th-3 (18.8 q/ha) as compared to control (15.5 q/ha).

Among different biological control agents tested *Pichiaguillier mondii* (Y-12) was found best and was at par with *Trichoderma harzianum* (Th-3) in reducing fruit rot incidence and increasing yield.

Table 6. Efficacy of bio-agents against chilli anthracnose in field

Treatment	Fruits/plot *($6m^2$)					Yield (healthy fruits)	Yield increase over check
	Fruits number		Fruit rot incidence	Fruits weight			
	Healthy fruits no.	Diseased fruits no.		Healthy fruits g	Diseased fruits g	q/ha	
Th-3	2,265.0	126.6	5.5	1,128.3	45.0	18.8	21.2
Y-73	2,008.3	150.0	7.4	1,006.6	50.6	16.7	7.7
Y-12	2,353.3	150.0	6.3	1,190.0	49.6	19.8	27.7
Carbendazim	2,558.3	100.0	3.9	1,275.0	37.0	21.2	36.7
Control	1,525.0	166.6	10.9	916.6	56.6	15.5	-
CD(0.05)	426.6	25.1	-	144.2	8.4	-	-
CV (%)	10.4	9.4	-	6.8	9.2	-	-

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

2.1.2.2 AAU, Anand

The experiment was carried out at Agronomy Farm, BACA, Anand Agricultural University, during *Kharif,* 2016, in RBD on chilli variety "GVC-131, with the following treatments T1: *Pichia guilliermondii* (Y12) seed treatment, seedling dip & foliar spray ($2x10^8$ cfu ml^{-1}) , T2: *Hanseniaspora uvarum* (Y73) seed treatment, seedling dip & foliar spray ($2x10^8$ cfu ml^{-1}), T3: *Trichoderma harzianum* (Th-3) seed treatment, seedling dip & foliar spray ($2x10^8$ cfu g^{-1}) , T4: *Pseudomonas fluorescence* seed treatment, seedling dip & foliar spray ($2x10^8$ cfu g^{-1}) , T-5: Recommended fungicidal control (carbendazim 0.05%) seed treatment, seedling dip & foliar spray and T-6: Untreated control

Results

The results indicated that the seed treatment, seedling dip and foliar spray of *Pichia guilliermondii* (Y12) was best with low disease intensity (6.23%) and higher yield (83.27 q/ha). The treatment was found at par with the treatment T4 - seed treatment, seedling dip and foliar spray of *Pseudomonas fluorescens* with disease intensity (6.58%) and yield (79.99 q/ha). These treatments were followed by T2- seed treatment, seedling dip and foliar spray of *Hanseniaspora uvarum* (Y73) with disease intensity (6.83%) and yield (75.60 q/ha) and T3- *Trichoderma harzianum* (Th-3) with disease intensity (8.51%) and yield (70.85 q/ha). None of the biocontrol treatments were superior to fungicide treatment (carbendazim

0.05%) where in lowest disease intensity (2.70%) and highest yield (90.52 q/ha) was recorded (Table 7 & Plate 3).

2.1.2.3 PAU, Ludhiana

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) and untreated control with four replications each. The chilli seedlings were transplanted as per agronomic norms with spacing of 2x3 feet (plant to plant and row to row). The chilli seedlings were treated with antagonist formulations just before transplantation. The formulations @20 ml were mixed with one litre water to obtain antagonist suspension for seedling treatment. Seedlings were uprooted carefully from the beds and the roots were dipped in these antagonist suspensions for 5-10 minutes and transplanted to main field. Secondly, foliar sprays of antagonists were given at the rate of 10 g per liter of water. The first spray was given at initiation of fruit ripening and the subsequent sprays were given at monthly intervals until last picking. The data on per cent fruit rot incidence and yield were recorded.

Disease incidence during the month of May was low and varied from 4.37 to 9.17%. During June, the per cent disease incidence varied from 13.71 to 21.38%, which was non-significantly different between various treatments. During month of July, lowest per cent fruit rot (19.26%) was recorded in chilli plot treated with chemical control (Indofil M 45@ 750 g in 250 litre water/acre), which was significantly better than all other treatments. This was followed by plots treated with *P. guilliermondii* and *T. harzianum*, which recorded 22.15 and 24.25% fruit rot incidence, respectively and were at par with each other (Table 8). During August also, lowest fruit rot incidence (19.24%) was in chemical treated plot. This was followed by *P. guilliermondii* and *T harzianum* which recorded 27.67 and 32.02% fruit rot incidence and were at par with each other. However, both were significantly better than *H. uvarum* (38.72%). All the treatments were significantly better than untreated control (39.80%). The yield was maximum (67.66 q/ac) in chemical treated plot and was significantly better than other treatments. Among bioagents, *P. guilliermondii and T. harzianum* treated plots recorded yield of 58.5 and 56.72 q/acre, respectively. Yield in untreated plot was 49.0q/acre, which was at par with *H. uvarum* (50.1q/acre) (Table 8).

Table 7. Biological control of chilli anthracnose disease at AAU, Anand

Sl. No.	Treatments	Disease intensity (%)					Disease control over untreated (%)	Yield (q/ha)
		At 1st spray	At 2nd spray	At 3rd spray	At 4th spray	Pooled		
T_1	*P. guilliermondii* (Y12) Seed treatment, Seedling dip & Foliar spray	15.88 (7.49)	16.59 (8.15)	13.58 (5.51)	11.78 (4.17)	14.45 (6.23)	63.69	83.27
T_2	*H.uvarum* (Y73) Seed treatment, Seedling dip & Foliar spray	15.84 (7.45)	15.65 (7.28)	15.08 (6.77)	14.04 (5.89)	15.15 (6.83)	60.20	75.60
T_3	*T. harzianum* (Th-3) Seed treatment, Seedling dip & Foliar spray	18.94 (10.54)	17.00 (8.55)	16.46 (8.03)	15.43 (7.08)	16.96 (8.51)	50.41	70.85
T_4	*P. fluorescens* Seed treatment, Seedling dip & Foliar spray	16.21 (7.79)	15.84 (7.45)	14.57 (6.33)	12.82 (4.92)	14.86 (6.58)	61.66	79.79
T_5	Recommended fungicide (Carbendazim 0.05%) control Seed treatment, Seedling dip & Foliar spray	11.14 (3.73)	9.94 (2.98)	8.73 (2.30)	7.98 (1.93)	9.45 (2.70)	84.27	90.52
T_6	Untreated control	21.57 (13.52)	23.16 (15.47)	25.45 (18.47)	27.69 (21.54)	24.47 (17.16)	-	44.13
S.Em.±	Treatment (T)	0.88	1.00	0.39	0.44	0.35	-	1.26
Period (P)		-	-	-	-	0.29	-	
T x P		-	-	-	-	0.71	-	
C.D. (5%)	T	2.65	3.03	1.16	1.31	1.00	-	3.80
P		-	-	-	-	0.82	-	-
T x P		-	-	-	-	2.00	-	-
C.V. %		10.59	12.28	8.94	9.82	8.90	-	10.40

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

Table 8. Evaluation of fungal antagonists against chilly anthracnose disease at PAU, Ludhiana

Treatments	Per cent Fruit rot incidence				Yield (q/acre)
	May	June	July	August	
Pichia guilliermondii	5.50	15.01	22.15^{b}	27.67^{b}	58.52
Hanseniaspora uvarum	6.55	15.56	27.88^{c}	38.72^{c}	50.16
Trichoderma harzianum	4.92	14.32	24.25^{bc}	32.02^{bc}	56.72
Indofil M45	4.37	13.71	19.26^{a}	19.24^{a}	67.66
Untreated control	9.17	21.38	38.58^{d}	39.80^{c}	49.0
CV %	18.21	14.42	5.92	9.13	4.53

* Letters followed by same letter is not significantly different at $P = 0.05$

Plate 3. Biological control of chilli anthracnose disease at AAU, Anand

Field operations

Anthracnose disease incidence under field conditions

***Pichia guilliermondii* (Y12) treated plant** | **Plant in a control treatment**

2.1.3 Large scale field demonstration of bio-control technologies in rice and tomato

2.1.3.1 Rice


Field view


Interaction with farmers

Large scale field demonstrations of bio-control technologies on rice crop were conducted at the field of 30 different farmers in Nainital district (Halduchur and Golapar area) covering an area of approximately 50 acre. The acreage of farmers was from 0.50-4.0 acre. Four kg of PBAT-3 (Th-14 + Psf-173) was distributed to each adopted farmer.

Bio- control technologies adopted by farmers were i) soil treatment: Pre-colonized (PBAT-3) FYM/vermicompost @10 q/ha, ii) seed bio-priming (10 g/kg seed), iii) seedlings dip treatment (10 g/lit water) for 30 min. prior to transplanting, iv) two foliar sprays with bio-agent, 1st at 45 DAS and 2nd at 70 DAS

Sheath blight (*Rhizoctonia solani*) and Brown spot (*Drechslera oryzae*) disease was observed at the fields of all the farmers. However, bacterial leaf blight (*Xanthomonas oryzae*), false smut (*Ustilaginoidea virens*) and bakanae disease (*Fusarium fujikuoroi*) were observed at some locations. An average yield of 70 q/ha was recorded from the farmers who had applied bio-control technologies along with need based pesticides under IPM programme as compared to an average yield of 58 q/ha by farmers adopted conventional practices, *i.e.*, use of pesticides.

2.1.3.2 Tomato

Field demonstrations were laid at 25 farmer's fields at village Devela Malla, Haldwani, District Nainital covering an area of about 15 acres. Pant bioagent-3 (PBAT-3) was applied as soil application with FYM/vermicompost colonized with PBAT-3, followed by seed bio-priming (10 g/kg seed), seedling dip treatment (10g/lit. water) and foliar sprays of PBAT-3 (10g/lit. water). Occurrence of fungal and bacterial diseases was very low. However, the crop was heavy infected with leaf curl virus (65-80%). Therefore, yield comparisons could not be made.

Nursery bed

Tomato plants infected with leaf curl virus

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

2.1.4.1 Chilli (Pusa Sadabahar)

Methods of application was i) Soil application: 10 g formulation + 1 kg vermicompost/treatment, ii) seed treatment: seed bio-priming with bio-agents @ 10 g or ml /kg seed, iii) metalaxyl (3g/kg seed) - standard check. Foliar spray - two foliar sprays @10g or ml / lit of water.1st spray at 15 and 2nd at 30 DAS. Two foliar sprays of metalaxyl @ 0.1% as above- (Standard check). The nursery trial was conducted at Vegetable Research Centre, Pantnagar, to evaluate nine potential isolates of bio-agents (*Trichoderma, Pseudomonas and Bacillus*) and one fungicide Metalaxyl as a standard check to prevent pre & post emergence damping off and to improve plant vigour at seedling stage. The experiment was laid in randomized block design in three replications with a plot size of 0.5x1.0 m^2.

Minimum pre-emergence mortality (15DAS) was observed with *Bacillus* (39.20%) followed by Th-14 (45.60%), TCMS 36 (47.47%) and Psf-173 (49.60%) and were at par with each other but significantly different from Metalaxyl (62.53%) and control (61.33%). Minimum post- emergence mortality (30-45DAS) was observed with Th-14 (0.98%) followed by TCMS-36 (4.82%) and PBAT-3 (4.88%) as compared to Metalaxyl (14.24%) control (11.72%) (Table 9).

Maximum seedling length was observed with *Bacillus sp*. (20.97cm) followed by Th-14 (20.60cm) and TCMS-36 (20.20cm) and was at par but significantly different from fungicide treatment (17.03cm) and control (17.13cm). However, significantly maximum fresh weight of seedling was observed with TCMS-36 (2.26g) as compared to other treatments and control (1.13g) (Table 8). Maximum plant vigour index was observed with *Bacillus* sp. (1274.77) followed by Th-14 (1120.64), TCMS-36 (1061.17) and Psf-173 (976.08) as compared to Metalaxyl (638.18) and control (662.49) (Table 10).

Table 9. Efficacy of promising bio-agents against seed and seedling mortality of chilli in nursery

Treatment	Plant Stand (15 DAS)	Pre –emergence mortality (15 DAS)	Plant stand (45 DAS)	Post- emergence mortality (15-45DAS)
	No.	(%)	No.	(%)
TCMS-43	98.33	60.7	86.00	12.54
TCMS-36	131.33	47.47	125.00	4.82
TCMS-9	105.33	57.87	96.33	8.54
Th-14	136.00	45.60	134.67	0.98
PBAT-3	116.00	53.60	110.33	4.88
Psf-173	126.00	49.60	119.00	5.56
Psf-2	106.67	57.33	97.67	8.43
Bacillus N18	152.00	39.20	137.67	9.43
Metalaxyl	93.67	62.53	80.33	14.24
Control	96.67	61.33	176.00	11.72
CD(0.05)	45.53	-	20.7	-
CV (%)	22.84	-	6.6	-

*250 counted seeds were sown in each treatment

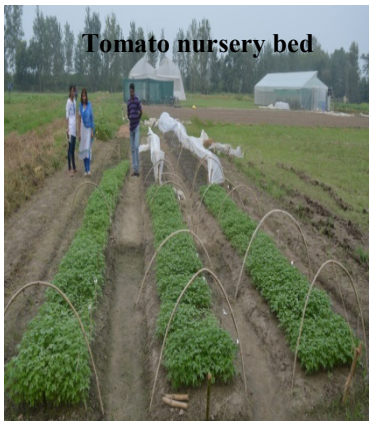
Table 10. Efficacy of promising bio-agents for plant vigour of chilli in nursery

	Length			Fresh weight			Vigour index
Treatment	Seedling (cm)	Shoot (cm)	Root (cm)	Seedling (g)	Shoot (g)	Root (g)	
TCMS-43	17.90	12.87	5.03	1.43	0.97	0.46	704.07
TCMS-36	20.20	14.60	5.60	2.26	1.62	0.63	1061.17
TCMS-9	18.05	12.93	5.12	1.48	1.02	0.46	760.51
Th-14	20.60	14.93	5.67	1.88	1.21	0.67	1120.64
PBAT-3	18.61	13.24	5.37	1.70	1.12	0.57	863.50
Psf-173	19.37	13.90	5.47	1.72	1.15	0.58	976.08
Psf-2	18.30	13.10	5.20	1.61	1.075	0.54	780.80
Bacillus N18	20.97	15.20	5.77	2.12	1.42	0.70	1274.77
Metalaxyl	17.03	12.37	4.67	1.15	0.78	0.36	638.18
Control	17.13	12.40	4.73	1.31	0.90	0.41	662.49
CD (0.05)	2.92	3.03	1.31	0.81	0.67	0.30	-
CV (%)	9.06	13.04	14.59	28.20	34.85	32.74	-

2.1.4.2 Tomato (S21)


Seed bio-priming

Minimum pre-emergence mortality (15DAS) was observed with Psf-173 (13.2%) followed by Psf-2 (14.67%), PBAT-3 (15.0%) and TCMS-36 (16.06%) and were at par with each other but significantly different from Metalaxyl (29.33%) and control (22.67%). Minimum post- emergence mortality (30-45DAS) was observed with Psf-2 (5.23%) followed by PBAT-3 (5.64.0%) as compared to Metalaxyl (16.50%) and control (15.34%) (Table 11).


Tomato nursery bed

Maximum seedling length was observed with Psf-173 (59.59cm) followed by Psf-2 (57.61cm), PBAT 3 (54.74cm) and Th-14 (51.82cm) and was at par but significantly different from Metalaxyl (42.76cm) and control (42.85cm). However, Maximum fresh weight was observed with Psf-173 (12.13g) followed by TCMS-36 (10.28g) and was at par but significantly different from Metalaxyl (6.60) and control (6.81) (Table 12).

Maximum plant vigour index was observed with Psf-173 (5172.12) followed by Psf-2 (4916.34), PBAT-3 (4653.01) and TCMS 36 (4461.89) as compared to Metalaxyl (3021.75) and control (3313.48) (Table 12).

Table 11. Efficacy of promising bio-agents against seed and seedling mortality of tomato in nursery

Treatment	Plant Stand (15 DAS)	Pre –emergence mortality	Plant stand (30 DAS)	Plant stand (45 DAS)	Post-emergence mortality (15-45 DAS)
	No.	(%)	No.	No.	(%)
TCMS-43	411.33	17.733	373.00	371.00	9.80
TCMS-36	419.67	16.06	413.67	395.00	5.88
TCMS-9	413.00	17.4.0	393.33	372.67	9.76
Th-14	418.33	16.33	406.67	393.00	6.06
PBAT-3	425.00	15.00	420.33	401.00	5.64
Psf-173	434.00	13.20	427.33	407.33	6.14
Psf-2	426.67	14.67	421.00	404.33	5.23
Bacillus N18	417.33	16.53	400.00	383.67	8.06
Metalaxyl	353.33	29.33	326.67	295.00	16.5
Control	386.67	22.67	357.33	327.33	15.34
CD (0.05)	32.88	-	37.19	29.47	-
CV (%)	4.68	-	5.50	4.58	-

*500 counted seeds were sown in each treatment

Table 12. Efficacy of promising bio-agents for plant vigour of tomato in nursery

Treatment	Length			Fresh weight			Vigour index
	Seedling (cm)	Shoot (cm)	Root (cm)	Seedling (g)	Shoot (g)	Root (g)	
TCMS-43	46.44	39.83	6.61	7.67	7.092	0.57	3820.46
TCMS-36	53.16	45.56	7.60	10.28	9.672	0.61	4461.89
TCMS-9	47.49	40.60	6.89	8.48	7.84	0.64	3922.95
Th-14	51.82	44.46	7.35	9.12	8.39	0.71	4335.49
PBAT-3	54.74	46.71	8.03	10.21	9.84	0.37	4653.01
Psf-173	59.59	50.79	8.80	12.13	11.35	0.77	5172.12
Psf-2	57.61	49.17	8.45	10.20	9.93	0.27	4916.34
Bacillus N18	50.67	43.31	7.35	8.67	8.13	0.53	4228.97
Metalaxyl	42.76	37.85	4.91	6.60	5.81	0.79	3021.75
Control	42.85	37.48	5.37	6.81	6.06	0.75	3313.48
CD (0.05)	8.68	8.28	2.66	3.43	3.4	0.24	-
CV (%)	9.98	11.08	21.79	22.23	23.53	24.02	-

2.1.4.3 Onion (Nasik Red)

Significantly minimum pre-emergence mortality (30DAS) was observed with PBAT-3 (13.07%) followed by *Bacillus sp.* (14.13%) and Psf-2 (15.07%) as compared to Metalaxyl (32.53%) and control (36.53%). However, minimum post- emergence mortality (30-60DAS) was observed with Psf-173 (11.09 %) followed by Th-14 (12.33%) as compared to control (20.59%) (Table 13).

Significantly maximum seedling length was observed with Psf-173 (27.14cm) followed by TCMS-36 (26.39cm) as compared to Metalaxyl (21.94 cm) and control (21.85cm). However, significantly maximum fresh weight was observed with psf173 (1.74g) followed by PBAT3 (1.60g) and was at par compared control (1.15) (Table 14).

Maximum plant vigour index was observed with Psf-173 (2218.24) followed by PBAT-3 (2096.25) as compared to metalaxyl (1480.22) and control (1386.54) (Table 14).

Table 13. Efficacy of promising bio-agents against seed and seedling mortality of onion in nursery

Treatment	Plant Stand (30 DAS)	Pre- emergence mortality	Plant stand (45 DAS)	Plant stand (60 DAS)	Post-emergence mortality (30-60DAS)
	No.	(%)	No.	No.	(%)
TCMS-43	192.0	23.20	163.33	154.00	19.79
TCMS-36	194.7	22.13	175.00	165.33	15.07
TCMS-9	181.7	27.33	165.33	146.67	19.27
Th-14	197.3	21.07	190.00	173.00	12.33
PBAT-3	217.3	13.07	191.67	173.67	20.09
Psf-173	204.3	18.27	183.67	181.67	11.09
Psf-2	212.3	15.07	179.67	179.33	15.54
Bacillus N 18	214.7	14.13	179.00	178.67	16.77
Metalaxyl	168.7	32.53	144.67	143.67	14.82
Control	158.7	36.53	131.33	126.00	20.59
CD(0.05)	21.60	-	18.77	17.88	-
CV (%)	6.4	-	6.4	6.4	-

*250 counted seeds were sown in each treatment

Table 14. Efficacy of promising bio-agents for plant vigour of onion in nursery

Treatment	Length			Fresh weight			Vigour index
	Seedling	Shoot	Root	Seedling	Shoot	Root	
	(cm)	(cm)	(cm)	(g)	(g)	(g)	
TCMS-43	22.87	16.64	6.23	1.05	0.98	0.07	1756.67
TCMS-36	26.39	20.06	6.33	1.51	1.43	0.08	2055.16
TCMS-9	22.98	16.85	6.13	1.06	0.99	0.07	1669.88
Th-14	23.24	16.96	6.28	1.06	0.97	0.09	1834.41
PBAT-3	24.11	17.79	6.33	1.60	1.52	0.08	2096.25
Psf-173	27.14	20.49	6.65	1.74	1.64	0.10	2218.24
Psf-2	24.17	17.11	7.06	1.23	1.16	0.08	2053.12
Bacillus N18	23.39	16.75	6.64	1.31	1.22	0.09	2008.71
Metalaxyl	21.94	15.81	6.13	1.15	1.09	0.06	1480.22
Control	21.85	15.89	5.96	0.99	0.92	0.07	1386.54
CD (0.05)	3.17	3.33	0.93	0.59	0.57	0.03	-
CV (%)	7.77	11.11	8.54	27.12	28.24	26.84	-

2.1.5 Molecular signatures of promising *Trichoderma* isolates validated under AICRP biological control at Pantnagar

Molecular characterization of *Trichoderma* isolates using ITS markers was carried out by i) extraction of fungal DNA: CTAB method is used for DNA extraction, ii) Quantification and characterization of genomic DNA: The highly conserved internal transcribed spacer (ITS) regions of the rDNA is used for the amplification and characterization. The internal transcribed spacer (ITS) regions of the rDNA repeat from the 3'end of the 18S and the 5'end of the 28S gene were amplified using the two primers, ITS 1 and 4 which were synthesized on the basis of conserved regions of the eukaryotic rRNA gene were used to amplify the internal transcribed spacer region of ribosomal DNA, which encompass the 5.8S rRNA gene and both ITS-1 and ITS-2 regions. PCR amplification of ITS region of 5.8S rRNA gene yielded an ITS fragment of 600 base pair (bp) length in all the isolates of *Trichoderma.* No inter- or intra-species ITS length diversity was detected. This could be due to the fact that 5.8s rRNA gene is known to be highly conserved at genus level and this only confirmed that all the isolates belonged to single genus *Trichoderma* as depicted. The identification up to species and strains level is to be done.

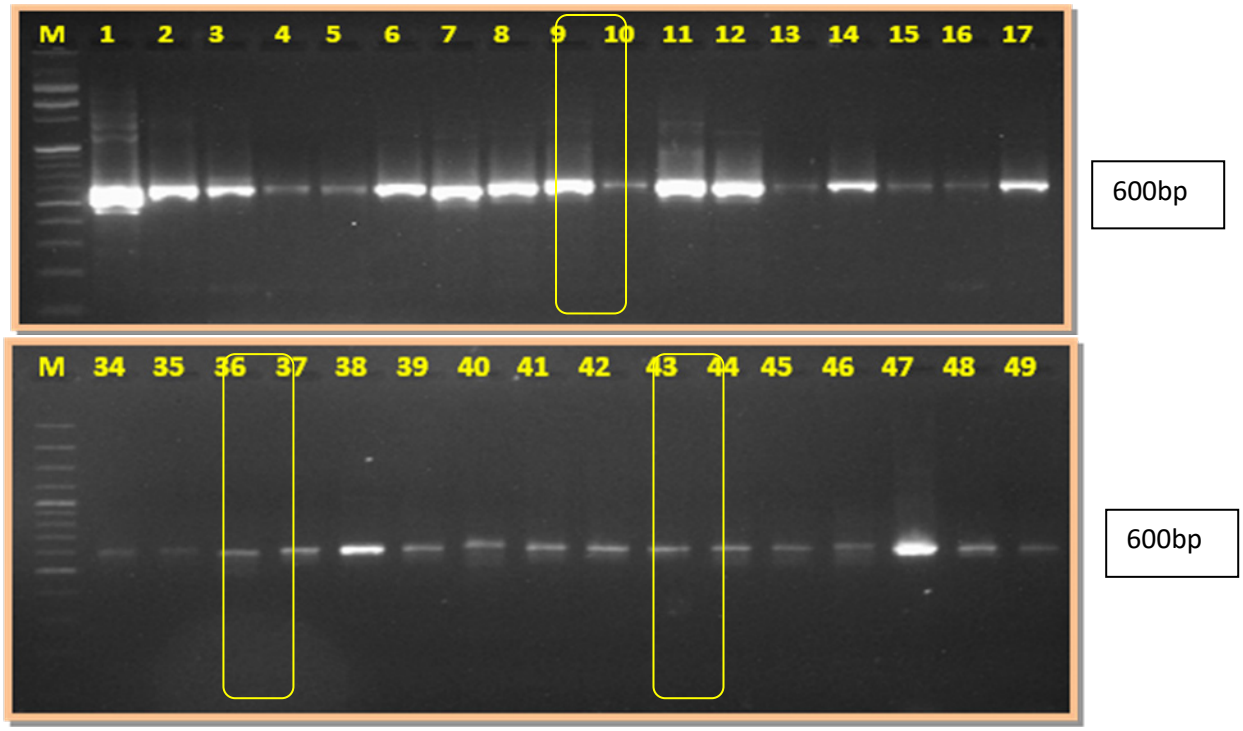


Fig. 6. DNA amplification of TCMS-9, TCMS-36 & TCMS-43 *Trichoderma* isolates with ITS 1 and ITS 4 primers

2.1.6 Development of consortium using promising *Trichoderma* and *Pseudomonas* isolates- *in vitro* compatibility testing.

Treatment:

i) TCMS9+Psf2
ii) TCMS36+Psf2
iii) TCMS43+Psf2
iv) TCMS36+SBIT32
v) TCMS36+TCMS43
vi) TCMS9+TCMS36
vii) TCMS9
viii) TCMS36
ix) TCMS43
x) SBIT32
xi) Psf2

control

2.1.6.1 Dual Culture Studies

Compatibility among *Trichoderma* isolates, and between *Trichoderma* and *Pseudomonas* isolates were studied by dual culture method. During the course of studies two *Trichoderma* isolates (TCMS-9 and TCMS-36) were found compatible with *P. fluorescens* (Psf-2). Among *Trichoderma* isolates TCMS-36 + SBIT-32 and TCMS36 + TCMS-9 were found compatible with each other (Table 15).

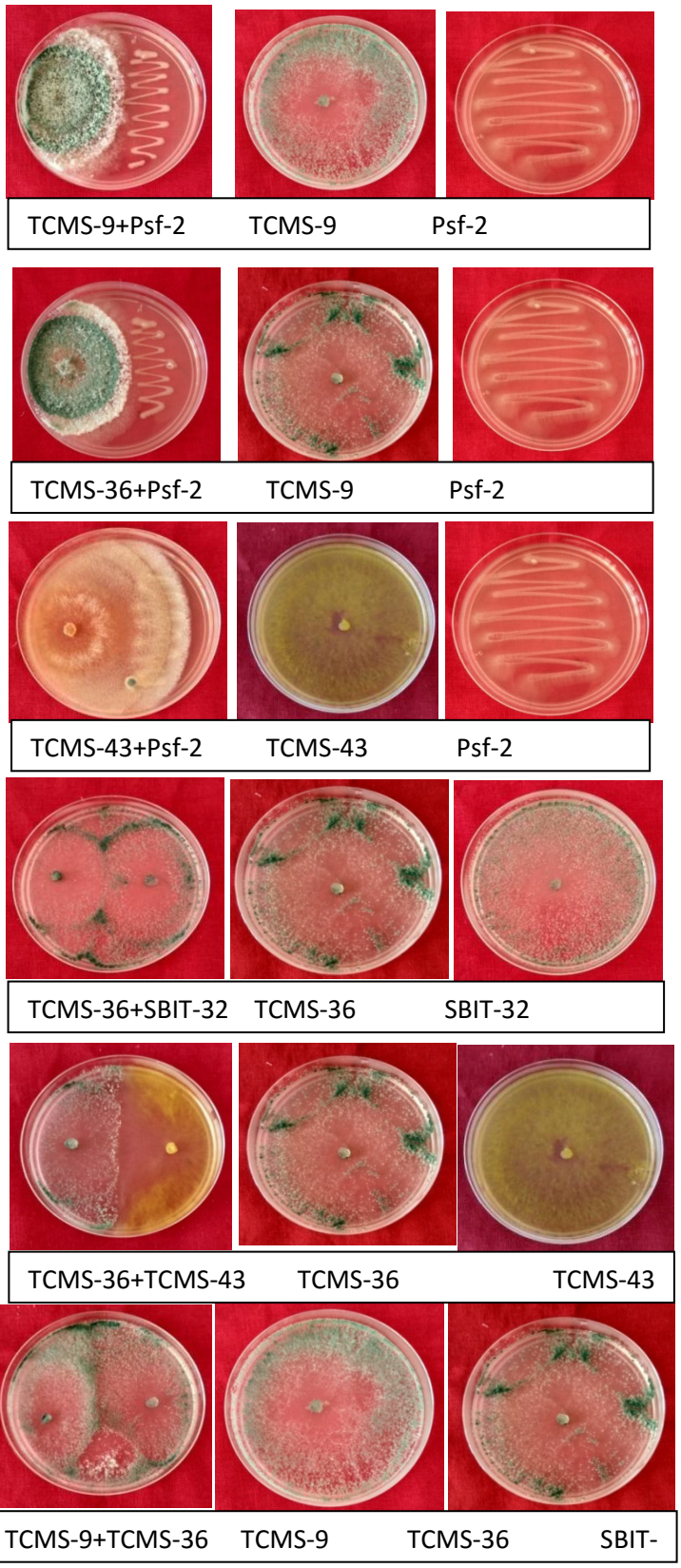


Fig. 7. Growth pattern of *Trichoderma* isolates and *Pseudomonas* in dual culture

Table 15. Compatibility among *Trichoderma* isolates and between *Trichoderma* and *Pseudomonas*

Trichoderma isolates	TCMS-36	Psf-2
SBIT 32	+	NA
TCMS 43	-	+
TCMS 9	+	+
TCMS 36	NA	+

(+) compatible (-) incompatible

2.1.6.2 Preparation of Consortium formulation (Talc-based)

The compatible isolates will be further tested after making Talc based consortium formulation. **No results**

2.1.7 Farmers training and other extension activities

A. Distribution of inputs to the farmers

B. Lab visit of CAFT Trainees

C. Lab visit of students of JNKVV, Jabalpur

3. Biological Control of Crop Pests

3.1 Biological control of Sugarcane Pests

3.1.1 Monitoring the sugarcane woolly aphid (SWA) incidence and impact assessment of natural enemies on its biosuppression (MPKV, PJTSAU, TNAU)

3.1.1.1 MPKV

The sugarcane fields were surveyed during the period between June, 2016 and March, 2017 for the incidence of sugarcane woolly aphid (SWA) and occurrence of its natural enemies (*Dipha aphidivora, Micromus igorotus,* syrphid, spiders and *Encarsia flavoscutellum*) from five agro-ecological zones of western Maharashtra covering Pune, Satara, Sangli, Kolhapur, Solapur, Ahmednagar and Nashik districts. The SWA incidence, pest intensity rating (1-6 scale) and natural enemies' population on leaf were recorded at five spots and five clumps per spot in each plot during crop growth period.

The SWA incidence was observed along riverside and canal areas with relative increase in Sangli and Kolhapur districts during this year. However, the natural enemies were noticed soon after the pest incidence. The average SWA incidence and pest intensity rating were 1.90 per cent and 2.43, respectively. The natural enemies recorded in the SWA infested fields were mainly the predators like *D. aphidivora* (0.55-3.20 larvae/leaf), *M. igorotus* (1.16-8.66 grubs/leaf), syrphid, *Eupeodes confrater* (0.66-1.80 larvae/leaf) and spider (0.13-0.52 /leaf) during July, 2016 to January, 2017 (Table 16). The parasitoid, *E. flavoscutellum* found well distributed and established in almost all sugarcane fields and suppressed the SWA incidence in Western Maharashtra.

Table 16. 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. flavoscu-tellum*	*E. confrater*	
Pune	1.60	2.20	1.20	4.00	2.42	0.83	0.25
Satara	2.24	2.25	1.40	4.80	7.12	0.96	0.32
Sangli	2.83	2.50	1.90	5.20	6.50	1.20	0.40
Kolhapur	4.56	3.85	3.20	8.66	8.50	1.80	0.52
Ahmednagar	0.66	2.00	0.66	2.33	1.50	0.50	0.10
Solapur	0.82	2.25	0.70	2.50	10.50	0.75	0.43
Nashik	0.66	2.00	0.55	1.16	0.75	0.66	0.13
Average Range	1.90 0.66-4.56	2.43 2.00-3.85	1.37 0.55-3.20	4.09 1.16-8.66	5.32 0.75-10.50	0.95 0.66-1.80	0.33 0.13-0.52

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

3.1.1.2 PJTSAU

The sugarcane woolly aphid (SWA) incidence and occurrence of natural enemies (*Dipha aphidivora, Micromus igorotus, Encarsia flavoscutellum,* syrphid and spider) were recorded from different sugarcane growing areas of Telangana, *viz.*, Kamareddy, Medak, Sadasivpet, Bodhan and Adlur Yellareddy.

Incidence of SWA was recorded in terms of no. of SWA per square cm along with percent incidence and corresponding grade as per the standard scale. Natural enemies' population of both *Dipha aphidivora* and *Micromus igoratus* were recorded on leaves at five spots and five clumps/ spot at monthly interval during crop growth period.

Table 17. Mean incidence of SWA and its natural enemies in different parts of Telangana

Parameter	Period of observation	Sugarcane growing areas of Telangana				
		Kamareddy	Bodhan	Medak	Sadasivpet	A.Yellareddy
SWA/2.5 Sq. Cm	July, 2016	0.0	0.0	0.0	0.0	0.0
	Aug, 2016	3.2	8.6	3.2	3.2	0.0
	Feb, 2017	0.0	0.0	0.0	5.3	0.0
	Mar, 2017	0.0	0.0	0.0	0.0	0.0
Dipha /leaf	July, 2016	0.0	16.6	3.6	0.0	0.0
	Aug, 2016	1.5	0.0	0.0	0.0	0.0
	Feb, 2017	0.0	0.0	0.0	1.2	0.0
	Mar, 2017	0.0	1.2	0.0	0.0	0.0
Micromus /leaf	July, 2016	0.0	0.0	0.0	0.7	0.0
	Aug, 2016	3.2	1.0	2.2	0.0	0.0
	Feb, 2017	0.0	0.0	1.0	0.0	0.0
	Mar, 2017	0.0	0.0	0.0	1.0	0.0
Encarcia /leaf	July, 2016	0.0	0.0	3.2	0.0	0.0
	Aug, 2016	0.0	0.0	1.4	0.0	0.0
	Feb, 2017	2.5	0.0	0.0	1.5	0.0
	Mar, 2017	4.6	0.0	0.0	0.0	0.0
Per cent incidence	July, 2016	3.6	0.0	0.0	0.0	0.0
	Aug, 2016	0.0	4.6	0.0	0.0	0.0
	Feb, 2017	11.3	1.2	0.0	2.6	0.0
	Mar, 2017	0.0	0.0	0.0	4.6	0.0
Grade	July, 2016	1.0	0.0	0.0	0.0	0.0
	Aug, 2016	0.0	1.0	0.0	0.0	0.0
	Feb, 2017	2.0	1.0	0.0	1.0	0.0
	Mar, 2017	0.0	0.0	0.0	1.0	0.0

Regular surveys undertaken as per the protocols in sugarcane growing areas of the state in collaboration with sugar mills have indicated only scanty presence of sugarcane woolly aphid (SWA) during 2016-17. As per the reports, SWA populations are rarely noticed in very few patches of sugarcane belt of Telangana. Sporadic incidence was noticed in Bodhan, Kamareddy, Sadasivpet and adjoining areas of Medak. The incidence of SWA, despite being patchy, was noticed only in July & August, 2016 and again in February and March 2017, while SWA incidence was not evidenced from September 2016 to January 2017 (Table 17).

3.1.1.3 TNAU

The incidence of sugarcane woolly aphid was noted in Coimbatore during November 2016 at low intensity up to 14.2 per cent clump damage with damage rating of 2.0 whereas, the pest was prevalent during March 2017 in Erode and in Namakkal district at low intensity at the damage rating of 2.0. The natural enemies associated with woolly aphid were *Dipha aphidivora*, *Micromus* and *Encarsia*.

3.1.2 Management of white grub, *Holotrichia consanguinea* Blanch in sugarcane using bioagents (ANGRAU)

The experiment was conducted in Endemic areas of Chadalada village (East Godavari Dist.) in Navabharat Ventures (Sugar division) operational area, Samarlakota, East Godavari Dist., Andhra Pradesh, in farmers field on variety 2000 A 240 during 2016-17 and following treatments were evaluated against the pest. T1: *Beauveria bassiana* @ 5 kg ha^{-1} (1 $x10^8$spores/ gm) in 250 kg FYM ha^{-1}; T2: *Metarhizium anisopliae* @ 5 kg ha^{-1} (1 $x10^8$spores/ gm) in 250 kg FYM ha^{-1}; T3: *Heterorhabditis indicao* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1}; T4: *Steinernema* sp. WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1}; T5: *Heterorhabditis indica* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1} two times at two monthly interval, T6: *Steinernema sp.* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1} two times at two monthly interval, T7: neem cake @ 500 kg ha^{-1}; T8: phorate 10G @ 15kg ha^{-1} and T9: untreated control.

Results

Treatments were applied after the onset of monsoon rains (23.07.2016) on four months age sugarcane crop. Sugarcane white grub damage was low (<5%) with the application of entomopathogenic fungi and entomopathogenic nematode treatments after onset of rains. White grub damage recorded was significantly low in *Heterorhabditis indica* in two applications (1.6%) and *Heterorhabditis indica* single application (2.81%), followed by *Metarhizium anisopliae* (4.04%), *Steinernema* sp. two times application (4.12%) and *Steinernema* sp. single application (4.58 %) (Table 18).

White grub population (number per 10 metre row) was low in *Heterorhabditis indica* applied twice (1.6) and *Heterorhabditis indica* single application (2.81) followed by *Metarhizium anisopliae* (2.96), *Steinernema* sp. applied twice (3.62), single application *Steinernema sp.* (4.31) and high in untreated control (13.82). In neem cake treatment it was 9.12 per 10 metre row, while in phorate, it was 7.01). Entomopathogenic nematode, *Heterorhabditis indica* gave highest percent reduction in white grub damage over control as two times application (90.25%) and single application (82.88%), followed by *Metarhizium anisopliae* (75.38%) and *Steinernema* sp. two times application (74.89%) compared to phorate (44.12%). Cane yield recorded high in *Heterorhabditis indica* two times application (101.1 t/ha) and *Heterorhabditis indica* single application (99.8 t/ha), followed by *Steinernema* sp. two times application (98.7 t/ha), *Steinernema* sp. single application (98.49 t/ha) and *Metarhizium anisopliae* (97.73 t/ha) compared to phorate (69.74 t/ha) and neem cake (86.02 t/ha), while it was low cane yield in control (47.12 t/ha).

Table 18. Efficacy of entomopathogenic fungi and entomopathogenic nematodes against white grub in sugarcane

Treatments	White grub damage (%)	White grubs / 10 m row*	Per cent reduction in White grub damage over control	Cane yield t/ha
T1: *Beauveria bassiana* @ 5 kg ha^{-1} (1 $x10^8$spores/gm) in 250 kg FYM ha^{-1}	5.12 (12.83)	4.08 (11.59)	68.8	92.82
T2: *Metarrhizium anisopliae* @ 5 kg ha^{-1} (1 $x10^8$spores/gm) in 250 kg FYM ha^{-1}	4.04 (11.35)	2.96 (9.89)	75.38	97.73
T3: *Heterorhabditis sp.* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1}	2.81 (9.64)	2.81 (9.64)	82.88	99.8
T4: *Steinernema sp.* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1}	4.12 (12.59)	3.62 (10.93)	74.89	98.49
T5: *Heterorhabditis indica* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1} two times at two month interval	1.6 (5.82)	1.6 (5.82)	90.25	101.1
T6: *Steinernema sp.* WP @ 20 kg ha^{-1} in 150 kg moist sand ha^{-1} two times at two month interval	4.58 (12.11)	4.31 (11.94)	72.09	98.70
T7: Neem cake @ 500 kg ha^{-1}	11.29 (19.46)	9.12 (17.37)	31.2	86.02
T8: Phorate 10G @ 15kg ha^{-1}	9.17 (17.43)	7.01 (15.32)	44.12	69.74
T9: Untreated control	16.41 (23.77)	13.82 (21.79)		47.12
CD ($P = 0.05$)	5.37	4.33		8.88
CV%	22.15	19.51		5.79

Figures in parenthesis are angular transformed values; *figures in parenthesis are square root transformed values

3.1.3 Bioefficacy of entomopathogenic fungi and entomopathogenic nematodes in suppression of termite in sugarcane (ANGRAU)

The experiment was carried out on sugarcane variety 2008 A 107 at Regional Agricultural Research Station, Anakapalle, and the following treatments were imposed, *viz*., T1: *Beauveria bassiana* @ 5kg ha^{-1} ($1x10^8$ spores/gm) in 250 kg FYM ha^{-1}; T2: *Metarhizium anisopliae* @ 5kg ha^{-1} ($1x10^8$ spores/ gm) in 250 kg FYM ha^{-1}; T3: *Heterorhabditis indica* WP @ 20 kg/ha in 150 kg moist sand ha^{-1}; T4: *Steinernema* sp. WP @ 20 kg/ha in 150 kg moist sand ha^{-1}; T5: neem cake @ 500 kg ha^{-1} at planting; T6: chlorpyriphos 50 TC @ 5 ml L^{-1} Soil drenching at planting and T7: untreated control.

Entomopathogenic fungi, *Beauveria bassiana* and *Metarhizium anisopliae* were mixed with FYM @ 2 kg / 100 kg FYM for 15 days enrichment before soil application. The formulations were obtained from NBAIR.

Results

Sugarcane germination recorded was high in *Metarhizium anisopliae* (58.99 %); *Heterorhabditis indica* (58.07 %) and low in control (49.62%). Bud damage recorded was low in *Metarhizium anisopliae* (40.97%), *Heterorhabditis indica* (41.9%) and *Beauveria bassiana* (42.71%) and high in control (50.35%). Seedling mortality was low in *Heterorhabditis indica* (13.2%); *Steinernema sp* (23.81%) and *Metarhizium anisopliae* (28.08%) compared high plant mortality in control (41.27%). Seed cane yield was recorded significantly high in *Heterorhabditis indica* (67.21 t/ha) followed by *Steinernema* sp. (65.3 t/ha) and *Metarrhizium anisopliae* (57.1 t/ha) compared to low cane yield in control (37.74 t/ha) and chlorpyriphos 50 TC (49.72 t/ha).

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

The following IPM modules were evaluated on sugarcane variety 2000A 56 at RARS, Anakapalle during 2016-17.

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

Results

Early shoot borer incidence (% deadheart) was recorded at 45, 60, 90 and 120 days after planting and internode borerdamage (%) was recorded at harvest. The results revealed that cumulative incidence of early shoot borer was noticed low in Module 6 - trash mulching + *T. chilonis* release @ 75,000/ha from 30 DAP for 6 times and 2 releases after node formation (9.48%) followed by Module 3 - Trash mulching+ *Trichogramma chilonis* release @ 50,000/ha from 30 DAP - 6 releases at 7-10 day interval and 2 releases after node formation (9.85%) (Table 19).

Cumulative incidence of early shoot borer was high in Module 9 - trash mulching (32.76%), Module 8 - trash mulching + soil application of carbofuran at planting and at 90

days after planting (17.0%) and Module 7- trash mulching + soil application of carbofuran at planting (20.05%). Internode borer incidence and intensity recorded low in Module 6 - trash mulching + *T. chilonis* release from 30 DAP - 6 releases at 7-10 day interval and 2 releases after node formation (20.46 % and 1.01%) and module 3 - trash mulching + *T. chilonis* release from 30 DAP for 6 times and 2 releases after node formation (25.0% and 1.18%) compared to Module 9 - trash mulching (40.48 % and 2.74%). Cane yield was

Table 19. Impact of different management module for the sustainable management of sugarcane shoot borers

Module	Cane yield t /ha	Sucrose (%)	NMC '000 /ha	Yield increase (%) over module 9	Cost of input for PP Rs./ha	Additional income Rs/ha	Incremental benefit cost ratio
Module 1 : Trash mulching + *T. chilonis* @ 50,000/ha - 4 releases	102. 17	19.1	57.69	16.3	500.00	34,368	68.74
Module 2 :Trash mulching + *T. chilonis* @ 50,000/ha - 4 + 2 releases	97.39	19.02	67.14	10.86	750.00	22,896	30.53
Module 3 :Trash mulching + *T. chilonis* @ 50,000/ha - 6+2 releases	114.72	19.71	68.25	30.59	1000.00	64,488	64.49
Module 4 :Trash mulching +*T. chilonis* @ 75,000/ha - 4+2 releases	110.21	19.12	65.88	28.25	1125.00	53,664	22.36
Module 5 :Trash mulching + *T. chilonis* @ 75,000/ha from 30 DAP for 6 releases	100.55	18.85	62.3	14.46	1125.00	30,624	27.22
Module 6 :Trash mulching + *T. chilonis* @ 75,000/ha from 30 DAP for 6 + 2 releases after node formation	125.51	19.69	74.44	42.87	1500.00	90,384	60.26
Module 7 :Trash mulching + Soil application of carbofuran 3G @ 33 kg/ha at planting	94.01	19.38	58.18	7.06	3280.00	14,784	4.5
Module 8 :Trash mulching + soil application of carbofuran 3G @ 33 kg/ha at planting and at 90 days after planting	91.06	19.39	55.07	3.66	4580.00	7704	1.68
Module 9: Untreated control (Trash mulching)	87.85	19.18	54.88		-		
CD(P=0.05)	23.51	1.67	14.06				
CV%	13.95	2.98	13.52				

recorded high in Module 6 - trash mulching + *T. chilonis* release from 30 DAP for 6 times and 2 releases after node formation (125.51 t/ha), Module 3 - trash mulching + *T. chilonis* release from 30 DAP for 6 times and 2 releases after node formation (114.72 t/ha) compared to low cane yield in Module 9 - Trash mulching (87.85 t/ha) (Table 19). Module 6 - Trash mulching + *T. chilonis* release from 30 DAP for 6 times and 2 releases after node formation are effective in managing shoot borers in sugarcane with high incremental benefit cost ratio (Table 19).

3.2 Biological control of Cotton Pests

3.2.1 Monitoring biodiversity and outbreaks of invasive mealy bugs on cotton (MPKV, PJTSAU, TNAU, UAS-R)

3.2.1.1 MPKV, Pune

The *Bt* cotton *var*. Jai, Bollgard II were sown on 26/06/2016 at 90x60 cm spacing in 40x40 m plot at Research Farm of Agril. Entomology Section, College of Agriculture, Pune. All the recommended agronomic practices were followed except pesticide application to maintain healthy crop growth. The incidence of cotton mealybug, *Phenacoccus solenopsis* and occurrence of its natural enemies monitored on randomly selected and tagged 25 plants from the plot at fortnightly interval.

The cotton field was under observation a week after germination till harvest of the crop to record incidence of *P. solenopsis* and its natural enemies. The pest incidence was noticed only in four plants in the experimental plot in 41st SMW, *i.e*., 2nd week of October (0.16 nymphs/twig) and persisted till December, 2016 (0.08 mealybug/twig). Maximum mealybug population (1.60 / twig) was recorded during 3rd week of November, 2016. No natural enemies including the parasitoid, *Aenasius arizonensis* (Girault) was not observed in the mealybug colonies. However, the predatory coccinellids, *M. sexmaculata, C. septempunctata* (2.00-2.72 grubs and/or beetles/plant) and chrysopid, *Chrysoperla zastrowi sillemi* (0.22-1.60 eggs and/or grubs/plant) were noticed on the plants during the period of mealybug infestation. However, the parasitism of *Aenasius arizonensis* (Girault) was negligible owing to low population of the mealybugs.

3.2.1.2 PJTSAU, Hyderabad

Fortnightly surveys were conducted in fields /orchards for mealybug incidence in Adilabad, Warangal, Rangareddy and Mahbubnagar districts of Telangana. Infested plant parts were brought back to the laboratory and held under caged conditions for emergence of natural enemies. Alternate host plants were also recorded during the surveys conducted. Specimens of mealy bugs and natural enemies collected were preserved for identification. Crop wise records were maintained for estimating extent of damage by the mealybug and also to quantify level of natural enemies present.

Four species of mealybugs, *viz.*, *Paracoccus marginatus, Maconellicoccus hirsutus*, *Phenacoccus solenopsis,* and *Ferrisia virgata* were recorded. Among them, *P. solenopsis* was the predominant species recorded on cotton. *Paracoccus marginatus* was observed on papaya, tapioca, mulberry, parthenium and other host plants. Largely, three genera of mealybugs, *viz*., cotton mealybug, papaya mealybug and grape mealybug were noticed for their presence in different crop ecosystems. Among them, cotton mealy bug, *Phenacoccus solenopsis* was found to be predominant. The natural enemies recorded are provided in

Table 20. And prominent were *Acerophagus papayae, Cryptolaemus montrouzieri, Scymnus coccivora, Coccinella septumpunctata* and *Chrysoperla* (Table 20).

Table 20. Mealy bug and their natural enemies in Telangana

Sl. No.	Host Crop/Plant	Mealy bug recorded	Natural enemies observed
1.	Cotton	*Phenococcus solenopsis Meconellicoccus hirsutus Paracoccus marginatus*	*Cryptolaemus montrouzieri, Coccinella septumpunctata Chrysoperla, Scymnus coccivora*
2.	Sunflower	*Phenococcus solenopsis Paracoccus marginatus*	*Acerophagus papaya, Chrysoperla*, *Cryptolaemus montrouzieri*, *Scymnus coccivora*, *Menochilus sexmaculatus*
3.	Bhendi	*Phenococcus solenopsis Meconellicoccus hirsutus Paracoccus marginatus*	*Cryptolaemus montrouzieri, Coccinella septumpunctata Chrysoperla, Scymnus coccivora*
4.	Papaya	*Paracoccus marginatus*	*Acerophagus papaya, Chrysoperla*, *Cryptolaemus montrouzieri*, *Scymnus coccivora*, *Menochilus sexmaculatus*
5.	Tapioca	*Paracoccus marginatus*	*Acerophagus papaya, Chrysoperla*, *Cryptolaemus montrouzieri*, *Scymnus coccivora*, *Menochilus sexmaculatus*
6.	Marigold	*Paracoccus marginatus*	*Acerophagus papaya, Chrysoperla*, *Cryptolaemus montrouzieri*, *Scymnus coccivora*, *Menochilus sexmaculatus*
7.	Hibiscus	*Phenococcus solenopsis Meconellicoccus hirsutus Paracoccus marginatus*	*Cryptolaemus montrouzieri, Coccinella septumpunctata Chrysoperla, Scymnus coccivora*
8.	Mulberry	*Meconellicoccus hirsutus Paracoccus marginatus*	*Cryptolaemus montrouzieri, Coccinella septumpunctata Chrysoperla, Scymnus coccivora*
9.	Parthenium	*Phenococcus solenopsis; Meconellicoccus hirsutus Paracoccus marginatus*	*Cryptolaemus montrouzieri, Coccinella septumpunctata Chrysoperla, Scymnus coccivora*
10.	Custard apple	*Paracoccus marginatus*	*Acerophagus papaya, Chrysoperla*, *Cryptolaemus montrouzieri*, *Scymnus coccivora*, *Menochilus sexmaculatus*
11.	Guava	*Meconellicoccus hirsutus*	*Scymnus coccivora,Cryptolaemus montrouzieri, Mallada* sp.
12.	Grape	*Meconellicoccus hirsutus*	*Scymnus coccivora,Cryptolaemus montrouzieri, Mallada* sp.

3.2.1.3 TNAU, Coimbatore

Cotton and other host plants observed during the period under report in Coimbatore, Erode and Tiruppur districts of Tamil Nadu revealed the occurrence of five species of mealybugs, *viz.*, *Paracoccus marginatus, Maconellicoccus hirsutus*, *Phenacoccus solenapsis, Nipaecoccus viridis* and *Ferrisia virgata.* Out of which the predominant species were *Phenacoccus solenapsis* and *Nipaecoccus viridis*. The incidence of papaya mealybug *Paracoccus marginatus* was noted in papaya, cotton, tapioca, mulberry, guava, cocoa and other host plants. The natural enemies, *viz., Acerophagus papayae, Aenasius arizonensis, 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.

3.2.1.4 UAS, Raichur

The incidence of mealy bug was noticed during second week of October (0.08 mealy bugs per 10 cm apical shoot length) and continued till harvest of the crop. The peak activity was noticed first fortnight of January (82.25 mealy bugs per 10cm apical shoot length) and the associated natural enemies population was also more with the incidence of mealybug. The primary parasitoid, *Anesius arizonesis* was high at second week of February (20.75 cocoons / 10 cm apical shoot length) and it has successfully suppressed the mealybug population. Similarly, the peak activity of *A*. *dactylopi* was noticed during first week of January and thereafter decline in population was noticed. Coccinellid activity was coincided with the peak activity of mealybug (Table 21).

Table 21. Monitoring biodiversity and outbreaks for invasive mealy bugs on cotton

Year 2016	Std Week	Mealy bugs per shoot length (10 cm)	Natural Enemies		
			Coccinellids	*Anseius arizonensis*	*Anagyrus dactylopii*
Sept 24-Oct 30	39	0.00	0.00	0.00	0.00
Oct 01-07	40	0.00	0.00	0.00	0.00
Oct 08-14	41	0.08	0.08	0.00	0.00
Oct 15-21	42	0.12	0.10	0.00	0.00
Oct 22-28	43	0.28	0.18	0.00	0.00
Oct 29-Nov 04	44	2.50	0.24	0.05	0.00
Nov 05-11	45	5.50	0.36	0.08	0.00
Nov 12-18	46	8.50	1.08	0.12	0.10
Nov 19-25	47	12.25	1.12	1.50	0.25
Nov 26-Dec 02	48	15.30	1.10	2.25	1.00
Dec 03-09	49	20.50	0.85	4.50	1.25
Dec 10-16	50	22.75	0.90	4.75	1.50
Dec 17-23	51	35.00	1.10	5.05	2.50
Dec 24-31	52	40.50	1.25	6.30	2.85
2017					

Jan 01-07	1	80.50	1.60	15.50	3.75
Jan 08-14	2	82.25	1.50	12.30	3.05
Jan 15-21	3	75.50	1.30	16.20	1.85
Jan 22-28	4	60.00	1.18	17.50	1.70
Jan 29-04	5	35.50	1.20	18.50	1.25
Feb 05-11	6	32.00	1.15	20.50	1.12
Feb12-18	7	30.50	1.10	20.75	1.06
Feb19-25	8	20.75	1.06	18.25	1.02

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

3.2.2.1 MPKV, Pune

Sucking pests' incidence and its natural enemies were recorded from randomly selected and tagged 25 plants from the aforesaid same plot at fortnightly interval. The pest population recorded on three leaves (top, middle, lower portion) per plant. Simultaneously, the natural enemies were also recorded on the plant. The data in Table 22 revealed that the incidence of aphids and thrips was recorded from 1st week of July, 2016 (27th SMW), while jassids and white flies were observed in the subsequent week (28th SMW). All these sucking pests were prevalant during the period from July to December, 2016. The incidence of aphids (12.32-31.40), jassids (3.20-7.12), thrips (5.75-15.32) and white flies (3.40-8.32) per three leaves per plant found relatively high from 1st week of August till end of October, 2016. The natural enemies, *viz.,* coccinellids, *M. sexmaculata* and *C. septempunctata* were recorded from 3rd week of July to 4th week of December, 2016. The highest population of coccinellids (6.32 grubs and/or beetles/plant) was observed 3rd week of September, 2016 (37th SMW). The chrysopid, *Chrysoperla zastrowi sillemi* Esben was noticed from 3rd week of July, 2016 (29th MW) and peak population (2.68 grubs/plant) was recorded in 3nd week of September, 2016. The spiders were noticed through out the crop growth period. The *Aphidius* sp. was recorded parasitizing the aphids on cotton in 3rd week of October, 2016.

Table 22. Incidence of sucking pests and their natural enemies in *Bt* cotton

Date of record		Av. population / 3 leaves / plant						
	Aphids	Jassids	Thrips	White flies	Mealybug	Chrysopid	Coccinellids	Spiders
06.07.2016	1.20	0.00	0.68	0.00	0.00	0.00	0.00	0.00
20.07.2016	3.60	1.92	2.12	1.92	0.00	0.32	2.22	0.33
04.08.2016	12.32	3.20	6.36	3.40	0.00	0.56	3.68	0.55
18.8.2016	22.80	5.12	9.52	6.56	0.00	1.92	4.32	0.68
01.09.2016	31.40	7.12	13.20	7.60	0.00	2.32	4.88	2.12
15.09.2016	25.20	6.52	15.32	7.80	0.00	2.68	6.32	1.68
29.09.2016	19.00	6.20	12.40	8.32	0.00	2.32	5.68	1.00
13.10.2016	14.76	4.60	7.76	7.92	0.16	1.68	4.68	1.00
27.10.2016	19.20	3.52	5.75	5.92	0.38	1.4	2.92	0.67
10.11.2016	9.20	2.80	3.64	4.72	1.20	0.32	0.44	0.33
24.11.2016	4.72	1.4	1.32	2.68	1.60	0.22	0.22	0.22
8.12.2016	2.80	1.32	0.88	2.32	1.20	0.00	0.33	0.22
24.12.2016	1.32	1.00	0.32	0.00	0.08	0.00	0.33	0.33

3.2.2.1 PJTSAU, Hyderabad

The *Bt* cotton plots were monitored at fortnightly intervals for the incidence of sap sucking pests and occurrence of natural enemies. 10 plants per quadrant were observed and data was gathered to study the effect of *Bt* cotton on biodiversity of pests and indigenous fauna of natural enemies. The *Bt* cotton growing areas of Telangana were surveyed for infestation and intensity of sucking pest incidence. The overall scenario showed incidence of Jassids to a greater extent followed by whiteflies and thrips. The associated natural enemies of sucking pests were noticed to be coccinellids followed by chrysopids and spiders (Table 23).

Table 23. Incidence of sucking pests and their natural enemies in *Bt* cotton

Standard week	Average No./3 leaves/plant			Natural enemies (No.)		
	Whiteflies	Jassids	Thrips	Chrysopids	Coccinellids	Spiders
32	0.67	1.80	2.67	0.00	0.00	0.33
34	1.40	2.67	9.80	0.33	1.67	0.67
36	4.80	9.33	16.33	1.67	9.80	1.33
38	2.33	2.80	5.80	2.67	6.33	0.67
40	2.67	1.67	4.33	1.33	2.67	0.80
42	5.33	2.80	8.67	0.67	2.33	0.33
44	2.80	2.67	7.80	0.33	0.67	1.67
46	1.67	2.00	6.67	1.67	0.33	1.00
48	2.33	2.33	5.33	0.00	0.22	0.33
50	1.67	1.67	2.67	0.22	0.00	0.67
52	0.40	1.33	2.33	0.00	0.10	0.33

3.2.2.1 UAS, Raichur

Twenty plants were randomly selected to record the incidence of cotton mirid bug at an interval of fifteen days. Number of mirid bugs was counted on squares and flowers. In each plant five squares and five flowers were observed for the incidence of mirid bugs and later converted to plant basis. The peak activity of mirid bug was noticed during second fortnight of October (3.00 mirid bugs /plant) and thereafter the decline in population was noticed. The incidence of mired bug was noticed on second fortnight of September and continued till second fortnight of November. The predator populations such as coccinellids, chrysoperla and spiders activity had no direct effect on the activity of mirid bug (Table 24).

Table 24. Incidence of mirid bug and its predators on *Bt* cotton ecosystem

Year 2015	Std Week	Number of mirid bugs/plant	Predators per plant		
			Coccinellids	Chrysoperla	Spiders
Aug 27-Sept 02	35	0.00	0.00	0.05	0.00
Sept 03-09	36	0.00	0.00	0.08	0.10
Sept 10-16	37	0.28	0.00	0.00	0.15
Sept 17-23	38	0.35	0.00	0.00	0.10
Sept 24-Oct 30	39	1.25	0.05	0.10	0.10
Oct 01-07	40	1.65	0.05	0.25	0.20
Oct 08-14	41	2.50	0.10	0.30	0.25
Oct 15-21	42	3.00	0.10	0.20	0.25

Oct 22-28	43	1.75	0.05	0.00	0.10
Oct 29-Nov 04	44	1.25	0.15	0.00	0.10
Nov 05-11	45	0.75	0.10	0.00	0.10
Nov 12-18	46	0.25	0.00	0.10	0.25
Nov 19-25	47	0.12	0.00	0.15	0.20
Nov 26-Dec 02	48	0.10	0.00	0.10	0.20
Dec 03-09	49	0.00	0.15	0.08	0.25
Dec 10-16	50	0.00	0.20	0.10	0.20
Dec 17-23	51	0.00	0.15	0.15	0.20
Dec 24-31	52	0.00	0.20	0.10	0.25
2017					
Jan 01-07	1	0.00	0.30	0.00	0.20
Jan 08-14	2	0.00	0.15	0.10	0.20
Jan 15-21	3	0.00	0.10	0.00	0.00

3.2.3 Biological suppression of sap sucking pests on *Bt* cotton (MPKV, Pune; UAS, Raichur)

3.2.3.1 MPKV, Pune

The *Bt* cotton *var*. Jai, Bollgard II was raised separately on the Research Farm of Agril. Entomology Section, College of Agriculture, Pune. Seeds were sown on 26th June, 2016 on ridges and furrows at 90 x 60 cm spacing in 40x40 m size plots. Three sprays were given at fortnightly interval startring from 3rd September, 2016. The sucking pests were recorded from randomly selected and tagged 5 plants per treatment plot in four replicates before treatment and 10 days after each spray. The pest population was recorded from three leaves (terminal shoots) per plant and seed cotton yield was recorded at each pickings.

The pooled means of three post counts were worked out and the data are presented in Table 25. The results show that the treatment with dimethoate 0.05 per cent found significantly superior over all the biopesticides in suppressing the population of sucking pests. It was however, at par with *L. lecanii* (1x10^8 conidia/g). The application of *M. anisopliae* (1x10^{8}conidia/g) was recorded as the next promising treatment. The yield of seed cotton recorded highest (17.60 q/ha) in dimethoate treated plots which was on par with *L. lecanii* (17.26 q/ha). The next effective treatments were *M. anisopliae* (1x10^8 conidia /g) (14.96 q/ha) and NSE 5 per cent (14.20 q/ha).

3.2.3.2 UAS, Raichur

Cotton var. KCH-14K59 Jadoo BG II was selected for the experiment. The treatments imposed were *Metarhizium anisopliae* (1x10^8 conidia/g), *Lecanicillium lecanii* (1x10^8 conidia/g), *Beauveria bassiana* (1x10^8 conidia/g), NSE 1500 ppm, dimethoate 36EC and untreated control. Each of biopesticide / neem / insecticide was sprayed four times during season, on 18-07-2016, 04-08-2016, 18-10-2016 and 06-11-2016. In each treatment five plants were randomly selected to record the incidence of leafhoppers, whitefly and aphids at one day before spray, 10 days and 20 days after each spray. The seed cotton yield was recorded in each treatment and subjected for statistical analysis.

Results

Leafhoppers: Twenty days after spray among the biocontrol agent's minimum leafhopper population of 2.74 per leaf was noticed in *Beauveria bassiana* @ 5gm/l and it was followed by *Lecanicillium lecanii* @ 5gm/l.

Table 25. Effect of biopesticides against sucking pest complex in cotton at Pune

Treatment	Av. sucking pest population / 3 leaves								Yield of seed cotton (q/ha)
	Aphids		Jassids		Thrips		White flies		
	Pre count	Post count	Pre count	Post count	Pre count	Post count	Pre count	Post count	
T_1: *M. anisopliae* (1 x 10^8 conidia /g) @ 5 g/ litre	30.15[a] (5.54)	10.56[b] (3.33)	6.60[a] (2.66)	2.34[b] (1.69)	15.00[a] (3.94)	3.04[b] (1.88)	8.45[a] (2.99)	2.68[b] (1.78)	14.96[a]
T_2: *L. lecanii* (1 x 10^8 conidia /g) @ 5 g/ litre	31.60[a] (5.67)	7.32[a] (2.80)	6.30[a] (2.61)	1.26[a] (1.33)	15.65[a] (4.02)	1.98[a] (1.57)	7.90[a] (2.90)	1.30[a] (1.34)	17.26[a]
T_3: *B. bassiana* (1 x 10^8 conidia /g) @ 5 g/ litre	30.00[a] (5.52)	15.69[c] (4.02)	7.45[a] (2.82)	4.35[c] (2.20)	15.30[a] (3.97)	4.60[c] (2.26)	8.60[a] (3.02)	4.12[c] (2.15)	13.63[b]
T_4: NSE 5%	31.25[a] (5.63)	11.93[b] (3.53)	6.55[a] (2.66)	3.29[b] (1.95)	14.85[a] (3.92)	4.36[b] (2.20)	9.00[a] (3.08)	3.23[b] (1.93)	14.20[a]
$_5$:Dimethoate 0.05%	29.85[a] (5.51)	6.04[a] (2.56)	7.00[a] (2.74)	0.95[a] (1.20)	14.90[a] (3.92)	1.26[a] (1.33)	8.65[a] (3.02)	0.60[a] (1.05)	17.60[a]
T_6: Untreated control	30.65[d] (5.58)	54.87[d] (7.44)	7.60[a] (2.85)	10.68[d] (3.34)	15.20[a] (3.96)	23.87[d] (4.94)	8.70[a] (3.03)	13.98[d] (3.81)	9.58[c]
CD (*P*= 0.05)	(NS)	(0.31)	(NS)	(0.28)	(NS)	(0.37)	(NS)	(0.34)	(3.40)

NS= Non-significant; Figures in parentheses are √ n+ 0.5 transformed values

Whitefly: *Beauveria bassiana* @ 5gm/l recorded lowest population of whitefly (2.36/leaf) and it was followed by *Lecanicillium lecanii* @ 5gm/l at 20 days after sowing.

Aphids: Among the bioagents, *Beauveria bassiana* @ 5gm/l recorded lowest population of aphids (8.24/leaf) and it was followed by *Lecanicillium lecanii* @ 5gm/l at 20 days after sowing.

Yield: The highest seed cotton yield 23.04 q/ha was noticed *Beauveria bassiana* @ 5gm/l and it was followed by *Lecanicillium lecanii* @ 5gm/l. Untreated control recorded minimum seed cotton yield of 16.86 q/ha (Table 26).

3.2.4 Bio-efficacy of microbial insecticides against sucking pests in *Bt* cotton (AAU, Anand)

The experiment was carried out at Agronomy farm, BACA, Anand Agricultural University during *Kharif,* 2016 on Bt. cotton BG-6 in RBD and the following treatments were imposed viz, T_1 *Beauveria bassiana* ($2x10^8$ cfu g^{-1}) @ 30 g /10 litres water, T_2 *Beauveria bassiana* ($2x10^8$ cfu g^{-1}) @ 40 g /10 litres water, T_3 *Lecanicillium lecanii* ($2x10^8$ cfu g^{-1}) @ 30 g /10 litres water, T_4 *Lecanicillium lecanii* ($2x10^8$ cfu g^{-1}) @ 40 g /10 litres water, T_5 *Metarhizium anisopliae* ($2x10^8$ cfu g^{-1}) @ 30 g /10 litres water, T_6 *Metarhizium*

anisopliae ($2x10^8$ cfu g^{-1}) @ 40 g /10 litres water, T_7 Recommended insecticide (Thiamethoxam @ 20 g10/litres water) and T_8 Control (water spray)

Results

The bio-efficacy of microbial insecticides was evaluated against Aphid, *Aphis gosypii*; Jassid, *Amrasca bigutulla bigutulla*; Whitefly, *Bemisia tabaci* and Thrips, *Thrips tabaci.* Considering the pest population in the experimental area, two sprays were given and observations were recorded from three leaves selected at random from five plants in each plot. The results revealed significant lower number of jassids (2.13), whiteflies (2.96), aphids (6.55) and thrips (4.37) were recorded in T_4 – *L. lecanii* (40g/10 l of water) followed by T_3 – *L. lecanii* (30g/10 l of water), T_2 – *B. bassiana* (40g/10 l of water) and T_1- *B. bassiana* (30g/10 l of water). None of the microbial insecticides were found superior to chemical insecticide used. It was found that lowest number of jassids (1.30), whiteflies (1.08), aphids (5.43) and thrips (1.37) were recorded in T_7 - chemical insecticide treated plot. The highest seed cotton yield was obtained in the treatment T_4 – *L. lecanii* (40g/10 l of water) (26.43 q/ha) followed by T_2 – *B.bassiana* (40g/10 l of water) (24.14 q/ha) and T_3 – *L. lecanii* (30g/10 l of water) (23.51 q/ha). However, the highest seed cotton yield was recorded in chemical insecticide (31.26 q/ha) treated plot (Table 27).

3.2.5 Monitoring of whitefly, its natural enemies and pink bollworm in cotton (PAU)

Regular surveys were conducted in cotton growing areas of Punjab (Fazilka, Bathinda, Mansa and Muktsar) and Haryana (Sirsa, Fatehabad) to monitor whitefly population and its natural enemies on cotton crop by the team comprising scientists from PAU campus, Regional Stations, Krishi Vigyan Kendras (KVKs) and Farm Advisory Service Scheme (FASS) centres.

3.2.5.1 Whitefly

The population of whitefly remained below ETH level (6 adults/ leaf) in almost all the cotton growing districts of Punjab except in some villages of Khuhian Sarvar block of Fazilka district (Fig. 8) during June-July. The PAU recommended strategy was successfully implemented in cotton growing areas through the joint efforts of farm experts from PAU and Department of Agriculture (Punjab). The execution of IPM strategy involving regular monitoring and surveillance and timely advisement to farmers regarding non-chemical and chemical approaches did not allow whitefly population to build up and it remained under control during *kharif* 2016 season. As a part of strategy, application of neem based biopesticides (Nimbecidine/Achook) were carried as initial sprays to conserve the natural enemies. Farmers were also acquainted with identification of natural enemies in cotton ecosystem. Besides this, weed eradication campaign and training programmes on cotton production and protection technology were also carried out by PAU and Department of Agriculture in all the cotton growing villages to create the awareness and farm literature regarding whitefly management was also distributed. The cooperation of farmers in execution of whitefly management strategy paid dividends and it was successfully managed through joint efforts.

Table 26. Biological suppression of sap sucking pests on *Bt* cotton at UAS, Raichur

Sl. No.	Treatments	Dosage g/ml/lit	No of leafhoppers per leaf			No. of whitefly per leaf			No. of aphids per leaf			Seed Cotton Yield (q/ha)
			IDBS	10 DAS	20 DAS	IDBS	10 DAS	20 DAS	IDBS	10 DAS	20 DAS	
1	*Metarhizium anisopliae* 1 x 10^8 conidia/g	5.00	12.32 (3.58)	7.18 (2.77)	5.82 (2.51)	4.18 (2.16)	3.36 (1.96)	3.08 (1.89)	20.42 (4.57)	17.38 (4.23)	15.24 (3.97)	20.24
2	*Lecanicillum lecanii* 1 x 10^8 conidia/g	5.00	11.46 (3.46)	5.86 (2.52)	4.36 (2.20)	4.36 (2.20)	2.82 (1.82)	2.42 (1.71)	20.18 (4.55)	11.24 (3.43)	8.38 (2.98)	22.68
3	*Beauveria bassiana* 1 x 10^8 conidia/g	5.00	12.84 (3.65)	3.82 (2.08)	2.74 (1.80)	4.28 (2.19)	2.76 (1.81)	2.36 (1.69)	20.64 (4.60)	11.06 (3.40)	8.24 (2.96)	23.04
4	NSE 5%	3.00	12.92 (3.66)	3.56 (2.01)	2.68 (1.78)	4.42 (2.22)	2.58 (1.75)	2.02 (1.59)	20.44 (4.58)	10.14 (3.26)	7.18 (2.77)	23.18
5	Dimethoate 36 EC	1.75	12.08 (3.55)	2.98 (1.86)	2.06 (1.60)	4.46 (2.23)	2.06 (1.60)	1.98 (1.57)	20.18 (4.55)	10.08 (3.25)	7.06 (2.75)	23.24
6	Untreated Control	-	12.14 (3.56)	12.82 (3.65)	12.86 (3.66)	4.08 (2.14)	4.12 (2.15)	4.16 (2.16)	20.26 (4.56)	20.54 (4.59)	20.82 (4.62)	16.86
S Em $\pm$			0.18	0.08	0.04	0.13	0.04	0.05	0.12	0.03	0.07	0.38
CD (P=0.05)			NS	0.25	0.13	0.40	0.12	0.15	0.36	0.09	0.21	1.14
CV %			10.32	11.04	10.62	10.18	11.04	11.32	11.08	11.46	10.42	11.24

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

Table 27. Impact of microbial insecticides on yield of *Bt* Cotton

Treatments		Cotton Seed yield (q/ha)
T1:	*Beauveria bassiana* @ 30 g /10 litres water	23.11^{bcd}
T2:	*Beauveria bassiana* @ 40 g /10 litres water	24.14^{bc}
T3:	*Lecanicillium lecanii* @ 30 g /10 litres water	23.51^{bcd}
T4:	*Lecanicillium lecanii* @ 40 g /10 litres water	26.43^{b}
T5:	*Metarhizium anisopliae* @ 30 g /10 litres water	20.01^{d}
T6:	*Metarhizium anisopliae* @ 40 g /10 litres water	21.14^{cd}
T7:	Recommended insecticide (Thiamethoxam @ 20 g /10 litres water)	31.26^{a}
T8:	Control (water spray)	16.07^{e}
S. Em. ±		1.08
C. D. at 5%		3.29
C.V. (%)		8.03

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

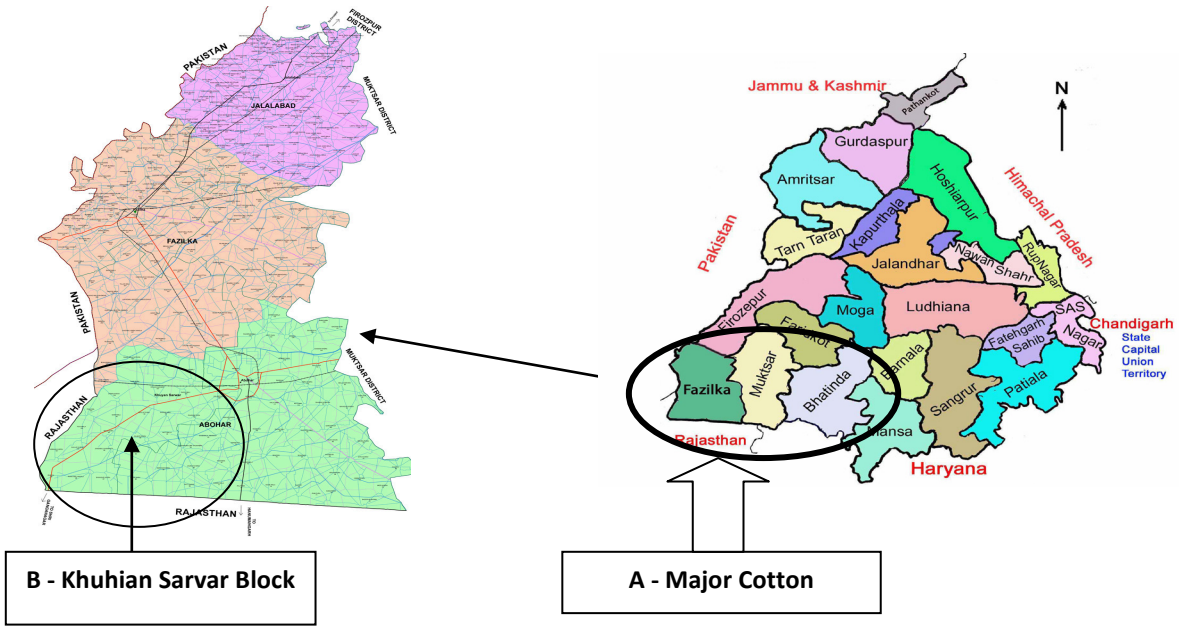


Fig. 8. A - Major cotton growing districts of Punjab; B- Khuhian Sarvar Block of Fazilka District

Predators

Among predators, coccinellids (*Coccinella septempuntata*, *Cheilomenes sexmaculata* and *Brumus suturalis*), green lacewing (*Chrysoperla zastrowi sillemi*), *Zanchius* sp. and spiders were recorded. Out of these, *Chrysoperla* was the predominant species. The population of coccinellids, *Chrysoperla*, spiders and *Zanchius* sp. varied from 0.0 to 1.0, 0.0 to 20.0, 0.0 to 7.5 and 0.0 to 1.0 per 10 plants, respectively. The population of predators was maximum till end July, but declined thereafter.

Parasitoids

Infested cotton leaves (nymphs & pupae of whitefly) were collected and brought to the Biocontrol laboratory to record the emergence of parasitoids. No parasitoid emerged from immature stages (nymphs and pupae) of whitefly collected from field.

3.2.5.2 Pink bollworm

No pink bollworm damage was recorded on Bt cotton crop

3.2.6 Diversity of sucking pests, bollworms and their natural enemies in transgenic Bt and non-Bt cotton (PAU)

Treatments

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

Bt cotton (NCS 855 BGII) and non-Bt cotton (F 2228) was sown at the Entomological Research Farm, Punjab Agricultural University (PAU), Ludhiana on 13th May, 2016 under sprayed and unsprayed conditions. The row-to-row spacing and plant-to-plant spacing was 67.5 and 75 cm for NCS 855 BGII and 67.5 and 60 cm for F 2228, respectively. Each plot was divided into three blocks as replicates. All agronomic practices recommended by PAU, Ludhiana were followed to raise the crop. Under sprayed conditions, imidacloprid 200 SL @ 100 ml/ha and flonicamid 50 WG were sprayed against sucking pests on the basis of the economic threshold level, *i.e.*, downward curling and yellowing of leaves at margins for leafhopper and six adults/ leaf for whitefly. The crop was sprayed three times for the control of bollworms on the basis of ETH level (5 % damage in freshly shed fruiting bodies) on non-Bt cotton. All sprays were done with the help of manually operated knapsack sprayer using 250 litres of water per hectare.

The population of sucking insect pests was recorded from 20 plants selected randomly from 3 fully formed leaves of the upper canopy from each block at weekly interval, *i.e.*, Standard Meteorological Weeks (SMW) throughout the cropping season. Damage by bollworms in green bolls was recorded from 20 randomly selected plants in each block at weekly intervals. *In situ* green bolls were counted from each plant and those showing damage were expressed as per cent green boll damage. Damage in freshly shed fruiting bodies comprising squares, flowers and green bolls was recorded on whole block basis throughout the cropping season at weekly

intervals. The old shed fruiting bodies were removed from each plot 24 hours prior to each observation to ensure the collection of freshly shed fruiting bodies. All the freshly shed fruiting bodies lying on the ground were collected and those showing bollworm damage were counted and per cent damage was worked out. The larval population of American bollworm, *Helicoverpa armigera*, spotted bollworm, *Earias vittella* and spiny bollworm, *E. insulana* was also recorded from 20 plants at weekly interval. Pink bollworm population was recorded from 20 green bolls at 120, 135 and 150 days of the sowing (DAS). The incidence in harvestable bolls was recorded on open boll and loculi basis at harvest from randomly selected 20 plants in each block. The population of predators was recorded on whole plant basis. The immature stages of whitefly were collected and brought to the laboratory to observe the emergence of parasitoids. Seed cotton yield was recorded on whole plot basis.

Among sucking insect pests, leafhopper, *Amrasca biguttula biguttula* and whitefly *Bemisia tabaci* were key pests and remained active throughout the cropping season on both Bt and non-Bt cotton. *Thrips tabaci* population was only observed in early stages of the crop growth, whereas, aphid, *Aphis gossypii* population remained nil throughout the cropping season. Among predators, coccinellids (*Coccinella septempuntata*, *Cheilomenes sexmaculata* and *Brumus suturalis*), green lacewing (*Chrysoperla zastrowi sillemi*), *Geocoris* sp., *Zanchius* sp. and spiders were recorded on both Bt and non-Bt cotton. No parasitoid emerged from immature stages (nymphs and pupae) of whitefly collected from field.

Bt cotton under unsprayed conditions

Under unsprayed conditions, the population of leafhopper, whitefly and thrips on Bt cotton varied from 0.2 to 5.8, 0.5 to 21.8, 0.0 to 9.0 per three leaves, respectively (Table 28). The peak population of leafhopper nymphs (5.8/ 3 leaves) was recorded in 28th SMW (second week of July). The population of whitefly was maximum (21.8/ 3 leaves) during 31st SMW (first week of August). Thrips population showed its peak (9.0/ 3 leaves) during 25th SMW (third week of June). No bollworm incidence was recorded on Bt cotton hybrid throughout the cropping season. Among predators, *Coccinella septempuntata* was predominant species. The population of coccinellids was observed during 29th to 34th SMW. *Chrysoperla* population was the maximum during 29th and 30 SMW. Population of *Geocoris* sp, spiders, and *Zanchius* sp. showed its peak during 29th, 33rd and 34th SMW, respectively on Bt cotton under unsprayed.

Bt cotton under sprayed conditions

Under sprayed conditions, the population of leafhopper, whitefly and thrips on Bt cotton were comparatively lower as compared to unsprayed conditions and it varied from 0.2 to 5.1, 0.3 to 21.4, 0.0 to 8.8 per three leaves, respectively. Similarly the population of predators like coccinellids, *Chrysoperla, Geocoris sp.* and *Zanchius* sp. was also relatively less under sprayed conditions as against unsprayed conditions. It varied from 0.0 to 1.0, 0.0 to 10.0, 0.0 to 4.0, 0.0 to 10.5 and 0.0 to 6.5 per 10 plants, respectively (Table 29). No bollworm incidence was recorded on Bt cotton hybrid throughout the cropping season.

Non-Bt cotton under unsprayed conditions

On non-Bt cotton, the population of leafhopper, whitefly and thrips varied from 0.2 to 6.0, 0.5 to 18.3, 0.0 to 12.7 per three leaves, respectively under unsprayed conditions. The peak population of leafhopper nymphs (6.0/ 3 leaves) was recorded in 28th SMW (second week of July). The population of whitefly adults was above ETH level (6 adults/ leaf) in 31st SMW (first week of August). Thrips population showed its peak (12.7/ 3 leaves) during 25th SMW (third week of June). Among bollworms, *Helicoverpa armigera*, *Earias vittella* and *E. insulana* were observed on cotton crop. Among these, *E. vittella* was the predominant species. Therefore, the damage in green bolls, freshly shed fruiting bodies and open bolls can be attributed primarily to *E. vittella* on non-Bt cotton. Under unsprayed conditions, the peak larval population of *E. vittella* (5.5/10 plants) were recorded in 36th SMW (1st week of September). The damage in freshly shed fruiting bodies and green bolls varied from 0.0 to 31.25 % and 0.0 to 3.90 %, respectively under unsprayed conditions. Among predators, the population of coccinellids was observed during 29th to 34th SMW. *Chrysoperla* population was the maximum during 29th SMW. Population of *Geocoris* sp, spiders, and *Zanchius* sp. showed its peak during 29th, 31st and 35th SMW, respectively on non-Bt cotton under unsprayed conditions (Table 30).

Non-Bt cotton under sprayed conditions

Under sprayed conditions, the population of leafhopper, whitefly and thrips on non-Bt cotton were comparatively lower as compared to unsprayed conditions and it varied from 0.1 to 4.5, 2.0 to 18.1 and 0.0 to 12.3 per three leaves, respectively. The damage in freshly shed fruiting bodies and green bolls varied from 0.0 to 14.58 % and 0.0 to 2.05 %, respectively, under unsprayed conditions (Table 35). Similarly the population of predators like coccinellids, *Chrysoperla, Geocoris sp.*, *Zanchius* sp. and spiders was also relatively less under sprayed conditions as against unsprayed conditions. It varied from 0.0 to 1.5, 0.0 to 3.0, 0.0 to 6.5, 0.0 to 11.0 and 0.0 to 7.5 per 10 plants, respectively.

Pooled data

The overall data based on mean of weekly observations recorded during 2016 have been compiled in Table 31. Based on the pooled mean of two wears (2015 & 2016), the incidence of sucking insect pests was less in sprayed conditions as compared to unsprayed conditions (Table 32). No bollworm incidence was observed on Bt cotton. However, on non-Bt cotton the mean larval population, damage in freshly shed fruiting bodies, green boll damage, damage in open bolls both on boll and loculi basis was comparatively more under unsprayed condition as against sprayed conditions. The seed cotton yield was more in Bt cotton in comparison to non-Bt cotton both under sprayed and unsprayed conditions. The predator population (spiders, coccinellids, *Chrysoperla*, *Geocoris* sp., and *Zanchius* sp) was more in unsprayed conditions as against sprayed conditions on both Bt and non-Bt cotton.

Table 28. Seasonal abundance of sucking insect pests and bollworms in Bt cotton under unsprayed conditions at Ludhiana during 2016

Standard weeks	Sucking insect pests / 3 leaves / plant		
	Leaf-hopper	White- fly	Thrips
23	0.2	2.3	0.4
24	0.7	3.9	4.1
25	1.9	7.3	9.0
26	2.2	2.6	3.0
27	5.1	5.8	1.2
28	5.8	6.9	0.6
29	2.9	5.4	0.4
30	1.5	12.8	0.3
31	4.4	21.8	0.0
32	3.2	13.7	0.0
33	1.8	8.4	0.0
34	0.7	3.7	0.0
35	1.1	1.1	0.0
36	0.7	3.6	0.0
37	0.2	2.7	0.0
38	0.4	4.3	0.0
39	2.0	1.9	0.0
40	0.5	0.5	0.0

Table 29. Seasonal abundance of sucking insect pests and bollworms in Bt cotton under sprayed conditions at Ludhiana during 2016

Standard weeks	Sucking insect pests / 3 leaves / plant		
	Leaf-hopper	White- fly	Thrips
23	0.2	2.1	0.5
24	0.5	4.0	4.1
25	2.0	7.4	8.8
26	2.4	2.5	3.1
27	5.1	3.7	1.4
28	1.0	7.1	1.0
29	1.4	5.5	0.5
30	1.0	10.8	0.4
31	3.7	21.4	0.0
32	0.6	3.5	0.0
33	1.1	3.2	0.0
34	0.6	2.9	0.0
35	1.0	1.0	0.0
36	0.5	2.9	0.0
37	0.2	1.9	0.0
38	0.3	3.8	0.0

Table 30. Seasonal abundance of predators in non-Bt cotton under sprayed conditions at Ludhiana during 2016

Standard weeks	Predators / 10 plants								
	Coccinellids			*Chrysoperla zastrowi sillemi*			*Geocoris* sp.	*Zanchius* sp.	Spiders
	Coccinella septempunctata	*Cheilomenes sexmaculata*	*Brumus suturalis*	*Eggs*	*Larvae*	*Adults*			
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
26	0.0	0.0	0.0	3.0	0.0	0.0	0.0	1.0	1.0
27	0.0	0.0	0.0	1.5	0.0	0.0	1.0	0.0	1.5
28	0.0	0.0	0.0	0.0	0.0	1.5	2.5	1.0	0.5
29	0.0	0.0	0.0	2.0	0.0	0.5	6.5	1.0	2.0
30	1.5	0.5	0.0	2.0	0.0	0.0	4.0	6.5	3.5
31	1.0	1.0	0.0	1.0	1.5	0.0	1.0	5.5	7.5
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	2.0
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	6.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	3.0
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	4.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	2.5
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	3.5
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	2.0
39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0

Table 31: #Overall incidence of insect pests and natural enemy population in Bt and non-Bt cotton under sprayed and unsprayed conditions at Ludhiana during 2016

Parameters	Bt cotton		Non-Bt cotton	
	Unsprayed	Sprayed	Unsprayed	Sprayed
Sucking pests				
Leafhopper (no./3 leaves)	1.94	1.28	2.00	1.30
Whitefly (no./3 leaves)	6.01	4.74	5.88	4.91
Thrips (no./3 leaves)	1.09	1.05	1.77	1.71
Aphid (no./3 leaves)	0.0	0.0	0.0	0.0
Bollworms				
H. armigera / 10 plants	0.0	0.0	0.13	0.04
E. vittella / 10 plants	0.0	0.0	1.71	0.75
E. insulana / 10 plants	0.0	0.0	0.17	0.08
P. gossypiella / 20 green bolls	0.0	0.0	0.0	0.0
FSFB (%)	0.0	0.0	10.75	5.26
E. vittella larvae/ 10 FSFB	0.0	0.0	0.19	0.07
Green boll damage (%)	0.0	0.0	2.24	1.18
Open boll damage (%)	0.0	0.0	20.30	10.42
Loculi damage (%)	0.0	0.0	10.79	5.73
Seed cotton yield (q/ha)	7.99	8.84	4.87	6.63
Predators / 10 plants				
Coccinella septempunctata	0.36	0.11	0.39	0.14
Cheilomenes sexmaculata	0.22	0.11	0.28	0.08
Brumus suturalis	0.03	0.0	0.03	0.0
Chrysoperla zastrowi sillemi				
• Eggs	1.31	0.83	1.06	0.53
• Larvae	0.36	0.11	0.31	0.08
• Adult	0.56	0.17	0.61	0.11
Geocoris sp.	0.89	0.28	0.83	0.33
Zanchius sp.	5.58	3.94	6.75	4.50
Spiders	3.22	2.39	3.33	2.25

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

Table 32. #Overall incidence of insect pests and natural enemy population in Bt and non-Bt cotton under sprayed and unsprayed conditions at Ludhiana (pooled mean of 2015 and 2016)

Parameters	Bt cotton		Non-Bt cotton	
	Unsprayed	Sprayed	Unsprayed	Sprayed
Sucking pests				
Leafhopper (no./3 leaves)	2.08	1.47	2.21	1.56
Whitefly (no./3 leaves)	6.92	4.94	6.54	5.33
Thrips (no./3 leaves)	2.48	2.39	3.63	3.38
Aphid (no./3 leaves)	0.0	0.0	0.0	0.0

Bollworms				
H. armigera / 10 plants	0.0	0.0	0.14	0.06
E. vittella / 10 plants	0.0	0.0	1.86	0.84
E. insulana / 10 plants	0.0	0.0	0.16	0.08
P. gossypiella / 20 green bolls	0.0	0.0	0.0	0.0
FSFB (%)	0.0	0.0	12.20	4.98
E. vittella larvae/ 10 FSFB	0.0	0.0	0.22	0.09
Green boll damage (%)	0.0	0.0	2.12	1.13
Open boll damage (%)	0.0	0.0	22.77	11.69
Loculi damage (%)	0.0	0.0	11.47	5.88
Seed cotton yield (q/ha)	7.29	8.12	6.29	4.67
Predators / 10 plants				
Coccinella septempunctata	0.38	0.17	0.36	0.13
Cheilomenes sexmaculata	0.25	0.11	0.34	0.13
Brumus suturalis	0.05	0.00	0.05	0.0
Chrysoperla zastrowi sillemi				
• Eggs	1.24	0.97	0.98	0.57
• Larvae	0.35	0.17	0.27	0.10
• Adult	0.48	0.14	0.67	0.25
Geocoris sp.	1.00	0.31	0.86	0.45
Zanchius sp.	4.93	3.28	6.07	4.00
Spiders	2.61	1.78	2.70	1.82

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

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

Location: Village Khuban (Fazilka)
Treatments: 3

A. Bio-intensive integrated pest management (BIPM)
- Cultivation of recommended Bt cotton hybrid (RCH 650 BG II)
- Recommended time of sowing (13.5.16)
- Growing rows of sorghum as a barrier crop around cotton fields.
- Application of recommended fertilizers
- Yellow sticky traps @ 50 per ha
- Two Augmentative releases of *Chrysoperla* sp. @ 10,000/ha during last week of June and 2nd week of July
- Spray of botanicals/ microbials
- Neem oil (Azadirachtin 10000 ppm) @ 10 ml/litre
- *Beauveria bassiana* (1×10^8) @ 10 g/litre
- *Lecanicillium lecanii* (1×10^8) @ 10 g/litre

B. Farmer's practice (Chemical control) – 5 sprays
- Thiamethoxam 25 WG @ 40 g/acre (Jassid)

- Ethion 50 EC @ 800 ml/acre
- Triazophos 40 EC @ 600 ml/acre
- Two sprays of Diafenthiuron 50 WP @ 200 g/acre

C. Untreated control

Plot size: BIPM - one acre; FP- one acre; Control- 100 m^2

Each plot was divided into three equal blocks representing replications. The data were recorded on the number of whitefly adults per 3 leaves throughout the cropping season at 10 days interval from 30 plants selected at random from each block. The population of predators was recorded on whole plant basis at 10 days interval. The immature stages of whitefly were collected and brought to the laboratory to observe the emergence of parasitoids. Seed cotton yield was recorded on whole plot basis.

The seasonal abundance of whitefly population in BIPM, chemical control and untreated control has been presented in Fig. 9. Based on the mean of all observations (Table 33), the population of whitefly was 4.82 per 3 leaves in chemical control and 9.43 per 3 leaves in BIPM practices. However, both the treatments were significantly lower than untreated control (16.09/ 3 leaves). The reduction in whitefly incidence was 41.43 and 70.04 per cent in BIPM and chemical control, respectively. The predator population was significantly more in BIPM (1.36/ plant) as compared to chemical control (0.39/ plant) and untreated control (0.98/ plant). The seed cotton yield in BIPM (22.80 q/ha) was at par with chemical control (23.70 q/ha). These yields were significantly better as compared to untreated control (21.30 q/ha). The yield increase in BIPM and chemical control was 7.04 and 11.27 per cent over untreated control, respectively.

Table 33. Effect of BIPM practices on whitefly incidence, predators and seed cotton yield during 2016

Treatments	*Number of whitefly adults/ 3 leaves	Per cent reduction over control	*Number of predators / plant	Seed cotton yield (q/ha)	Per cent increase over control
BIPM	9.43^{b}	41.43	1.36^{a}	22.80^{a}	7.04
Chemical Control	4.82^{a}	70.04	0.39^{c}	23.70^{a}	11.27
Untreated control	16.09^{c}	-	0.98^{a}	21.30^{b}	-

* Mean of 12 observations recorded at 10 days interval; Predators include chrysopids, spiders and coccinellids

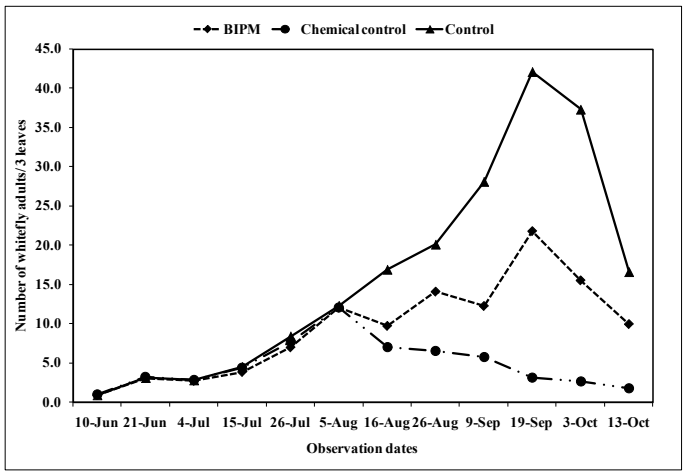


Fig. 9. Seasonal abundance of whitefly in different treatments at village Khuban (Fazilka) during *Kharif*, 2016

Plate 4. Habitat manipulation for the management of *Bemisia tabaci* on cotton at village Khuban (Fazilka)

3.2.8 Field evaluation of biopesticides for the management of whitefly, *Bemisia tabaci* on Bt cotton (PAU)

Two field experiments were conducted during *Kharif* season of 2016 at farmer's field in villages Bakainwala (Block Khuhian Sarvar) and Khuban (Block Abohar), district Fazilka, Punjab to test the efficacy of different biopesticides against cotton whitefly. A randomized block design was used in the experiments, with a plot size of 25 m^2. The cotton variety RCH 650 BG II was sown with inter and intra row spacing of 67.5 x 75 cm. There were 15 treatments in total, each with three replications. The treatments included application of Myco-Jaal 10% SC (*Beauveria bassiana*) @ 800, 1000 and 1200 ml/ha, Varunastra 2% AS (*Lecanicillium lecanii*) @ 800, 1000 and 1200 litres/ha, Kalichakra 1% WP (*Metarhizium anisopliae*) @ 800, 1000 and 1200 g/ha, Neem baan 1% (Azadirachtin 10000 ppm) @ 1000, 1250 and 1500 ml/ha, Oberon 240 SC (spiromesifen) @ 500 ml/ha, Polo 50 WP (diafenthiuron) @ 500 g/ha and untreated control. One spray was applied at Bakainwala and two sprays of biopesticides were applied at Khuban using standard 250 litres of water per ha. Water spray was used for the untreated control. The observations on population of whitefly adults from 3 leaves (top, middle and lower canopy)

of 5 randomly selected plants in each plot were recorded before spray, 7 and 10 days after spray. The seed cotton yield was recorded on whole plot basis.

At village Bakainwala, all the treatments were significantly better than untreated control in reducing the incidence of whitefly in cotton (Table 34). Significantly lower population was recorded in diafenthiuron 50 WP (5.11 and 7.11 adults/ 3 leaves) and spiromesifen 240 SC (5.67 and 7.78 adults/ 3 leaves) at 7 and 10 DAS, respectively. Among the biopesticides/botanicals, lowest incidence was recorded in Neem baan 1% @ 1250 ml/ha (7.67 and 14.78 adults/ 3 leaves at 7 and 10 DAS) and it was at par with its lower dose, i.e. 1500 ml/ha (7.89 and 15.33 adults/ 3 leaves at 7 and 10 DAS). *L. lecanii* 2% AS (1200 ml/ ha) and *M. anisopliae* 1% WP (1200 g/ha) were at par with each other in managing whitefly population. Significantly higher incidence (24.89 and 24.22 adults/ 3 leaves at 7 and 10 DAS, respectively) was recorded in untreated control. Significantly higher seed cotton yield was recorded in diafenthiuron 50 WP (22.48 q/ha) and it was at par with spiromesifen 240 SC (22.15 q/ha), Neem baan 1% (20.57-20.85 q/ha), *L. lecanii* 2% AS @ 1200 ml/ha (20.89 q/ha) and *M. anisopliae* 1% WP @ 1200 ml/ha (20.46 q/ha). Lowest yield was recorded in untreated control (18.02 q/ha).

At village Khuban, all the treatments were significantly better than untreated control in reducing the incidence of whitefly in cotton (Table 35). After 1st spray, significantly lower incidence was recorded in diafenthiuron 50 WP (10.33 and 9.67 adults/ 3 leaves at 7 and 10 DAS, respectively). It was at par with spiromesifen 240 SC, wherein incidence was 11.67 and 10.88 adults/ 3 leaves at 7 and 10 DAS, respectively. Among biopesticides/botanicals, Neem baan 1% @ 1500 ml/ha recorded significantly lower incidence and it was at par with Neem baan 1% @ 1250 ml/ha. Higher doses of *L. lecanii* 2% AS @ 1200 ml/ ha and *M. anisopliae* 1% WP @ 1200 ml/ha were at par with each other in managing whitefly population. Maximum incidence (35.67 and 37.33 adults/ 3 leaves at 7 and 10 DAS, respectively) was recorded in untreated control. Similar trend was observed after 2nd spray. Among biopesticides/botanicals, Neem baan 1% @ 1250 and 1500 ml/ha (13.67 to 15.67 adults/ 3 leaves at 7 and 10 DAS) was significantly better than other treatments. *L. lecanii* 2% AS @ 1200 ml/ ha (17.89 and 16.33 adults/ 3 leaves) and Neem baan 1% @ 1000 ml/ha (18.00 and 16.33 adults/ 3 leaves) were also effective in reducing whitefly. Highest incidence of 30.33 and 24.77 adults/ 3 leaves was recorded in control plots at 7 and 10 DAS, respectively. Significantly higher yield was recorded in diafenthiuron 50 WP (22.78 q/ha) followed by spiromesifen 240 SC (22.50 q/ha). The latter was at par with Neem baan 1% (21.09-21.31 q/ha), *L. lecanii* 2% AS (20.56-21.05 q/ha) and *M. anisopliae* 1% WP (20.55 q/ha). Lowest seed cotton yield was recorded in untreated control (18.28 q/ha).

Table 34. Field evaluation of biopesticides against cotton whitefly at village Bakainwala during 2016

Treatment	Dose (g or ml/ha)	Whitefly population/ 3 leaves			Seed cotton yield (q/ha)
		Before spray	7 DAS	10 DAS	
Beauveria bassiana 10% SC	800	15.44	12.00 (3.60)	19.33 (4.51)	19.31
B. bassiana 10% SC	1000	16.33	11.56 (3.54)	17.89 (4.34)	19.57
B. bassiana 10% SC	1200	16.33	10.78 (3.43)	17.67 (4.32)	20.04

Lecanicillium lecanii 2% AS	800	16.00	10.33 (3.36)	17.85 (4.34)	19.78
L. lecanii 2% AS	1000	16.11	9.67 (3.26)	16.55 (4.18)	20.21
L. lecanii 2% AS	1200	16.45	9.11 (3.18)	16.11 (4.13)	20.89
Metarhizium anisopliae 1% WP	800	14.78	11.22 (3.49)	17.67 (4.32)	19.83
M. anisopliae 1% WP	1000	15.78	10.67 (3.41)	16.33 (4.16)	20.13
M. anisopliae 1% WP	1200	15.67	9.67 (3.26)	15.89 (4.11)	20.46
Neem baan 1% (Azadirachtin 10000 ppm)	1000	16.11	8.56 (3.09)	16.11 (4.14)	20.57
Neem baan 1% (Azadirachtin 10000 ppm)	1250	15.44	7.89 (2.98)	15.33 (4.04)	20.72
Neem baan 1% (Azadirachtin 10000 ppm)	1500	15.67	7.67 (2.94)	14.78 (3.97)	20.85
Spiromesifen 240 SC	500	15.33	5.67 (2.58)	7.78 (2.96)	22.15
Diafenthiuron 50 WP	500	16.44	5.11 (2.47)	7.11 (2.84)	22.48
Untreated Control	-	15.89	24.89 (5.08)	24.22 (5.02)	18.02
CD		NS	(0.23)	(0.27)	2.06

DAS – days after spray; Figures in parentheses are means of square root transformed values

Table 35. Field evaluation of biopesticide against cotton whitefly at village *Khuban* during 2016

Treatment	Dose (g or ml/ha)	Whitefly population/ 3 leaves					Seed cotton yield (q/ha)
		Before spray	After 1st spray		After 2nd spray		
			7 DAS	10 DAS	7 DAS	10 DAS	
Beauveria bassiana 10% SC	800	27.89	24.33 (5.03)	30.33 (5.59)	23.00 (4.90)	19.44 (4.52)	19.54
B. bassiana 10% SC	1000	25.33	22.56 (4.85)	27.66 (5.35)	21.89 (4.78)	18.66 (4.43)	19.78
B. bassiana 10% SC	1200	25.83	21.22 (4.71)	26.88 (5.26)	20.56 (4.63)	17.89 (4.34)	20.37
Lecanicillium lecanii 2% AS	800	29.11	20.89 (4.68)	26.67 (5.14)	19.89 (4.56)	17.44 (4.29)	20.19
L. lecanii 2% AS	1000	26.74	19.22 (4.50)	25.44 (5.06)	18.33 (4.39)	17.00 (4.24)	20.56
L. lecanii 2% AS	1200	23.22	18.00 (4.36)	24.66 (5.32)	17.89 (4.39)	16.33 (4.16)	21.05

Metarhizium anisopliae 1% WP	800	25.22	22.33 (4.83)	27.34 (5.16)	21.89 (4.78)	18.78 (4.45)	19.94
M. anisopliae 1% WP	1000	23.67	21.33 (4.72)	25.67 (5.02)	20.66 (4.65)	17.56 (4.30)	20.18
M. anisopliae 1% WP	1200	26.55	19.89 (4.57)	24.33 (4.96)	20.00 (4.58)	17.33 (4.28)	20.55
Neem baan 1% (Azadirachtin 10000 ppm)	1000	23.33	17.33 (4.28)	23.66 (4.97)	18.00 (4.35)	16.89 (4.22)	21.09
Neem baan 1% (Azadirachtin 10000 ppm)	1250	24.22	16.00 (4.12)	23.67 (4.90)	15.22 (4.02)	15.67 (4.08)	21.20
Neem baan 1% (Azadirachtin 10000 ppm)	1500	28.85	15.67 (4.08)	23.00 (3.55)	13.67 (3.82)	15.00 (4.00)	21.31
Spiromesifen 240 SC	500	25.55	11.67 (3.56)	10.88 (3.44)	8.44 (3.07)	7.67 (2.94)	22.50
Diafenthiuron 50 WP	500	26.67	10.33 (3.37)	9.67 (3.26)	7.78 (2.96)	6.89 (2.81)	22.78
Untreated Control	-	26.00	35.67 (6.05)	37.33 (6.19)	30.33 (5.60)	24.77 (5.08)	18.28
CD		NS	(0.25)	(0.41)	(0.31)	(0.30)	2.08

3.2.9 Evaluation of biopesticides procured from NBAIR against cotton whitefly (2016) (PAU)

The evaluation of microbial bioformulations against cotton whitefly was conducted on cotton variety RCH 650 BG II. Six microbial bioformulations (supplied by NBAIR, Bengaluru) viz. *Beauveria bassiana*, *Lecanicillium lecanii, Metarhizium anisopliae, Isaria fumosoroseus* (F1) - *Isaria fumosoroseus* (F2) and *Isaria fumosoroseus* (F3) along with untreated control were evaluated against cotton whitefly under pot conditions. There were nineteen treatments with five pots per treatment. The bioformulations were sprayed three times at ten days. The data were recorded on adult population 5 and 7 days after spray (DAS). None of the treatment was found to be effective in reducing the incidence of whitefly.

3.2.10 Monitoring and biological suppression of pink bollworm, *Pectinophora gossypiella* (UAS-R)

3.2.10.1 Monitoring of pink bollworm, *Pectinophora gossypiella* through pheromone traps

Three acre for monitoring through trap and 500 sqm for destructive sampling of pink bollworm under unprotected situation. The variety was KCH-14K59 (Jadoo) BG II. Four pink bollworm pheromone traps were installed over an area of 3 acre and the number of moths trapped were counted at weekly interval and expressed as number of moths per trap. In unprotected situation destructive sampling for pink bollworm larvae and locule damage were

recorded by selecting 25 bolls in an area of 500 sqm at weekly interval and expressed as number of larvae per 25 bolls and per cent locule damage per plant.

The moth activity was noticed from second week of August and continued till harvest of the crop. Maximum moth catches were noticed during second week of December (28.75 moths /trap) and it also coincided the highest number of larvae (12.28/25 bolls). Maximum locule damage of of 28.08 per cent was noticed at second week of November (Table 36).

Table 36. Monitoring of pink bollworm, *P. gossypiella* through pheromone trap

Year 2016	Std Week	No. of moths / trap	Pink bollworm larvae / 25 bolls	Locule damage/ plant
Jul02-Jul08	27	0	0	0
Jul09-Jul15	28	0	0	0
Jul16-Jul22	29	0	0	0
Jul23-Jul29	30	0	0	0
Jul30-Aug05	31	3.00	0	0
Aug06-Aug12	32	5.25	1.26	15.34
Aug 13-19	33	7.75	4.21	23.87
Aug 20-26	34	10.5	5.81	24.25
Aug 27-Sept 02	35	8.75	5.96	24.11
Sept 03-09	36	8.5	6.54	24.97
Sept 10-16	37	11.25	6.22	24.31
Sept 17-23	38	12	7.05	25.27
Sept 24-Oct 30	39	8	7.29	25.56
Oct 01-07	40	13.5	8.25	25.98
Oct 08-14	41	15	7.64	26.43
Oct 15-21	42	10	8.14	26.46
Oct 22-28	43	16.75	8.52	27.02
Oct 29-Nov 04	44	8.25	9.56	26.31
Nov 05-11	45	21	9.41	28.01
Nov 12-18	46	22	11.02	28.08
Nov 19-25	47	18.5	11.41	27.84
Nov 26-Dec 02	48	16.25	11.98	26.88
Dec 03-09	49	18	11.72	26.9
Dec 10-16	50	26	12.16	27.04
Dec 17-23	51	28.75	12.28	26.88
Dec 24-31	52	20.25	10.71	26.51
Jan 01-07	1	10.42	9.51	27.33
Jan 8-14	2	8.32	9.76	26.9
Jan 15-21	3	5.12	10.02	27.18
Jan 22-28	4	3.16	9.27	28.18

3.2.10.1 Biological suppression of pink bollworm, *Pectinophora gossypiella*

The cotton variety was KCH-14K59 (Jadoo) BG II wassown on 19th June 2016, quadrate of 200 sqm for each treatment with maize as a border crop. *Trichogrammatoidea bactrae* was released 3 times @ 2.5 lakh/ha at 10 days interval, single release, two releases and three releases, chemical sprays and untreated control. In each treatment five plants were randomly selected to record the per cent recovery of egg parasitoid, *T. bactrae* through sentinel cards at weekly interval. To record the number of pink bollworm larvae and locule damage destructive sampling was followed in each treatment. At picking stage number of good opened bolls (GOB) and bad opened bolls (BOB) were recorded on plant basis and expressed as number of GOB and BOB per plant. Seed cotton yield was recorded in each treatment and expressed as q/ha.

Highest per cent recovery of 29.77 was noticed in continuous release of *T. bactrae* at 45-55, 65-75 and 90-100 days after sowing and it was statistically superior over all the other treatments. Lowest recovery of *T. bactrae* was noticed in chemical control while in no release of *T. bactrae* per cent recovery was 11.15 per cent. Minimum larvae of pink bollworm were noticed in continuous release of *T. bactrae* (4.42/ 25 bolls) while in no release pink bollworm larvae were 10.77 per 25 bolls and it was statistically inferior. Locule damage was also low in continuous release of *T. bactrae* (8.22/plant). Highest GOB (43.62/plant) and lowest BOB (8.78/plant) was noticed in continuous release of *T. bactrae*. Maximum seed cotton yield of 22.40 q/ha was noticed in continuous release of *T. bactrae* and it was at par with T_4 and T_5 which recorded 21.07 and 21.57 q/ha seed cotton yield, respectively. Untreated control (No release) recorded 18.54 q/ha seed cotton yield (Table 37).

Table 37. Biological suppression of pink bollworm, *Pectinophora gossypiella*

Sl.. No	Particulars	Per cent recovery	Pink bollworm larvae / 25 bolls	Locule damage / plant	GOB/ Plant	BOB/ plant	Seed cotton Yield
T_1	Release of *T. bactrae* @ 2.5 lakh/ha at 45-55 DAS	15.55 (23.22)	6.97 (2.73)	13.88 (21.88)	35.95 (6.04)	13.53 (3.75)	19.88
T_2	Release of *T. bactrae* @ 2.5 lakh/ha at 65-75 DAS	16.49 (23.96)	6.43 (2.63)	12.49 (20.70)	37.39 (6.16)	12.92 (3.66)	20.16
T_3	Release of *T. bactrae* @ 2.5 lakh/ha at 90-100 DAS	18.56 (25.52)	6.04 (2.56)	11.18 (19.53)	38.20 (6.22)	12.34 (3.58)	20.38
T_4	T1 followed by T2	20.98 (27.26)	5.72 (2.49)	10.60 (19.00)	38.42 (6.24)	11.75 (3.50)	21.07
T_5	T2 followed by T3	21.44 (27.59)	5.10 (2.37)	10.12 (18.54)	38.61 (6.25)	11.14 (3.41)	21.57
T_6	Continuous three releases (T1, T2, T3)	29.77 (33.07)	4.42 (2.22)	8.22 (16.67)	43.62 (6.64)	8.78 (3.05)	22.40
T_7	Chemical control	4.88 (12.77)	3.83 (2.08)	4.36 (12.05)	52.32 (7.27)	6.41 (2.63)	26.29

T_8	No releases	11.15 (19.51)	10.77 (3.36)	19.22 (26.00)	34.92 (5.95)	17.03 (4.19)	18.54
S Em ±		0.13	0.05	0.31	0.11	0.08	0.46
CD (P=0.05)		0.40	0.16	0.94	0.34	0.13	1.38
CV %		10.08	11.14	10.62	10.08	10.92	11.06

Figures in parentheses are square root transformed values; *figures in parentheses are arcsine transformed values

3.3 Biological control of Tobacco Pests

3.3.1 Bio-intensive integrated management of tobacco aphid, *Myzus nicotianae* Blackman in Central Black Soils of Andhra Pradesh (CTRI, Rajahmundry)

Treatments

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

Replications: 3; Design: RBD; Variety: Siri (FCV); Plot size: 15x15m

Observations

1. Per cent aphid infested plants
2. Aphid population (score) on 5 infested plants (top and middle leaf)
3. Per cent Sooty mold incidence (low, medium and high)
4. Yield parameters of tobacco (green leaf, cured leaf, bright grade, medium grade and low grade)

Methodology

A replicated field trial for the second consecutive year was conducted at CTRI Research Station, Guntur, Andhra Pradesh during 2016-17 for the management of tobacco aphid, *Myzus nicotianae* Blackman. Three modules *viz*., bio, bio + chemical and chemical were tested for preventing aphid infestation in Flue Cured Virginia tobacco variety, Siri. The crop was planted on 18th November, 2016 with the recommended spacing of 70x70 cm. The treatments consisted of maize border (two rows), an entomopathogenic fungus (*Lecanicillium lecanii* @ 10^{13} spores/ha), recommended chemical pesticide (imidacloprid @ 0.03%) and their combinations. The plot with only chemical spray, *viz*., one spray of imidacloprid @ 0.03% and one spray of

thiamethoxam @ 0.02% served as recommended chemical control plot. An unsprayed plot without any border crop was maintained for comparison (control). Two rows of border crop with 30 cm spacing were sown simultaneously with the plantings of tobacco. Sprayings were given at 55 and 65 days after planting (DAP). All other recommended practices were followed to raise the crop. Observations on aphid infested plants and sooty mold incidence were recorded at regular intervals. Aphid population was recorded on five randomly selected plants in each plot and various yield parameters, *viz*., green leaf, cured leaf, bright grade, medium grade and low grade were also recorded. Data recorded on the above observations were analyzed statistically and presented in Tables from 38 to 41.

Experimental results

Aphid infestation

The second year data revealed that all the treatments were significantly superior over control in reducing aphid infestation after 10 days of second spray (Table 38). The per cent reduction of infestation over control ranged from 30.51 to 100. Cent per cent reduction of infestation was recorded in chemical control plot with and without maize border. In control plot (no border and no spray), the per cent aphid infested plants were 23.50. Among other treatments, border crop sprayed with *L. lecanii* @ 10^{13} spores/ha at 55 days and imidacloprid 0.03% at 65 days was superior with 94.34% reduction of aphid infestation followed by the same treatments without border crop (92.21%). Entomopathogenic fungus alone sprayed at 55 and 65 days reduced aphid infestation by 70.21% and border crop alone reduced infestation by 30.51%, whereas, the combination of both bio-agent and border crop reduced aphid infestation by 70.93%.

Aphid population

The aphid population counted on infested plants in each treatment showed similar trend (Table 39). Aphid population was confined to top and middle leaves (1-5 score). After ten days of second spray i.e. 75 DAP, aphid population was nil both on top and middle leaves in chemical control plot with and without border crop. In case of maize border with 2 sprays of bio-agent and maize border with one spray of bio-agent and one spray of insecticide, aphid population was nil on middle leaves and drastically reduced on top leaves also. The population was also less in plot sprayed with *L. lecanii* twice at 55 and 65d with 1.33 and 0.66 scores on top and middle leaves, respectively. In control plot, population scores of 4.00 and 2.66 on top and middle leaves were recorded.

Sooty mold incidence

As aphid population was moderate to high, the level of sooty mold formation was also medium to high. All the treatments were significantly superior over control in reducing sooty mold incidence (Table 40). Sooty mold incidence was zero in the plots received either two sprays or one spray of pesticide in combination with maize border or entomopathogenic fungus or both. The incidence of other viral diseases was nil. In control plot, sooty mold incidence was high (21.33%) followed by maize border alone (14.00%), bio-agent alone (5.66%) and border crop + bio-agent (4.00%).

Yield

Green leaf and cured leaf yields were significantly more in treatments over control. In case of cured leaf, bright grades were more in treatment plots, whereas, low and medium grade yields were more in control plot (Table 41). Highest yields of 12900, 1872 and 1175 kg/ha of green leaf, total cured leaf and bright leaf, respectively were recorded in chemical control plot with border crop, whereas, lowest yields of 11930, 1705 and 885 kg/ha of green leaf, total cured leaf and bright leaf were recorded in control plot. In all the remaining treatments, green leaf and total cured leaf yields varied from 12160 to 12850 and 1720 to 1860 kg/ha, respectively.

Pooled analysis

The data recorded during two years i.e. 2015-16 & 2016-17 were pooled and analyzed statistically (Table 42). All treatments were significantly superior over control. Aphid infestation was nil and cured leaf yields were more i.e. 1945 and 1941 kg/ha in chemical control plot with and without border crop, respectively. Bio-intensive plot with border crop, entomopathogenic fungi and one spray of insecticide was on par with chemical control plots where, aphid infestation was reduced to 95.10% and yields were more (1902 kg/ha). There was no significant difference between two seasons in respect of aphid infested plants, aphid population on infested plants and sooty mold incidence. However, yields were significantly more during first year (2015-16) than second year (2016-17) because of the difference in rainfall amount received and pattern of rainfall. From the above two years data it can be stated that bio-intensive IPM module with two rows of maize border as barrier crop, one spray of *Lecanicillium lecanii* @ 10^{13} spores /ha at 55 DAP and one spray of imidacloprid @ 0.03% at 65 DAP exhibited 95.10% reduction of infestation by tobacco aphid, *Myzus nicotianae* Blackman and 5.26% increase of cured leaf yields over untreated control which was on par with recommended chemical control practice.

Table 38. Integrated management of aphid infestation - % infested plants (2016-17)

Sl. No.	Treatments	Aphid infested plants (%)			Per cent reduction of infestation over control at 75 days
		Pre count (55 days)	10 days after 1st spray (65days)	10 days after 2nd spray (75days)	
1	Maize border (2 rows) + *L. lecanii* @10^{13} spores/ha at 55 & 65 days	8.66	7.00	6.83	70.93
2	Maize border + *L. lecanii* @10^{13} spores/ha at 55 days+ imidacloprid 0.03% at 65 days	9.00	8.33	1.33	94.34
3	Maize border + imidacloprid 0.03% at 55days + thiamethoxam 0.02% at 65 days	9.33	3.83	0.00	100.00
4	Maize border (2 rows)	8.00	11.83	16.33	30.51
5	*L. lecanii* @10^{13} spores/ha at 55& 65 days	12.83	10.66	7.00	70.21
6	*L. lecanii* @10^{13} spores/ha at 55 days + imidacloprid 0.03% at 65 days	13.00	9.33	1.83	92.21
7	Imidacloprid 0.03% at 55 days + thiamethoxam 0.02% at 65 days	12.33	3.66	0.00	100.00
8	Control (no border & no spray)	12.66	17.00	23.50	-
	S.Em±	0.85	0.53	0.36	2.46
	C.D at 5%	2.46	1.53	1.05	7.14
	C.V (%)	8.54	7.95	7.35	11.32

Table 39. Integrated management of aphid infestation - aphid population (2016-17)

Sl.No.	Treatments	Aphid population (score)					
		Pre count (55 days)		10 days of 1st spray (65 days)		10 days of 2nd spray (75days)	
		Top leaf	Middle leaf	Top leaf	Middle leaf	Top leaf	Middle leaf
1	Maize border (2 rows) + *L. lecanii* @10^{13} spores/ha at 55 & 65 days	2.00	0.83	1.33	0.66	1.00	0.00
2	Maize border + *L. lecanii* @10^{13} spores/ha at 55 days+ imidacloprid 0.03% at 65 days	1.66	1.00	1.66	0.66	0.66	0.00
3	Maize border + imidacloprid 0.03% at 55days + thiamethoxam 0.02% at 65 days	1.83	1.33	0.66	0.00	0.00	0.00
4	Maize border (2 rows)	2.00	1.33	3.00	2.00	3.33	2.00
5	*L. lecanii* @10^{13} spores/ha at 55 & 65 days	2.66	1.00	2.00	1.33	1.33	0.66

6	*L. lecanii* @10^{13} spores/ha at 55 days + imidacloprid 0.03% at 65days	3.00	1.66	2.00	1.00	1.00	0.66
7	Imidacloprid 0.03% at 55 days + thiamethoxam 0.02% at 65 days	2.83	1.33	1.00	0.33	0.00	0.00
8	Control (no border & no spray)	2.66	1.33	3.33	2.00	4.00	2.66
	S.Em±	0.18	0.23	0.07	0.12	0.07	0.06
	C.D at 5%	0.50	NS	0.20	0.30	0.20	0.17
	C.V (%)	11.20	18.15	7.50	10.55	10.70	8.74

Aphid score

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

Table 40. Integrated management of aphid infestation - sooty mold incidence (2016-17)

Sl. No.	Treatments	Per cent sooty mold infested plants			
		Total	Low	Medium	High
1	Maize border (2 rows) + *L. lecanii* @10^{13} spores/ha at 55 & 65 days	4.00 (11.47)	2.66 (9.36)	1.33 (6.54)	0.00 (0.00)
2	Maize border + *L. lecanii* @10^{13} spores/ha at 55 days+ imidacloprid 0.03% at 65 days	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
3	Maize border + imidacloprid 0.03% at 55days + thiamethoxam 0.02% at 65 days	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
4	Maize border (2 rows)	14.00 (22.37)	2.33 (8.74)	6.66 (14.78)	5.00 (12.88)
5	*L. lecanii* @10^{13} spores/ha at 55 & 65 days	5.66 (13.76)	3.66 (11.02)	2.00 (8.13)	0.00 (0.00)
6	*L. lecanii* @10^{13} spores/ha at 55 days + imidacloprid 0.03% at 65days	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
7	Imidacloprid 0.03% at 55 days + thiamethoxam 0.02% at 65 days	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
8	Control (no border & no spray)	21.33 (27.50)	4.00 (11.48)	4.66 (12.42)	12.66 (20.83)
	S.Em±	0.36	0.25	0.70	1.69
	C.D at 5%	1.04	0.73	2.03	4.90
	C.V (%)	9.27	6.93	16.18	21.85

Figures in parentheses are arc sine transformed values

Table 41. Integrated management of aphid infestation - yield (kg/ha) during 2016-17

Sl. No.	Treatments	Green leaf	Cured leaf	Bright grade	Medium grade	Low grade
1	Maize border (2 rows) + *L. lecanii* @10^{13} spores/ha at 55 & 65 days	12190	1775	1075	465	235
2	Maize border + *L. lecanii* @10^{13} spores/ha at 55 days+ imidacloprid 0.03% at 65days	12400	1820	1095	510	215
3	Maize border + imidacloprid 0.03% at 55 days + thiamethoxam 0.02% at 65 days	12900	1872	1175	592	105
4	Maize border (2 rows)	12525	1720	930	410	380
5	*L. lecanii* @10^{13} spores/ha at 55 & 65 days	12160	1750	1010	450	290
6	*L. lecanii* @10^{13} spores/ha at 55 days + imidacloprid 0.03% at 65 days	12580	1835	1080	490	265
7	Imidacloprid 0.03% at 55 days + thiamethoxam 0.02% at 65 days	12850	1860	1150	590	120
8	Control (no border & no spray)	11930	1705	885	405	415
	S.Em±	59.70	8.16	6.83	4.72	3.55
	C.D at 5%	173.15	23.66	19.80	13.70	10.30
	C.V (%)	9.83	7.45	8.20	8.92	9.15

Table 42. Integrated management of tobacco aphid *Myzus nicotianae* – pooled data

Sl. No.	Treatments	Mean reduction of aphid infested plants (%)	Mean aphid population on top leaf (score)	Mean sooty mold affected plants (%)	Mean cured leaf yield (kg/ha)
1	Maize border (2 rows) + *L. lecanii* @10^{13} spores/ha at 55 & 65 days	72.50	0.83	4.67 (12.53)	1868
2	Maize border + *L. lecanii* @10^{13} spores/ha at 55 days+ imidacloprid 0.03% at 65 days	95.10	0.50	0.00 (0.00)	1902
3	Maize border + imidacloprid 0.03% at 55days + thiamethoxam 0.02% at 65 days	100.0	0.00	0.00 (0.00)	1945
4	Maize border (2 rows)	33.1	3.17	13.83 (21.95)	1828
5	*L. lecanii* @10^{13} spores/ha at 55 & 65 days	66.66	1.08	6.33 (14.50)	1850
6	*L. lecanii* @10^{13} spores/ha at 55 days + imidacloprid 0.03% at 65days	91.90	0.92	0.00 (0.00)	1905
7	Imidacloprid 0.03% at 55days + thiamethoxam 0.02% at 65 days	100.0	0.00	0.00 (0.00)	1941
8	Control (no border & no spray)	-	3.92	22.17 (28.10)	1807

	S.Em±	2.33	0.07	0.38	8.60
	C.D at 5%	6.74	0.20	1.11	24.92
	C.V (%)	9.60	11.39	9.13	7.20
Seasons		80.05	1.19	6.12	1970
2015-16		79.74	1.42	(9.88)	1792
2016-17				5.62	
				(9.39)	
	S.Em±	1.75	1.06	0.52	14.32
	C.D at 5%	NS	NS	NS	41.50
Seasons x Treatments					
	S.Em±	1.14	0.72	0.40	10.18
	C.D at 5%	3.30	2.08	1.16	29.40

Figures in parentheses are arc sine transformed values

3.4 Biological control of Rice Pests

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

Two entomopathogenic fungi, namely, *Beauveria bassiana* (local isolate) and *Metarhizium anisopliae* were evaluated at three different doses each along with ICAR- NBAIR strain of *B.bassiana* against rice bug, *Leptocorisa oratorius*. The experiment was conducted at farmer's field at Valliyode, Vadakkenchery, Palghat District (Fig. 10) during the period from July to October, 2016 as per the details given below.

Name and address of the farmer: Sri Radhakrishnan, Valliyode, Vadakkencherry
Treatments: 11
Replication: 3
Plot size: 5x4 m2
Location: Vadakkenchery

Treatments

T1: *Beauveria bassiana* (local isolate) @ $2x10^7$ spores/ml
T2: *B.bassiana* (do) @ $2x10^8$ spores/ml
T3: *B.bassiana* (do) @ $2x10^9$ spores/ml
T4: *Metarhizium anisopliae* @ $2x10^7$ spores/ml
T5: *M. anisopliae* @ $2x10^8$ spores/ml
T6: *M. anisopliae* @ $2x10^9$ spores/ml
T7: *B. bassiana* (NBAIR strain) @ $2x10^7$ spores/ml
T8: *B.bassiana* (do) @ $2x10^8$ spores/ml
T9: *B.bassiana* (do) @ $2x10^9$ spores/ml
T10: Malathion @ 500 g a.i ha^{-1}
T11: Untreated control

The treatments were applied twice at 15 days interval starting from 67 days after transplantation, after recording the average bug population/m^2. Yield was recorded after harvest. The results are presented in Table 43.

There were no significant differences between treatments in terms of mean bug population, five and ten days after the first spray. However, ten days after treatment, the lowest

population of 9.0 bugs /m^2 was recorded in plots treated with *B. bassiana* (NBAII strain) @10^9 spores/ml. This was followed by *B. bassiana* (local isolate) *and Metarhizium anisopliae* (both applied at @ 10^9 spores/ml), both recorded an identical bug population of 12.33/m^2. Untreated plots recorded the highest mean population of 23 bugs/m^2.

Fifteen days after first spray, malathion (500g a.i/ha) recorded the lowest mean bug population of 8.33 bug/m^2 and was significantly superior to all other treatments. This was followed by *B. bassiana* (NBAIR strain) with 9.33 bugs/m^2 at a concentration of 10^9 spores/ml.

The mean bug population showed no significant difference between treatments either at five or ten days after the second spray. However, the lowest bug population of 2/m^2 was recorded in the case of *B. bassiana* (NBAII strain) applied @10^9 spores/ml, followed by malathion, applied @ 500g a.i ha^{-1}, with a mean count of 2.67 bugs/m^2.The above treatments continued to record lowest mean bug population 10 days after second spray as well, with malathion and the fungus recording values of 6.33 and 8.00 bugs/m^2, respectively. Significant differences could not be observed between the different treatments in yield. The highest yield of 0.72 kg/m^2 was recorded in case of plots treated with *M. anisopliae* (10^9 spores/ml), followed by *B. bassiana* (NBAIR strain) applied @ 10^8 spores/ml (0.67 kg/m^2).

Fig. 10. View of the experimental plot at Velliyode, Vadakkenchery

Table 43. Effect of entomopathogenic fungi on rice bug, *Leptocorisa oratorius* population

Treatment	Pre count	Mean number of bugs/m^2 after first spray			Mean number of bugs/m^2 after second spray		Yield (kg/m^2)
		5 DAT	10 DAT	15 DAT	5 DAT	10 DAT	
T1: Metarhizium anisopliae @10^7 spores/ml	19.67 (4.40)	11.33 (3.30)	16.33 (4.00)	9.67 (0.70)	11.67 (2.60)	3.67 (1.77)	0.43 (13.84)
T2: *M. anisopliae* @ 10^8 spores/ml	15.33 (3.92)	12.33 (3.40)	12.33 (3.58)	12 (4.16)	4.67 (2.24)	4.33 (1.78)	0.48 (22.26)
T3: *M. anisopliae* @10^9 spores/ml	19.67 (4.06)	13.00 (3.60)	16.00 (3.84)	9.67 (2.72)	21.33 (3.71)	9.00 (2.90)	0.72 (25.35)
T4: *Beauveria bassiana* (local isolate) @ 10^7 spores/ml	3.33 (1.73)	11.00 (3.28)	15.00 (3.78)	18.00 (3.71)	17.00 (3.66)	2.33 (3.97)	0.49 (22.01)
T5: *B.bassiana* (local isolate) @10^8 spores/ml	11.00 (3.36)	20.00 (4.45)	15.33 (3.97)	12.33 (3.50)	19.00 (4.36)	9.67 (3.47)	0.55 (24.20)

T6: *B.bassiana* (local isolate) @109 spores/ml	26.33 (5.16)	11.00 (3.24)	12.33 (3.56)	18.67 (3.40)	7.33 (2.67)	10.00 (2.34)	0.60 (23.34)
T7: *B.bassiana* (NBAIR Strain) @ 10^7 spores/ml	14.00 (3.50)	16.00 (3.88)	12.00 (3.41)	12.33 (4.49)	18.67 (3.22)	7.33 (2.91)	0.58 (24.39)
T8- *B.bassiana* (NBAIR Strain) @10^8 spores/ml	18.33 (4.19)	11.00 (3.26)	16.00 (3.95)	10.67 (2.87)	6.33 (3.59)	9.67 (2.69)	0.67 (25.95)
T9- *B.bassiana* (NBAIR Strain) @10^9 spores/ml	17.33 (4.15)	12.67 (3.54)	9.00 (3.06)	9.33 (2.91)	2.00 (1.97)	8.00 (3.26)	0.42 (21.58)
T10: Malathion @ 2ml/l	12.67 (3.60)	21.67 (4.61)	14.33 (3.68)	8.33 (3.53)	2.67 (1.44)	6.33 (1.86)	0.60 (24.20)
T11: Control	13.00 (3.17)	14.00 (3.66)	23.00 (4.79)	21.33 (2.77)	13.67 (2.48)	10.33 (3.37)	0.45 (21.47)
CD at 10%	NS	6.6	NS	0.57	NS	NS	NS

* Values indicate mean no of bugs/m2 (Values in parentheses are square root transformed values)

3.4.2 Natural enemy complex of rice yellow stem borer and leaf folder (PAU)

The seasonal incidence of sucking as well as lepidopteran pests was recorded on rice variety *Pusa Basmati* 1121 at Entomological Research Farm, Punjab Agricultural University, Ludhiana. The crop was sown in first week of June, 2016 and was transplanted in first week of July, 2016. The seedlings were transplanted with inter and intra row spacing of 20x15 cm. 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. Observations were recorded from 20 randomly selected plants at weekly interval for natural enemies' population starting after 30 days of transplanting. The population of predators was recorded on whole plant basis. The population of spiders was also recorded using pit fall traps. Different life stages i.e. egg, larvae and pupae of rice stem borer and leaf folder were collected and brought to the laboratory to record parasitism.

Among predators, population of dragonflies, damselflies, coccinellids and spiders were recorded (Table 44). The population of dragonflies and damselflies varied from 0.0 to 0.3 and 0.0 to 1.1 per plant, respectively. The population of spiders varied from 0.1 to 1.0 spiders per plant during the season with maximum population (1.0 spiders/plant) during 37th SMW (2nd week of September). The population of spiders in pitfall collection varied from 0.0 to 5.6 spiders/trap during the season with maximum population (5.6 spiders/trap) during 37th SMW (2nd week of September).

Among the parasitoids, eight species were found associated with stem borer and leaf folder (Table 45). Three species of egg parasitoids, namely, *T. chilonis*, *T. japonicum* and *Telenomus* sp were recorded from stem borer only. The natural parasitism in the eggs of stem borer ranged from 3.96 to 18.02 per cent. *Stenobracon nicevillei* was recorded from stem borer larvae and *Cotesia* sp was recorded from leaf folder larvae. *Bracon* sp was associated as larval parasitoid with both stem borer and leaf folder and the parasitism in the larvae of these pests varied from 2.39 to 5.60 per cent. Among the pupal parasitoids, *Tetrastichus* sp. was recorded from the pupae of stem borer as well as leaf folder, whereas *Xanthopimpla* sp. was recorded from pupae of stem borer only. The parasitism varied from 1.43 to 3.88 per cent in the pupae of stem borer and leaf folder.

Table 44. Seasonal abundance of sucking insect pests and their natural enemies in rice under unsprayed conditions at Ludhiana during 2016

Standard Met. Weeks	Predators population/plant			Pitfall collection
	Dragonfly	Damselfly	Spiders	Spiders/ trap
32	0.1	0.0	0.2	0.1
33	0.0	0.1	0.4	1.2
34	0.1	0.4	0.1	1.6
35	0.0	0.0	0.7	0.2
36	0.1	1.1	0.2	0.7
37	0.3	0.8	1.0	5.6
38	0.0	0.6	0.2	3.4
39	0.1	0.0	0.0	0.2
40	0.0	0.0	0.0	0.8

Table 45. Parasitoids of rice stem borer and leaf folder at Ludhiana during 2016

Parasitoids	Host	Parasitism (%)
Egg Parasitoids		
Trichogramma chilonis	*Scirpophaga incertulas*	5.78
T. japonicum	*S. incertulas*	3.96
Telenomus sp	*S. incertulas*	18.02
Larval Parasitoids		
Stenobracon nicevillei	*S. incertulas*	4.48
Bracon sp	*S. incertulas* & *C. medinalis*	2.39
Cotesia sp	*Cnaphalocrocis medinalis*	5.60
Pupal Parasitoids		
Tetrastichus sp	*S. incertulas* & *C. medinalis*	3.88
Xanthopimpla sp	*S. incertulas*	1.43

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

The mean incidence of insect pests and natural enemies in organically as well as conventionally (chemical control) grown *basmati* rice was recorded at village Sahauli (Patiala). The area was divided into two blocks representing two treatments, i.e. T1 – organic and T2 - conventional of 1 acre each. T1 and T2 fields were divided into three blocks representing replications. All the observations were recorded from randomly selected 20 hills from each block. The observations on stem borers infestation (dead hearts), leaf folder damage leaves (at least 1/3rd leaf area damaged) and plant hopper population were recorded at weekly intervals starting from 30 DAT. White ears incidence by stem borers was recorded one week before the harvest of the crop. The population of predators was recorded on whole plant basis as well as through sweep nets. The population of spiders was also recorded using pit fall traps. Different

life stages i.e. egg, larvae and pupae of rice stem borer and leaf folder were collected and brought to the laboratory to record parasitism.

The overall incidence of rice stem borer and leaf folder was less in conventionally managed fields as compared to organic fields (Table 46). The mean dead heart incidence was 4.60 and 4.06 per cent in organic and conventional fields, respectively. The mean incidence of white ears was 5.11 and 2.82 per cent in organic and conventional fields, respectively. Similarly, leaf folder damage in organic fields was 2.29 as compared to 0.94 per cent in conventional fields. The population of plant hoppers was 4.36/hill in organic and 4.87/hill in conventional fields. However, the population of natural enemies was high in organic fields than in conventional fields. The population of spiders on whole plant basis was 0.45 and 0.10 spiders per hill in organic and conventional fields, respectively. The population of spiders in pitfall collection was high in organic fields (1.00 spiders/trap) during the season as compared to conventional fields (0.67 spiders/trap). The similar trend was observed in sweep net collection wherein the mean population of spiders (6.33/plot), dragonflies (1.67/plot) and damselflies (3.26/plot) was higher than in conventional plots (Table 47). The corresponding figures in conventional plots were 4.07, 0.24 and 0.98 per plot, respectively.

Natural parasitism of major insect pests in organically as well as conventionally grown rice revealed that parasitism in the eggs, larvae and pupae of stem borer and leaf folder ranged from 1.97 to 20.18 and 0.31 to 2.44 per cent in organic and conventional rice, respectively (Table 48). Parasitoids like *T. chilonis*, *T. japonicum*, *Telenomus* sp were recorded from the eggs of *S. incertulas. Telenomus* sp was most dominant with highest parasitism in organic (20.18%) and conventional fields (2.44%). Larval parasitoids namely, *Stenobracon nicevillei*, *Bracon* sp and *Cotesia* sp were recorded from stemborer and leaf folder larvae. The per cent parasitism by these parasitoids varied from 3.19 to 5.01 and 1.81 to 2.12 in organic and conventional fields, respectively. Pupal parasitoids, *Tetrastichus* sp, *Brachymeria* sp and *Xanthopimpla* sp were recorded from stem borer and leaf folder pupae with per cent parasitism ranging from 1.97 to 4.04 and 0.31 to 2.16 in organic and conventional fields, respectively.

Table 46. Mean incidence of insect pests and natural enemy count in organic and conventional rice at village Sahauli during 2016

Particulars	Organic	Conventional
Dead hearts (%)	4.60	4.06
White ears (%)	5.11	2.82
Leaffolder damaged leaves (%)	2.29	0.94
Plant hoppers (No./ hill)	4.36	4.87
Spiders (No./ hill)	0.45	0.10
Pitfall catch (spiders/ trap)	1.00	0.67

* Average of weekly observations; White ears one week before the harvest of the crop

Table 47. Diversity of natural enemies in sweep net in organic and conventional rice plots at village Sahauli during 2016

Natural enemies	Mean* no. of natural enemies/plot	
	IPM	Conventional
Spiders	6.33	4.07
Dragonflies	1.67	0.24
Damselflies	3.26	0.98

*Mean of eight observations

Table 48. Parasitism level of rice stem borer and leaf folder in organic and conventional *basmati* rice at Sahauli during 2015

Parasitoids	Host	Parasitism (%)	
		Organic	Conventional
Egg Parasitoids			
Trichogramma chilonis	*S. incertulas*	5.84	1.64
T. japonicum	*S. incertulas*	3.63	0.97
Telenomus sp.	*S. incertulas*	20.18	2.44
Larval Parasitoids			
Stenobracon nicevillei	*S. incertulas*	5.01	1.83
Bracon sp.	*S. incertulas* & *C. medinalis*	3.19	2.12
Cotesia sp.	*C. medinalis*	5.27	1.81
Pupal Parasitoids			
Tetrastichus sp.	*S. incertulas* & *C. medinalis*	4.04	2.16
Brachymeria sp.	*S. incertulas* & *C. medinalis*	1.97	0.82
Xanthopimpla sp.	*S. incertulas*	2.08	0.31

Pooled (2015 and 2016)

The pooled analysis of two years (2015 & 2016) revealed that dead hearts, white ears, per cent leaves folded was significantly lower in conventional fields than in organic practices (Table 49). However, lower plant hoppers' population was recorded in organic fields than in conventional practices. Higher populations of natural enemies were observed in organic practices than in conventional practices.

Table 49. Mean incidence of insect pests in organic and conventional fields in *basmati* rice during 2015 & 2016 (pooled)

Treatment	Dead hearts (%)	White ears (%)	Leaffolder damaged leaves (%)	Plant hoppers (No./ hill)	Mean* no. of natural enemies/plot		
					Spider	Dragonfly	Damselfly
Organic	4.12	4.08	2.33	2.18	5.34	1.50	5.13
Conventional	3.60	2.69	1.02	2.44	5.20	0.96	2.12

3.4.4 Seasonal abundance of predatory spiders (PAU)

Regular surveys were conducted to collect spiders from rice growing areas (Ludhiana, Patiala, Sangrur, 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. A total of nine species were recorded from the rice fields. The detail of relative abundance is given in Table 50. *Neoscona* sp. was the predominant species (74.48%) at all the locations followed by *Tetragnatha javana* (13.54%). Species diversity (0.929) was calculated as per Shannon-Weiner index of diversity. Species evenness (0.404) and dominance index (0.596) was worked out as per formulae given by Krebs and Southwood, respectively. H (diversity index): 0.929388, species evenness: 0.403628; dominance index: 0.596372.

Table 50. Diversity of spiders in rice during 2016

Sl. No.	Species	Family	Relative abundance (%)
1	*Neoscona* sp.	Araneidae	74.48
2	*Tetragnatha javana*	Tetragnathidae	13.54
3	*Tetragnatha maxillosa*	Tetragnathidae	5.73
4	*Argiope catenulate*	Araneidae	2.08
5	*Leucage venusta*	Tetragnathidae	1.56
6	*Oxyopes salticus*	Oxyopidae	1.04
7	*Thomisus* sp.	Thomisidae	0.78
8	*Dolomedes fimbriatus*	Pisauridae	0.52
9	*Bianor* sp.	Salticidae	0.26

3.5 Biological control of Maize Pests

3.5.1 Bio suppression of *Chilo partellus* with *Trichogramma* chilonis on *rabi* maize (ANGRAU)

Treatments

T1: Release of *Trichogramma chilonis* beginning from 15 days after seedling emergence (DAE),
T2: Release of *Trichogramma chilonis* beginning from 20 DAE
T3: Release of *Trichogramma chilonis* beginning from 25 DAE.

The sub plot treatments comprised of releases of *T.chilonis* @ 50,000/ha, 75,000/ha and 100,000/ha each thrice at 7-10 days interval.

Results

The results indicated that deadhearts caused by maize stem borer damage was significantly low in field release of *Trichogramma chilonis* @1,00,000 per ha from 15 days after seedling emergence three times at weekly interval (2.04% DH) and field release of *T. chilonis* @75,000 per ha from 15 days after seedling emergence three times at weekly interval (2.4%DH) compared to field release of *T. chilonis* @75,000 per ha from 25 days after seedling emergence three times at weekly interval (5.41% DH) and field release of *T. chilonis* @1,00,000 per ha from 25 days after seedling emergence three times at weekly interval (4.52% DH).

Stem tunneling caused by *Chilo partellus* was significantly low in field release of *T. chilonis* @1,00,000 per ha from 15 days after seedling emergence three times at weekly interval (1.13 cm/plant) and field release of *T. chilonis* @ 75,000 per ha from 15 days after seedling emergence three times at weekly interval (1.33 cm/plant) Exit holes / plant recorded was significantly low in field release of *T. chilonis* @1,00,000 or 75,000 or 50,000 per ha from 15 days after seedling emergence three times at weekly interval (0.67 exit holes /plant) as compared to field release of *T. chilonis* @75,000 or 1,00,000 per ha from 25 days after seedling emergence three times at weekly interval (2.0 exit holes/plant).

Cob yields recorded significantly high in field release of *T. chilonis* @100,000 per ha from 15 days after seedling emergence three times at weekly interval (75.43 '000/ha) than at dosages of 75,000/ha (74.76,000/ha) (Table 51).

Table 51. Bio suppression of *Chilo partellus* with *Trichogramma chilonis* on *rabi* maize

Treatment	Stem borer damage (%DH) at 45 DAE	Exit holes/ plant	Stem tunneling (cm) /plant	Cob yield ('000/ha)
MI S1 : Release of *Trichogramma chilonis* beginning from 15DAE@ 50,000/ha ,thrice at 7-10 days interval	2.84	0.67	2.07	70.04
MIS2 : Release of *Trichogramma chilonis* beginning from 15DAE @ 75,000/ha ,thrice at 7-10 days interval	2.4	0.67	1.33	74.76

MIS3 : Release of *Trichogramma chilonis* beginning from 15DAE@ 1,00,000/ha ,thrice at 7-10 days interval	2.04	0.67	1.13	75.43
M2S1 : Release of *Trichogramma chilonis* beginning from 20 DAE@ 50,000/ha ,thrice at 7-10 days interval	3.87	1.33	2.97	68.66
M2 S2: Release of *Trichogramma chilonis* beginning from 20 DAE@ 75,000/ha ,thrice at 7-10 days interval	3.01	1.0	3.17	68.66
M2S3 : Release of *Trichogramma chilonis* beginning from 20 DAE@1,00,000/ha ,thrice at 7-10 days interval	2.82	1.0	3.87	69.72
M3S1 : Release of *Trichogramma chilonis* beginning from 25 DAE @ 50,000/ha ,thrice at 7-10 days interval	5.58	2.33	11.53	62.73
M3S2 : Release of *Trichogramma chilonis* beginning from 25DAE@ 75,000/ha ,thrice at 7-10 days interval	5.41	2.0	5.87	66.26
M3S3 : Release of *Trichogramma chilonis* beginning from 25DAE @1,00,000/ha ,thrice at 7-10 days interval	4.52	2.00	5.3	67.65
CD ($P = 0.05$) Main treatment	0.69	0.21	0.60	6.82
Sub treatment	NS	NS	NS	NS
Interaction	NS	NS	NS	NS

3.5.2 Evaluation of NBAIR entomopathogenic strains against maize stem borer (ANGRAU; PJTSAU)

3.5.2.1 ANGRAU, Anakapalle

The experiment was carried out at RARS, Anakapalle on variety DHM 117 and following treatments were imposed

T1: Bb -5a @ 5 ml/lt
T2: Bb -7 @ 5 ml/lt
T3: Bb-14 @ 5 ml/lt
T4: Bb -19 @ 5 ml/lt
T5: Bb-23 @ 5 ml/lt
T6: Bb-45 @ 5 ml/lt
T7: Ma -35 @ 5 ml/lt
T8: carbofuran whorl application @ 8 kg/ha
T9: Untreated control

Results

Six *Beauveria* strains, one *Metarhizium* strain obtained from NBAIR, were evaluated and ompared with chemical (carbofuran whorl application) and untreated control. NBAIR entomopathogenic strains were applied as first spray at 20 days after seedling emergence and second spray at 30 days after first spray. Lab reared *Chilo partellus* neonates were released in leaf whorls of each treatment using bazooka applicator @ 5-8 larvae /plant at 5 days after first spray.

Maize stem borer damage recorded was significantly low in all the NBAIR entomopathogenic strains, *i.e*., Bb -19 (1.5 % DH), Bb 23 (2.32%DH), Bb -7 (2.58 %DH), Bb -5a (2.64 % DH), Bb 14 (3.14% DH) and Ma 35 (1.8%DH) as compared to Carbofuran whorl application (6.34 %DH) and untreated control (12.48%DH). The data on exit holes/ plant revealed that Bb14, Bb19 (1.56 exit holes/plant) and Bb 45 (1.67 exit holes/plant) recorded significantly less damage as compared to carbofuran (5.67 exit holes/plant) and untreated control (6.44 exit holes/plant).

Stem tunneling caused by *Chilo partellus* was significantly low in Bb14 (2.06 cm/plant), Bb19 (4.2 cm/plant), Bb7 (4.54 cm/plant), Bb 5a (5.23 cm/plant) and Bb 45 (6.89 cm/plant) and Bb 45 (6.89 cm/plant) as compared to carbofuran (8.72 cm/plant) and untreated control (18.47 cm/plant). Cobs yields were higher in strain Bb 5a and Bb19 (71.37 ’000/ha and 68.94 ’000/ha respectively) and was low in carbofuran whorl application (60.49’000/ha) and untreated control (50.62 ’000/ha).

3.5.2.2 PJTSAU, Hyderabad

Location

Agri. Research Station, PJTSAU, Tandur (Rangareddy District)

Treatments

T1: Bb 23 (1x 10^8 conidia /ml) @ 5 ml/lt
T2: Bb 45 (1x 10^8 conidia /ml) @ 5 ml/
T3: Bb 14 (1x 10^8 conidia /ml) @ 5 ml/
T4: Ma 35 (1x 10^8 conidia /ml) @ 5 ml/
T5: Ma 36 (1x 10^8 conidia /ml) @ 5 ml/t
T6: Ma 52 (1 x 10^8 conidia /ml) @ 5 ml/
T7: Carbofuran whorl application @ 8 kg/ha at 20 DAE
T8: Untreated control

Formulated isolates will be applied thrice at an interval of 30 days, starting from 20 day after emergence of plant

Design **:** RBD
Replications **:** Three
Spacing **:** 60cmX30cm
Date of Sowing **:** February, 2017

Variety : DHM 117
Season : *Rabi*, 2016-17.
Duration : Three years.

Observations
1. Counts of dead hearts will be recorded at weekly interval starting from initial incidence of stem borer.
2. Leaf damage will be recorded at weekly interval starting from initial incidence of stem borer.
3. Number of exit holes/plant will be recorded.
4. Extent of stem tunneling will be computed.
5. Cob Yield will be recorded at harvest.

Status of the trial

The crop has been sown recently during February, 2017. The outcome of the experiment will be submitted within week after getting yield data recorded.

3.6 Biological control of Pulses Pests

3.6.1 Evaluation of biocontrol agents against pod borers of cowpea (KAU)

An experiment was carried out for the evaluation of biocontrol agents against pod borers of cowpea at College of Horticulture, Vellanikkara from July to October, 2016 as per the details given below.

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

Treatments

T1: Three sprays of *Beauveria bassiana* ($1x10^8$ spores/ml) at 7 days interval
T2: Three sprays of *B. bassiana* ($1x10^8$ spores/ml) at 15 days interval
T3: Three sprays of *Bacillus thuringiensis* NBAIR formulation @ 1 kg/ha at 7 days interval
T4: Three sprays of *B. thuringiensis* NBAIR formulation @ 1 kg/ha at 15 days interval
T5: Quinalphos 25 EC-250 g a.i/ha
T6: Control

Results

The results are presented in Table 52. There were no significant differences between the treatments. However, five days after first spraying, plots treated with quinalphos 25 EC 250 g a.i ha-1 recorded the lowest infestation of 16.84 per cent, followed by plots treated with *Bacillus thuringiensis* applied at seven days interval, recording 17.65 per cent infestation. The highest infestation was recorded in untreated control (47.52%). Ten days after first spray, all the

treatments with entomopathogens recorded values comparable to the insecticide treatment. Fifteen days after first spray, *B.thuringiensis* sprayed at 15 days interval recorded the lowest mean infestation of 10.56 per cent, followed by *Beauveria bassiana* at 15 days interval with 16.59 per cent mean infestation.

Table 52. Effect of entomopathogenic fungi on pod infestation by pod borer in cowpea

Treatment	Pre count	Percent pod borer infestation after first spray			Percent pod borer infestation after second spray	
		5DAS	10DAS	15DAS	5DAS	10DAS
B. bassiana at 7 days interval	15.36 (3.77)	20.51 (4.48)	10.59 (3.30)	23.72 (3.90)	11.28 (2.87)	2.33 (1.41)
B. bassiana at 15 days interval	11.85 (3.36)	18.9 (4.33)	10.04 (3.21)	16.59 (3.03)	11.78 (3.36)	33.01 (5.65)
B.thuringiensis NBAII formulation at 7 days interval	10.62 (3.25)	17.65 (4.17)	16.12 (4.03)	20.74 (4.85)	16.19 (3.92)	9.59 (2.80)
B.thuringiensis NBAII formulation at 15 days interval	14.91 (3.32)	19.68 (4.34)	12.25 (3.83)	10.56 (3.45)	16.3 (4.06)	33.99 (5.69)
Quinalphos 25 EC-250 g a.i/ha	29.4 (5.36)	16.84 (3.97)	11.62 (3.45)	31.62 (4.86)	32.26 (5.66)	36.43 (5.63)
Control	14.41 (3.78)	47.52 (4.62)	26.62 (3.21)	26.66 (4.11)	39.97 (6.19)	17.33 (3.02)
CD at 5%	NS	NS	NS	NS	NS	NS

Values indicate mean percent infestation of pods. Values in parenthesis are square root transformed values. DAS-days after spraying.

Five days after the second spray, plots treated with *B. bassiana* at seven and 15 days interval had the lowest mean infestation of 11.28 and 11.78 per cent respectively. *Bacillus thuringiensis* also recorded infestation levels lower than those recorded by plots treated with insecticide. Highest mean infestation of 39.97 per cent was recorded by untreated plots. Plots treated with *B.bassiana* at seven days interval had the lowest infestation (2.33%) and was followed *Bacillus thuringiensis*, also applied at seven days interval (9.59%).

3.6.2 Demonstration of NBAIR liquid formulation (PDBC-BT1 and NBAIR-BTG4) against pigeon pea pod borer *(Helicoverpa armigera)* (UAS-R; AAU-A)

3.6.2.1 UAS-R

Large scale demonstration of NBAII BTG 4 *Bt* was done in a Askihal village of Raichur taluka over an area of 10 ha. Totally ten farmers were selected to demonstrate the effectiveness of NBAII BTG 4 *Bt* in comparison with farmers practice.

The results indicated that NBAII BTG 4 *Bt* recorded 9.04 per cent damage compared to farmers practice which recorded 8.26 per cent pod damage. Similarly the grain damage was 1.64

was noticed in NBAII BTG 4 *Bt* compared to farmers practice (1.23%). NBAII BTG 4 *Bt* recorded 10.36 q/ha grain yield and in farmers practice it was 11.42 q/ha grain yield (Table 53).

Table 53. Performance of NBAII BTG 4 *Bt* in comparison with farmers practice at Kurdi village, Raichur

Sl. No.	Particulars	% Pod damage	% Seed damage	Grain Yield (q/ha)
1.	NBAII BTG 4 *Bt*	9.04	1.64	10.36
2.	Farmers Practice	8.26	1.23	11.42
T test		0.15*	0.21*	0.11*

3.6.2.2 AAU, Anand

Experimental details not provided

3.6.3 Evaluation of microbial agents for management of lepidopteran pests on moong bean (*Spodoptera litura* and *Helicoverpa armigera*) (PAU)

The experiment was conducted on moong bean (variety PAU 911) sown at the Entomological Research Farm, Punjab Agricultural University, Ludhiana. The experiment was conducted in plot size of 20 m2 in Randomized block design during 2016. There were 10 treatments with three replications. These treatments were liquid formulation of *Bacillus thuringiensis* PDBC Bt1 (1%), Bt 1(2%), NBAII BT G4 (1%), NBAII Bt G4 (2%), Delfin WG @ 1 and 2 Kg/ha, *Beauveria bassiana* (Mycojaal) 1.5 and 2.0 Kg/ha, chlorpyriphos 20EC @ 3.75 litre/ha 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. The minimum pod damage (18.36%) was recorded in chlorpyriphos 20 EC @ 3.75 l/ha which was statistically at par with Delfin WG @ 2 Kg/ha (19.10%), PDBC Bt1 (2%) (19.51%), Delfin WG @ 1 Kg/ha (19.64%) and NBAIR G4 2% (19.87%), and they provided comparable control of *H. armigera* (Table 54). *Beauveria bassiana* (Mycojaal) @ 2.0 Kg/ha (22.76%) and 1.5 Kg/ha (23.07%) was not effective and was comparable with control (24.39%). Per cent pod damage reduction over control varied from 5.41 to 24.72 per cent. Chlorpyriphos 20EC @ 3.75 l/ha recorded 24.72 per cent reduction in pod damage over control followed by Delfin WG @ 2 Kg/ha (21.68%) and PDBC Bt1 2 % (20.00%).

Yield was maximum in chemical control (9.15 q/ha) which was statistically at par with Delfin WG @ 2 Kg/ha (8.35q/ha). Delfin WG @ 1 Kg/ha, PDBC Bt1 (2%) and NBAII Bt G4 (2%) also provided comparable yield although numerically less. *Beauveria bassiana* (Mycojaal) treatments were not effective and were at par with untreated control.

Table 54. Evaluation of microbial agents for the management of *H. armigera* on moongbean during 2016

Treatment	Pooled per cent pod damage	Per cent pod damage reduction over control	Yield (q/ha)
PDBC Bt1 (1%)	20.77b (27.09)	14.84	7.15c
PDBC Bt 1(2%)	19.51 ab (26.20)	20.00	8.28 ab
NBAII Bt G4 (1%)	21.18 bc (27.39)	13.16	7.80 b
NBAII Bt G4 (2%)	19.87 ab (26.44)	18.53	8.17 b
Delfin WG@1Kg/ha	19.64 ab (26.29)	19.47	8.28 ab
DelfinWG @ 2Kg/ha	19.10 a (25.90)	21.68	8.35 ab
Beauveria bassiana (1.5Kg/ha)	23.07 c (28.69)	5.41	5.35 d
Beauveria bassiana (2.0Kg/ha)	22.76 c (28.48)	6.68	5.37 d
Chlorpyriphos 20EC (3.75 l/ha)	18.36 a (25.36)	24.72	9.15 a
Control	24.39 c (29.58)	-	5.20 d
CD (5%)	(1.09)	-	0.97

3.6.4 Evaluation of potential isolates of *Pseudomonas, Trichoderma, Bacillus* and microbial consortia against major diseases of cowpea. (KAU; RARS-Kumarakom)

The experiment was laid out at RARS, Kumarakom with 6 treatments and 5 replications in RBD and treatments were imposed during November/ December 2016. But even after inoculation of the pathogen (*Colletotrichum sp*.) disease incidence did not occur. Hence the experiment has to be repeated.

3.7 Biological control of Oilseed Pests

3.7.1 Biological suppression of mustard aphid, *Lipaphis erysimi* Kaltenbach (AAU-A, OUAT, PAU, MPUAT)

3.7.1.1 AAU, Anand

The experiment was conducted at Agronomy farm. BACA, AAU, Anand, during 2016-17, on the variety GM 1 with the following treatments.

Tl: *Metarhizium anisopliae* @ 5 g/ liter ($2x10^8$ cfu g^{-1})
T2: *Lecancillium lecanii* @ 5 g/ liter ($2x10^8$ cfu g^{-1})
T3: *Beauveria bassiana* @ 5g/ liter ($2x10^8$ cfu g^{-1})
T4: NSKE @ 5% suspension
T5: *L. lecanii* + *M. anisopliae* 5g/ liter ($2x10^8$ cfu g^{-1})
T6: *B. bassiana* + *L. lecanii* 5g/ liter ($2x10^8$ cfu g^{-1})
T7: Dimethoate 30 EC @ 0.06%
T8: Untreated control

Treatments were given fortnightly interval in the evening hours at initiation of aphid infestation. The aphid population was recorded on 5 randomly selected plants by following 0-5 index method as per the methodology described by Patel *et al.,* (1995) (0: Plant free from aphid infestation, 1: Only few aphids with very little injury, 2: Small colonies on few twigs, no curling or yellowing of leaves, 3: Aphid colonies on almost all the twigs, stunted growth, curling and yellowing of leaves, 4: and 5 : Very heavy population of aphids on inflorescence, leaves, stem and siliqua.

Results

The results of the experiment on bioefficacy of different biological control agents on mustard aphid reveals that significantly lower aphid index count was recorded in the treatment T_6 – *B. bassiana* + *L. lecanii* @ 5g/ liter (1.88) which was at par with the treatment T_5 – *L. lecanii* + *M. anisopliae* @ 5g/ liter (1.96). None of the microbial insecticides found superior than chemical insecticide used. Similarly among the microbial insecticides treatments, highest seed yield was obtained in the treatment T_6 – *B. bassiana* + *L. lecanii* @ 5g/ liter (9.66 q/ha) followed by T_5 – *L. lecanii* + *M. anisopliae* @ 5g/ liter (9.24 q/ha). However, the highest seed cotton yield was recorded in chemical insecticide treated plot (10.69 q/ha).

3.7.1.2 OUAT, Bhubaneswar

The experiment was conducted at OUAT farm on the variety NRCHB-101 during 2016-17, spacing was 30 cm×10 cm, spraying dates 11.12.2016, 26.12.2016 and 10.01.2017. The date of harvest was 14.02.2017.

Results

The aphid population per five cm twig one day before spraying and untreated control in different treatments ranged from 13.77 to 37.40. The effect of all the biopesticides are short lived

and they were found effective maximum up to 7 days. The aphid population in pesticide treated plots reduced significantly as compared to untreated control 5 days after spraying. The chemical pesticides dimethoate was found effective up to 10 days after spraying but in all the biopesticides including neem seed kernel extract, the aphid population gradually recovered after 7 days of spraying. The post effect of all the biopesticides remained at par, but the aphid population reduced significantly in combined application of *Metarrhizium* and *Lecanicillium*. Significantly highest yield (8.23q/ha) with highest B: C ratio (1.55) was also recorded in the combined application of biopesticides. Lowest yield (5.76 q/ha) was noted in the untreated control (Table 55).

3.7.1.3 PAU, Ludhiana

The field experiment to evaluate different biopesticides against *Brevicorynae brassicae*/ *Lipaphis erysimi* in mustard was conducted at Entomological Research Farm PAU, Ludhiana. The seeds of the mustard (Variety- Raya PBR 91) were sown on November 3, 2016. Each block was further divided into sub-plots as replicates. The crop was grown as per PAU recommendations. The following different biopesticides along with farmer's practice and untreated control were evaluated. There were three replications for each treatment and each treatment was given at ten days interval. Aphid population was recorded from 10 cm apical twig per plant from 5 randomly selected plants per plot. The data were recorded before treatment and after 5, 7 and 10 days of treatment. The seed yield of mustard per plot was taken at end of harvesting and has been expressed as quintals per ha.

The data in Table 56 & Plate 5 showed that insecticide Dimethoate @ 4 ml/litre of water significantly reduced the aphid population from 53.06 to 0.67 after two sprays at 10 days interval. Among all the treatments of biopesticides i.e. *Beauveria bassiana*, *Lecanicillium lecanii*, *Metarhizium anisopliae* and Neem oil, aphid population was found to be non-significant and at par with untreated control. The yield was also significantly higher in chemical control. All tested biopesticides were found ineffective in the management of aphid, *Brevicoryne brassicae*/ *Lipaphis erysimi* on mustard.

3.7.1.4 MPUAT, Udaipur

Report not provided.

Table 55. Effect of biopesticides on aphid population and yield of mustard during *rabi* 2016-17 at Bhubneswar

Treatments	Aphid population/ 5 cm twig													
	1DBFS	5DAFS	7DAFS	10DASS	1DBSS	5DASS	7DASS	10DASS	1DBTS	5DATS	7DATS	10DATS	Yield(q/ha)	B: C ratio
T_1: *Metarrhizium anisopliea* 2×10^8 (spores/g) @ 5g/litre	16.50 (4.12)*	1.70 (1.48)	8.50 (3.00)	11.60 (3.48)	19.80 (4.51	12.07 (3.55)	15.73 (4.03)	17.60 (4.25)	36.17 (6.06	17.10 (4.20)	19.33 (4.45)	21.93 (4.74)	5.84	1.13
T_2: *Lecanicilium lecanii* 2×10^8 (spores/g) @ 5g/litre	18.43 (4.35)	2.13 (1.62)	10.47 (3.31)	12.37 (3.59)	17.10 (4.20)	12.23 (3.56)	14.27 (3.84)	14.20 (3.83)	37.40 (6.16)	13.73 (3.77)	15.03 (3.94)	19.60 (4.48)	6.60	1.21
T_3: *Beauveria bassiana* 2×10^8 (spores/g) @ 5g/litre	19.20 (4.44)	0.73 (1.08)	5.70 (2.49)	8.60 (3.02)	17.00 (4.18)	11.93 (3.52)	13.80 (3.78)	14.67 (3.89)	33.73 (5.85)	18.80 (4.39)	19.57 (4.48)	22.60 (4.81)	7.44	1.44
T_4: NSKE @ 5% suspension	15.83 (4.04)	6.73 (2.69)	9.43 (3.15)	12.57 (3.62)	17.10 (4.20)	10.47 (3.31)	12.60 (3.62)	15.50 (4.00)	32.77 (5.77)	20.10 (4.54)	23.60 (4.91)	5.50 (5.10)	6.46	1.38
T_5: *M. anisopliae* + *L. lecanii* 2×10^8 (spores/g) @ 5g/litre	18.47 (4.35)	4.70 (2.28)	5.53 (2.45)	7.57 (2.84)	22.23 (4.77)	9.87 (3.19)	12.57 (3.61)	15.83 (4.03)	33.43 (5.82)	20.20 (4.55)	21.27 (4.67)	23.37 (4.88)	8.23	1.55
T_6: Dimethoate @ 0.06% spray	16.53 (4.13)	2.10 (1.61)	1.53 (1.41)	3.63 (2.03)	21.07 (4.65)	3.73 (2.05)	4.23 (2.17)	7.17 (2.76)	33.60 (5.84)	7.20 (2.77)	9.70 (3.19)	12.17 (3.56)	6.70	1.43
T_7: Untreated control	19.60 (4.48)	15.63 (4.01)	13.77 (3.78)	16.33 (4.10)	20.40 (4.57)	16.83 (4.16)	19.83 (4.54)	21.57 (4.69)	33.53 (5.83)	28.57 (5.39)	37.80 (6.18)	34.73 (5.93)	5.76	1.15
S.E.(m)±	- (0.05)	- (0.09)	- (0.09)	- (0.20)	- (0.07)	- (0.08)	- (0.10)	- (0.08)	- (0.05)	- (0.06)	- (0.05)	- (0.07)	0.14	
C.D. (0.05)	- (0.15)	- (0.28)	- (0.28)	- (0.58)	- (0.20)	- (0.25)	- (0.29)	- (0.25)	- (0.15)	- (0.19)	- (0.14)	- (0.21)	0.42	
C.V. (%)	- (2.01)	- (8.95)	- (6.96)	- (11.08)	- (2.64)	- (4.88)	- (5.15)	- (3.90)	- (1.48)	- (2.74)	- (1.91)	- (2.76)	3.15	

*Figures in parentheses are $\sqrt{(x+0.5)}$ transformed values; DBFS- Day Before 1st Spraying, DAFS- Days After 1st Spraying, DBSS- Day Before 2nd Spraying, DASS- Days After 2nd Spraying; DBTS- Day Before 3rd Spraying, DATS- Days After 3rd spraying.

Table 56. Evaluation of biopesticides against *Brevicoryne brassicae*/ *Lipaphis erysimi* in mustard (2016-17)

Sl. No.	Treatments	Aphid population					Yield (q/ha)
		Pre-treatment	Spray I		Spray II		
			5 DAS	7 DAS	5 DAS	7 DAS	
T_1	*Beauveria bassiana* (1 x 10^8) @ 8 ml/litre	62.87	75.00^b (8.72)	60.90^b (7.87)	67.07^b (8.25)	83.13^b (9.17)	14.10^b
T_2	*Beauveria bassiana* (1 x 10^8) @ 10 ml/litre	87.67	73.07^b (8.60)	56.80^b (7.60)	64.03^b (8.06)	75.77^b (8.76)	14.13^b
T_3	*Beauveria bassiana* (1 x 10^8) @ 12 ml/litre	43.87	73.07^b (8.58)	55.87^b (7.54)	63.0^b (8.00)	76.90^b (8.82)	14.12^b
T_4	*Lecanicillium lecanii* (1 x 10^8) @ 8 ml/litre	73.80	74.33^b (8.65)	61.53^b (7.91)	67.60^b (8.28)	82.93^b (9.16)	14.18^b
T_5	*Lecanicillium lecanii* (1 x 10^8) @ 10 ml/litre	42.40	70.47^b (8.45)	56.47^b (7.58)	66.53^b (8.22)	76.20^b (8.78)	14.17^b
T_6	*Lecanicillium lecanii* (1 x 10^8) @ 12 ml/litre	41.67	70.47^b (8.44)	56.00^b (7.55)	62.33^b (7.96)	77.20^b (8.84)	14.22^b
T_7	*Metarhizium anisopliae* (1 x 10^8) @ 8 gm/litre	51.40	74.73^b (8.67)	59.33^b (7.77)	63.73^b (8.05)	81.93^b (9.11)	14.12^b
T_8	*Metarhizium anisopliae* (1 x 10^8) @ 10 gm/litre	46.53	72.47^b (8.56)	57.07^b (7.62)	64.33^b (8.08)	77.13^b (8.84)	14.10^b
T_9	*Metarhizium anisopliae* (1 x 10^8) @ 12 gm/litre	80.26	71.00^b (8.44)	54.20^b (7.43)	60.27^b (7.74)	76.27^b (8.79)	14.13^b
T_{10}	Neem oil (1%) @ 6 ml/litre (Azadirachtin 10000 ppm)	40.73	73.60^b (8.59)	60.83^b (7.86)	66.73^b (8.23)	81.60^b (9.09)	14.15^b
T_{11}	Neem oil (1%) @ 7 ml/litre (Azadirachtin 10000 ppm)	51.47	72.87^b (8.41)	55.47^b (7.51)	62.13^b (7.94)	82.40^b (9.13)	14.18^b
T_{12}	Neem oil (1%) @ 8 ml/litre (Azadirachtin 10000 ppm)	41.60	71.67^b (8.52)	56.27^b (7.56)	62.87^b (7.99)	76.67^b (8.81)	14.17^b
T_{13}	Dimethoate @ 4 ml/litre	53.06	10.20^a (3.35)	6.47^a (2.73)	3.47^a (2.07)	0.67^a (1.03)	17.13a
T_{14}	Control (Water spray)	40.07	75.00^b (8.59)	58.93^b (7.74)	67.33^b (8.26)	82.67^b (9.14)	14.16^b
	CD (P = 0.05)	NS	1.63	0.35	0.69	0.34	1.52

Plate 5. Evaluation of biopesticides against aphids in mustard

3.8 Biological control of Sorghum Pests

3.8.1 Field evaluation of NBAII entomopathogenic strains against stem borer, *Chilo partellus* (Swinhoe) in sorghum (UAS-R)

The trial was taken on sorghum variety M 35-1, design was RBD and crop was sown on 15.10.2016. The treatments given were - T1: *Beauveria bassiana* - 5a ($1x10^8$ conidia/g), T2: *Beauveria bassiana* - 7 ($1x10^8$ conidia/g), *Beauveria bassiana* - 14 ($1x10^8$ conidia/g), T4: *Beauveria bassiana* - 23 ($1 x 10^8$ conidia/g), T5: *Beauveria bassiana* - 45 ($1 x 10^8$ conidia/g), T6: *Metarhizium anisopliae* - 35($1 x 10^8$ conidia/g) and T7: untreated control. The dosage was 1.50 ml/lit. In each treatment number of dead hearts was counted just before first spray, 10 days and 20 days after each spray. Post harvest observations were recorded on the length of tunneling by larvae, number of entry hole, number of larvae and pupae. Grain and fodder yield were recorded in each treatment and analyzed statistically.

Results

Number of dead hearts

The number of dead hearts before initiation of spray ranged from 6.06 to 6.42 per plot. On 10 days after spray, *Beauveria bassiana* -7 @ 1.5 ml/l was recorded minimum dead hearts (6.32/ plot) which was at par with *Metarhizium anisopliae* - 35 @ 1.5 ml/l which recorded 9.08 dead hearts per plot. Untreated control recorded 11.64 per plot dead hearts which was statistically inferior. Similar trend was noticed on 20 days after spray. Observations after second spray, *Beauveria bassiana* -7 @ 1.5 ml/l recorded minimum dead hearts and there was no significant increase in number of dead hearts compared to untreated control which recorded 13.64 dead hearts per plot after 10 days of second spray (Table 57).

Post harvest observation

Minimum tunneling of 11.28 cm was noticed in *Beauveria bassiana* -7 @ 1.5 ml/l and it was at par with *Metarhizium anisopliae* - 35 @ 1.5 ml/l which recorded 13.50 cm tunneling while untreated control recorded the highest tunneling of 58.50 cm. The number of entry hole was low (0.68/ plot) in *Beauveria bassiana* -7 @ 1.5 ml/l and it was at par with *Metarhizium anisopliae* - 35 @ 1.5 ml/l which recorded 0.75 entry holes per plot while untreated control recorded 2.06 entry holes per plot. Over all the presence of larvae and pupae were negligible in all the treatments. However, *Beauveria bassiana* -7 @ 1.5 ml/l recorded minimum population of larvae and pupae compared to untreated control.

Yield

The highest grain yield of 11.56 q/ha was recorded in *Beauveria bassiana* -7 @ 1.5 ml/l and it was at par with *Metarhizium anisopliae* - 35 @ 1.5 ml/l which recorded 10.92 q/ha grain yield. Untreated control recorded 8.06 grain yield. *Beauveria bassiana* -7 @ 1.5 ml/l recorded 4.62 t/ha fodder yield and it was followed by *Metarhizium anisopliae* - 35 @ 1.5 ml/l which recorded 4.12 t/ha. Untreated control recorded lowest fodder yield of 2.52 t/ha (Table 58).

Table 57. Evaluation of NBAII entomopathogenic strains against sugarcane stem borer, *Chilo partellus* (Swinhoe) in sorghum

Sl. No.	Treatments	Dosage gm/ml/l	Number of dead hearts per plot				
			I Spray			II Spray	
			1DBS	10 DAS	20 DAS	10 DAS	20 DAS
1	*Beauveria bassiana* - 5a (1×10^8 conidia/g)	1.50	6.36 (2.62)	7.48 (2.82)	7.52 (2.83)	7.64 (2.85)	7.78 (2.88)
2	*Beauveria bassiana* - 7 (1×10^8 conidia/g)	1.50	6.28 (2.60)	6.32 (2.61)	6.48 (2.64)	6.52 (2.65)	6.64 (2.67)
3	*Beauveria bassiana* - 14 (1×10^8 conidia/g)	1.50	6.04 (2.56)	7.78 (2.88)	7.84 (2.89)	7.92 (2.90)	8.08 (2.93)
4	*Beauveria bassiana* - 23 (1×10^8 conidia/g)	1.50	6.12 (2.57)	6.44 (2.63)	6.52 (2.65)	6.58 (2.66)	6.76 (2.69)
5	*Beauveria bassiana* - 45 (1×10^8 conidia/g)	1.50	6.36 (2.62)	8.14 (2.94)	8.26 (2.96)	8.32 (2.97)	8.38 (2.98)
6	*Metarhizium anisopliae*- 35 (1×10^8 conidia/g)	1.50	6.42 (2.63)	9.08 (3.10)	9.12 (3.10)	9.18 (3.11)	9.24 (3.12)
7	Untreated control	--	6.38 (2.62)	11.64 (3.48)	12.72 (3.64)	13.64 (3.76)	14.28 (3.84)
S Em $\pm$			0.18	0.02	0.03	0.06	0.04
CD ($P = 0.05$)			NS	0.07	0.10	0.18	0.12
CV %			10.52	11.24	10.62	10.44	12.18

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

Table 58. Post harvest observation of evaluation of NBAII entomopathogenic strains against sugarcane stem borer, *Chilo partellus* (Swinhoe) in sorghum

Sl. No.	Treatments	Dosage gm/ml/ l	TLM	NEH	No. Of larvae	No. Of pupae	Seed yield (q/ha)	Fodder yield (t/ha)
1	*Beauveria bassiana* - 5a (1×10^8 conidia/g)	1.50	26.5 (5.20)	1.08 (1.26)	0.12 (0.79)	0.04 (0.73)	9.58	3.82
2	*Beauveria bassiana* - 7 (1×10^8 conidia/g)	1.50	11.28 (3.43)	0.68 (1.09)	0.00 (0.71)	0.00 (0.71)	11.56	4.62
3	*Beauveria bassiana* - 14 (1×10^8 conidia/g)	1.50	23.5 (4.90)	0.94 (1.20)	0.04 (0.73)	0.05 (0.74)	9.32	3.58
4	*Beauveria bassiana* - 23 (1×10^8 conidia/g)	1.50	22.25 (4.77)	0.78 (1.13)	0.02 (0.72)	0.01 (0.71)	10.68	3.76
5	*Beauveria bassiana* - 45 (1×10^8 conidia/g)	1.50	26.85 (5.23)	1.02 (1.23)	0.12 (0.79)	0.06 (0.75)	9.34	3.04
6	*Metarhizium anisopliae*- 35 (1×10^8 conidia/g)	1.50	13.5 (3.74)	0.75 (1.12)	0.04 (0.73)	0.02 (0.72)	10.92	4.12
7	Untreated control	--	58.5 (7.68)	2.06 (1.60)	0.18 (0.82)	0.12 (0.79)	8.06	2.52
S Em $\pm$			0.41	0.05	0.04	0.03	0.35	0.13
CD (P=0.05)			1.24	0.93	0.12	0.10	1.05	0.39
CV %			10.28	10.32	11.84	10.66	12.08	10.42

DBS: Day before spray; DAS: Day after spray; *figures in parentheses are square root transformed value

3.9 Biological control of Tropical Fruit Crop Pests

3.9.1 Monitoring the incidence of papaya mealy bugs (PMB) and its natural enemies on papaya and other alternate hosts (AAU-A; MPKV; KAU; TNAU)

3.9.1.1 AAU, Anand

Survey for ascertaining the outbreak of mealybug, *Paracoccus marginatus* was carried out at farmers' fields in Anand, Kheda, Vadodara, Chhotaudepur and Sabarkantha districts of Gujarat, at fortnightly intervals during the year 2016-17. Only trace incidence was observed in the surveyed fields. The samples of mealy bug infested papaya fruits were brought to the laboratory and were reared on sprouted potato. The parasitoid, *Acerophagus papayae* was noticed parasitizing mealybug.

Percentage of plants infested with mealy bug was assessed by observing 25 randomly selected plants and intensity of damage (grade in the scale of 1-5, *viz*., 1- very low, 2-llow, 3 – medium, 4-high and 5 – very high) was determined. The observations were recorded on non host crops infested, pesticides used and natural enemies . The observations revealed that the farmers used insecticides, profenophos 50 EC @ 10 ml/litre of water and Chlorpyruiphos 20 EC @ 20 ml/litre of water. Among the natural enemies, *Acerophagus papayae* was found occurring in the farmers fields.

3.9.1.2 MPKV, Pune

The papaya orchards were surveyed for the incidence of PMB in all ten districts of Western Maharashtra. It was relatively very low with 1.0 pest intensity rating during this year. The pest incidence noticed maximum in Shahada (Nandurbar), followed by Shirpur (Dhule) and Chopada (Jalgaon) areas. The encyrtid parasitoid, *Acerophagus papayae* found parasitizing the mealy bugs in almost all the papaya orchards surveyed and it was ranged from 0.6 to 4.8 adults / leaf.

Natural enemies recorded in papaya mealy bug colonies

Encyrtid parasitoid, *Acerophagus papaya*, *Spalgius epius*, *Coccinella septempunctata*, *Scymnus* sp., *Monochilus sexmaculatus*, *Illeis cincta*, anthocorids, *Mallada* sp., *Brumoides* sp., syrphids and spiders.

Alternate hosts of papaya mealybug in Maharashtra

During the survey, the papaya mealybug was also observed on Parthenium (*Parthenium hysterophorus* L.), Safed chafa (*Plumeria alba*), Mulberry (*Morus alba*) as alternate hosts in the vicinity of papaya orchards.

3.9.1.3 KAU, Thrissur

Random surveys were carried out in Ernakulam, Thrissur, Palghat, Wayanad and Calicut districts of Kerala. Infestation of papaya mealy bug was observed on isolated plants at

Vellanikkara and Paravattani in Thrissur district. While *Acerophagus papayae* as well as *Spalgis epius* were observed at Vellanikkara, the parasitoid alone was observed at Paravattani.

3.9.1.4 TNAU, Coimbatore

The infestation of *Paracoccus marginatus* was noted in crops like papaya, tapioca, mulberry, guava, cocoa, *Coccinea*, brinjal, cotton, tomato and hibiscus crops. The incidence of papaya mealybug was recorded in Coimbatore, Erode, Tiruppur, Salem, Karur, Theni, Vellore, Dindigul, Perambalur, Tiruvannamalai, Villupuram, Namakkal, Nagapattinam, Trichy, Cuddalore districts of Tamil Nadu. The prevalence was high in Erode, Tiruppur and Coimbatore. The occurrence of this pest escalated from moderate level of infestation in Erode, Tiruppur and Coimbatore districts during June, to high infestation level in the month of July, August, September and October. Subsequently, the incidence started dwindling from November onwards. The host crops were tapioca, guava, mulberry and the period of severe infestation was July, August, September, October and November. In all the places of occurrence of *Paracoccus marginatus* the parasitoid *Acerophagus papayee*, *Anagyrus lockii* and predator *Cryptolaemus montrouzieri*, *Spalgius* and *Mallada* were noted.

3.9.2 Field evaluation of entomopathogenic fungi against banana pseudostem borer *Odoiporus longicollis* (KAU)

An experiment was laid out at the Banana Research Station, Kerala Agri. University at Kannara for the field evaluation of the two entomopathogenic fungi, namely, *Metarhizium anisopliae* and *Beauveria bassiana* for the management of the banana pseudostem borer *Odoiporus longicollis*. Each fungus was applied in two different methods of application such as trunk spraying and leaf axil filling.

Design: RBD
Treatments: 6
Replication: 3 (10 plants/replication)

Treatments

T1: *Metarhizium anisopliae* (108 spores/ ml) - leaf axil filling
T2: *M. anisopliae* (108 spores/ ml) – spraying
T3: *Beauveria bassiana* (108 spores/ ml) - leaf axil filling
T4: *B. bassiana* (108 spores/ ml) – spraying
T5: Chlorpyriphos spraying @ 2.5 ml/l
T6: Control

The treatments were applied at monthly intervals starting from October 2017. The experiment is in progress. The observation recorded so far is presented in Table 59.

Table 59. Effect of entomopathogenic fungi on infestation by banana pseudostem borer

Sl.no	Treatment	Mean infestation (%)
1.	*Metarhizium anisopliae* - leaf axil filling	43
2.	*M. anisopliae* – spraying	50
3	*Beauveria bassiana* – leaf axil filling	50
4	*B. bassiana* – spraying	16
5	Chlorpyriphos leaf axil filling	3
6	Chlorpyriphos spraying	3
7	Control	36

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

Design: CRD
Replication: 3
Treatments: 12

Treatments

Lecanicillium lecanii @ 10^7, 10^8, 10^9 spores/ml
Beauveria bassiana @ 10^7, 10^8, 10^9 spores/ml
Metarhizium anisopliae @ 10^7, 10^8, 10^9 spores/ml
Paecilomyces fumosoroseus @ 10^7, 10^8, 10^9 spores/ml

The experiment could not be carried out as any infestation of banana root mealybug *Geococcus citrinus* could not be recorded in the farm. The root mealybugs collected from Thamarassery in Wayanad as well as Ramannattukara in Calicut comprised of *Dysmicoccus brevipes* populations.

3.9.4 Laboratory evaluation of entomopathogenic fungi against pepper root mealy bug *Formicoccus polysperes* (KAU)

Design: CRD
Replication: 3
Treatments: 12

Treatments

Lecanicillium lecanii @ 10^7, 10^8, 10^9 spores/ml
Beauveria bassiana @ 10^7, 10^8, 10^9 spores/ml
Metarhizium anisopliae @ 10^7, 10^8, 10^9 spores/ml
Paecilomyces fumosoroseus @ 10^7, 10^8, 10^9 spores/ml

The mealy bug population collected from Wayanad is being maintained in the laboratory and the laboratory evaluation is in progress.

3.9.5 Field evaluation of *Lecanicillium lecanii* against pineapple mealy bug *Dysmicoccus brevipes* (KAU)

Design: RBD
Treatments: 5
Replications: 4 (20 plants /replication)
Location: College of Horticulture, Vellanikkara

Treatments

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

The pineapple crop was raised at AICRP on BCCP&W, Vellanikkara. Mealybug population was collected from infested plants in the Pineapple Research Station of Kerala Agricultural University, Vellanikkara. However, the pest failed to establish in the experimental plot even after repeated inoculation.

3.9.6 Entomopathogenic nematodes for management of Red palm weevil (*Rhynchophorus ferrugineus*) (KAU)

Experimental details not provided

3.9.7 Survey for pest incidence in mango ecosystem in coastal Andhra Pradesh and field evaluation of bio pesticide formulations against mango hoppers, *Idioscopus* sp (DRYSRHU)

Experimental Details

Survey will be taken up in coastal districts of AP to record the pest status in mango. Orchards having about 50- 100 trees were selected for spraying experiment. The selected blocks must be isolated from each other since hoppers are migratory.

Treatment details

T1: *Beauveria bassiana* talc formulation @ 10 g /l
T2: *Lecanicillium lecanii* talc formulation @10 g /l
T3: *Metarhizium anisopliae* talc formulation @ 10 g /l
T4: *Bacillus thuringiensis* @ 2 g /l
T4: Chemical insecticide - imidacloprid @ 0.4 ml/l
T5: Botanical insecticide - azadirachtin 1500 ppm - @ 5 ml/l
T6: Untreated control

Frequency of spray

Weekly sprays (a total of three / four sprays), initiating with the incidence of hoppers-first generation. If hopper population is very severe the spray can be done once in 5 days.

Data to be recorded in survey experiment

Survey will be taken up in major mango growing districts in the coastal region of the state from December to April. In a district 5 villages are to be selected and in each village 5 gardens and in each garden 10 trees should be observed. The surveys will be carried out at monthly intervals.

Data to be recorded in the spraying experiment

The hoppers population in each treatment is to be recorded before and after treatment. Observations are to be made from 10 trees, from each tree four inflorescence number of hoppers/inflorescence will be recorded.

Results

The survey was carried out in mango growing mandals of East Godavari, West Godavari and Krishna districts of A.P. A high incidence of thrips and hopper population on mango was recorded in the months of January and February in the mango gardens surveyed in these district. The spraying experiment was carried out in Gudapalli village in East Godavari district. The first spray was given on 23/1/2017 and subsequent four sprays were given at weekly intervals. Data on surviving hopper population were transformed into $\sqrt{x+0.5}$ values before subjecting to analysis of variance.

The results in Table 60 show that among biopesticides the spraying of *Lecanicillium lecanii*, *Beauveria bassiana* and *Metarhizium anisopliae* were effective in suppressing mango hoppers and reduction in hoppers population after four sprays were observed in these treatments. The chemical insecticide treatment imidacloprid was most effective and was followed by *L. lecanii* treatment.The mean surviving population was recorded as 10,4.5, 2.0 and nil hoppers in *L. lecanii* treatment as against 8.0,3,5,1.0 and nil population in Imidacloprid treatment. In untreated control block, a high population of mango hoppers ranging from 22.5 per cent was recorded consistently.

Table 60. Field evaluation of bio pesticide formulations against mango hoppers, *Idioscopus* sp. in Andhra Pradesh

S.No.	Treatments	Dosage	Hopper population/ per tree (for 4 inflorescence), 7 days after spray				
			Pre count	1st spray	2nd spray	3rd spray	4th spray
1	T1- *Beauveria bassiana*	@ 10 g / L	20 (4.52)	11 (3.38)	8.5 (2.99)	4.5 (2.23)	1.5 (1.40)
2	T2- *Lecanicillium lecanii*	@ 10 g / L	20 (4.47)	10 (3.23)	4.5 (2.23)	2 (1.58)	0 (0.70)
3	T3- *Metarhizium anisopliae*	@ 10 g / L	22 (4.70)	13 (3.67)	11 (3.38)	7.5 (2.82)	1.5 (1.40)
4	T4- *Bacillus thuringiensis*	2 g /L	23 (4.84)	18 (4.30)	15 (3.93)	8.5 (2.99)	4.5 (2.23)
5	T5- Imida cloprid	0.4ml/L	26 (5.14)	8 (2.91)	3.5 (1.99)	1 (1.22)	0 (0.70)
6	T6- Azadirachtin 1500 ppm	5 ml/L	21.5 (4.68)	15 (3.93)	11 (3.38)	6.5 (2.64)	1.5 (1.40)
7	T7- Untreated Control	-	22.5 (4.78)	23.5 (4.89)	23 (4.84)	21 (4.63)	15 (3.93)
	SEM		-	0.13	0.13	0.08	0.12
	CD(5%)		NS	0.46	0.45	0.30	0.44

Figures in parentheses are √x+0.5 transformed values

3.9.8 Survey and monitoring of mealybugs and their natural enemies on fruit crops (DRYSRHU)

Survey was conducted to understand the prey and host plant associations of *S. epius* during 2016 at the experimental orchards of ICAR-Indian Institute of Horticultural Research, Bengaluru. Observations were recorded on different fruit crops like Annona (*Annona squamosa*), Mango (*Mangifera indica*), Grapes (*Vitis vinifera*), Papaya (*Carica papaya*), Guava (*Psidium guajava*) and other wild hosts like Hibiscus (*Hibiscus sinensis*), Jatropha (*Jatropha curcas*) which were infested by mealybugs. Among these hosts significant numbers of *S. epius* larvae were observed on Jatropha infested with *Ferrisia virgata.* In this study we found that Jatropha was highly preferred host plant and *F. virgata* as most preferred prey for *S. epius,* followed by Annona with *Maconellicoccus hirsutus.*

In annona we monitored continuously for predators and parasitoids of melaybugs. The predominant melaybug species observed in annona was *Maconellicoccus hirsutus* followed by *Ferrisia virgata* and *Planoccocus citri* during 216-17. There were three major predators which co–occurred on annona mealybug. The predominant predator was predatory gall midge *Triommata coccidivora,* followed by lycaenid butterfly *Saplgis epius* and lady bird beetle *Cryptolaemus montrouzeri* (Fig. 11).

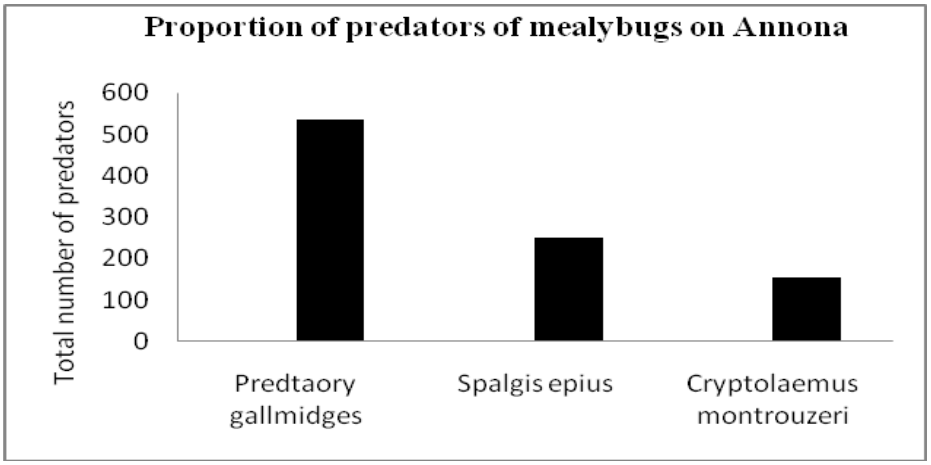


Fig. 11. Co-existence of predator complex on mealybugs in Annona

Fixed plot surveys for predators and parasitoids were carried out at IIHR, Bengaluru during 2016-17. Predatory gall midges, *Tirommata coccidivora* (Diptera: Cecidomyiidae) identified as one of the potential predators of mealybugs. The natural incidence of these predatory gall midges was observed upto 75-100%. These gall midges predate on all mealybug species, *viz.*, *Maconellicoccus hirsutus, Ferrisia virgata, Rastrococcus iceryoides, and Planococcus citri.* Among these mealybugs *M. hirsutus* on annona was highly preferred by the predatory gall midge, *T. coccidivora.*

During this period the popultion of predatory gall midge was high as compared to the regular predator *Cryptolaemus montrouzeri*. Predatory gallmidge *Triommata coccidivora* was reared from *Maconellicoccus hirsutus, Rastorococcus iceryoides, Ferrisia virgata.* We also surveyed the parts of Tamil Nadu, Andhra Pradesh and Karnataka (Table 61).

Table 61. Incidence of natural enemies of mealybugs

S. No.	Location	Host	Melaybug species	Prasitoid/Predator	Mealybug colony	Total Number of predators/parasitoids
1	Bengaluru, Karnataka	Mango	*Rastrococcus iceryoides*	*Aenasius advena*	2	25 adults
2	Bengaluru, Karnataka	Mango	*R. iceryoides*	*Anagyrus sp*	2	20 adults
3	Bengaluru, Karnataka	Mango	*R. iceryoides*	*Aenasius advena*	2	3 adults
4	Bengaluru, Karnataka	Mango	*R. iceryoides*	*Aenasius advena*	2	1adult
5	Bengaluru, Karnataka	Guava	*F. virgata*	*Spalgis epius*	1	6 larvae
6	Bengaluru, Karnataka	Guava	*F. virgata*	*Aenasius advena*	2	10 adults
7	Bengaluru, Karnataka	Guava	*F. virgata*	*Cryptoleamus montrouzeri*	4	7 larvae
8	Bengaluru, Karnataka	Mango	*R. iceryoides*	*Triommata coccidivora*	2	35 adults

9	Bengaluru, Karnataka	Annona	*M. hirsutus*	*Triommata coccidivora*	50	500 adults
10	Bengaluru, Karnataka	Annona	*M. hirsutus*	*Spalgis epius*	35	250 larvae
11	Bengaluru, Karnataka	Annona	*M. hirsutus*	*Cryptolaemus montrouzeri*	20	155 larvae
12	Salem, Tamil Nadu	Papaya	*P. marginatus*	*Acerophagus papayae*	4	25 adults
13	Salem, Tamil Nadu	Mulberry	*P. marginatus*	*Acerophagous papayae*	5	15 adults
14	Chittoor, Andhra Pradesh	Annona	*M. hirsutus*	*Cryptoleamus montrouzeri*	10	18 larvae
15	Chittoor, Andhra Pradesh	Annona	*M. hirsutus*	*Spalgis epius*	15	25 larvae
18	Hosur, Tamil Nadu	Mango	*R. iceryoides*	Nil	Nil	Nil

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

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 a cadaver application (wrapping two cadavers 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. At 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 were made with each treatment, once during the 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 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 76.50 and 73.50 per cent at Pasighat and Rengging, respectively. Among the EPN treatments, CAU-1 stem injection (34.00 % reduction) was observed as the best treatment and it was closely followed by CAUH-1 stem injection (27.50% reduction), CAUH-2 stem injection (26.50% reduction) and NBAII-01 stem injection (26.19% reduction) at Pasighat. However, at Rengging, CAUH-1 stem injection gave the highest reduction in trunk borer infestation among the EPNs with a 32.68 per cent reduction and it was closely followed by NBAII-01 stem injection (31.25% reduction) and CAU-1 stem injection (30.20% reduction) (Table 62). The stem injections of the EPNs were found more effective than their respective cadaver treatments.

Table 62. Bio-efficacy of entomopathogenic nematodes against citrus trunk borer applied as stem injection and cadaver against *Pseudonemophas versteegi* in *Citrus reticulate*

Treatments	Pasighat (average of three orchard)			Rengging (average of three orchard)		
	Trunk borer/10 plants before treatment	Trunk borer/10 plants after treatment	Per cent reduction after treatment	Trunk borer/10 plants before treatment	Trunk borer/10 plants after treatment	Per cent reduction after treatment
CAU-1 Stem injection	12.87 (21.02)*	8.50 (16.95)	34.00 (35.67)	11.31 (19.65)	7.90 (16.32)	30.20 (33.34)
CAU-2 Stem injection	9.10 (17.56)	7.00 (15.34)	23.10 (28.73)	11.87 (20.15)	8.60 (17.05)	27.60 (31.69)
CAU-3 Stem injection	11.66 (19.97)	9.00 (17.46)	22.86 (28.56)	9.74 (18.19)	7.00 (15.34)	28.18 (32.06)
CAUH-1 Stem injection	9.70 (18.15)	7.10 (15.45)	27.50 (31.63)	12.35 (20.57)	8.32 (16.76)	32.68 (34.87)
CAUH-2 Stem injection	10.34 (18.76)	7.60 (16.00)	26.50 (30.98)	10.05 (18.48)	7.00 (15.34)	30.36 (33.44)
CAU-1 Cadaver application	8.97 (17.43)	7.12 (15.48)	20.65 (27.03)	9.32 (17.78)	8.00 (16.43)	14.20 (22.14)
CAU-2 Cadaver application	10.02 (18.45)	8.20 (16.64)	18.20 (25.25)	10.72 (19.11)	8.65 (17.10)	19.35 (26.10)
CAU-3 Cadaver application	9.54 (17.99)	8.00 (16.43)	16.25 (23.77)	11.37 (19.11)	9.60 (18.05)	15.60 (23.26)
CAUH-1 Cadaver application	11.83 (20.12)	9.25 (17.71)	21.85 (27.87)	11.40 (19.73)	8.90 (17.36)	21.96 (27.94)
CAUH-2 Cadaver application	13.20 (21.30)	10.50 (18.91)	20.50 (26.92)	12.14 (20.39)	9.20 (17.66)	24.26 (29.51)
NBAII-01 Stem injection	9.75 (18.19)	7.20 (15.56)	26.19 (30.78)	16.63 (24.07)	8.00 (16.43)	31.25 (33.99)
NBAII-01 Cadaver application	10.42 (18.83)	8.20 (16.64)	21.36 (27.53)	12.08 (20.34)	10.20 (18.63)	15.61 (23.27)
Dichlorvos Stem injection	19.14 (25.94)	4.50 (12.25)	76.50 (61.00)	26.41 (30.92)	7.00 (15.34)	73.50 (59.02)
Untreated control	8.60 (16.64)	8.20 (16.64)	5.60 (13.69)	11.30 (19.64)	10.60 (19.00)	6.20 (14.42)
SE(m)±	0.59	0.45	1.19	1.17	0.54	0.42
CD at (P = 0.05%)	1.77	1.35	5.50	3.49	1.61	1.25
CV%	5.36	4.86	6.90	9.89	5.57	2.40

*Figures in the parentheses are angular transformed values

3.9.10 Effect of biopesticides for the management of Mango hopper, pests *Idioscopus* spp in field condition (KAU Vellayani)

Experiment details

Design : CRD
Replication : 3
Treatments : 4

Treatments

T1 : *Beauveria bassiana* 2 % (ITCC 6063) 20g/l
T 2 : Azadiractin1 % SC (Azadin plus)
T 3 : Malathion 50 % EC (Malik) 0.1%
T 4 : Check

Observation:

Number of hopper 10 cm/ panicle

Result

Field studies conducted on management of mango hoppers revealed that all the treatments, *viz*., *B. bassiana* (ITCC 6063) 2 per cent, malathion 0.1 per cent, and azadirachtin 1 per cent were significantly superior to the untreated control. *B. bassiana* (ITCC 6063) 2 per cent and azadirachtin 1 per cent were superior to control in reducing the population of hoppers (Table 63).

Table 63. Effect of biopesticides for the management of Mango hopper, pests *Idioscopus* spp. in field condition

Treatments	Mean number of hoppers /panicle			
	3DAS	5DAS	10DAS	15DAS
T1 : *Beauveria bassiana*	4.08 (2.01)	4.67 (2.15)	4.92 (2.21)	4.83 (2.19)
T2: Azadiractin	2.83 (1.68)	2.83 (1.68)	5.92 (2.43)	4.58 (2.14)
T3 : Malathion	1.67 (1.28)	5.17 (2.27)	7.50 (2.73)	6.58 (2.56)
T4: Check	12.00 (3.46)	13.08 (3.61)	15.67 (3.95)	16.50 (4.06)
CD (0.05)	(0.154)	(0.159)	(0.148)	(0.114)

3.9.11 Effect of biopesticides for the management of Mango webber *Orthaga* spp. in field condition (KAU, Vellayani, CISH)

3.9.11.1 KAU, Vellayani

Experiment details

Design : RBD
Replication : 3
Treatments : 4

Treatments

T1 : *Beauveria Bassiana* 2 % (ITCC 6063) 20g/l
T2 : Azadiractin1 % SC (Azadin plus) 1ml/l
T3 : Malathion 50 % EC (Malik) 2ml/l
T4 : Check

Observation

Number of active webs/plant

Result

Significant reduction in the damage by the leaf Webbers was observed at 3rd, 5th, 10th and 15th day of intervals, when Azadirachtin @ 1 ml/l and biopesticides, *Beauveria bassiana* ITCC 6063 @ *20* g /l were applied. Insecticide Malathion 50% EC @ 2ml/L was also found effective against the mango webber pest (Table 64).

Table 64. Effect of biopesticides for the management of Mango webber, pests *Orthaga* spp in field condition

Treatments	Percentage of active webs/plant			
	3 DAS	5 DAS	10 DAS	15 DAS
T1 : *Beauveria bassiana*	52.41	43.690	41.350	39.573
T2: Azadirachtin	59.11	56.180	54.416	47.516
T3 : Malathion	46.76	48.250	47.603	42.81
T4: Check	62.43	61.133	61.963	62.696
CD (0.05)	9.827	10.238	7.984	9.147

3.9.11.1 CISH, Lucknow

Population of coccinellid predators which feeds on mango hopper and mealybug was recorded during 11th-17th SMW, and the highest number of beetles (2.5/panicle) recorded at

13th SMW. The most abundant species was *Coccinella septempunctata.* Reduviid predator was observed in mango orchard during 39th SMW, eggmass & neonates also found during 40th-43rd SMW.

3.9.12 Field evaluation of *Beauveria bassiana* W/P formulation against tea mosquito bug in Guava (TNAU)

Variety	:	Lucknow 49
No of treatments	:	5
No of replications	:	4
No. of sprays	:	4
Location	:	Mangalakaraipudur
Name of the farmer		Th.K.Vijendrakumar

A field experiment was laid out with five treatments and four replications to evaluate the bioefficacy of *Beauveria bassiana* WP formulation of IIHR. Each treatment comprises of 40 trees with 10 trees in each replication. The treatments of *Beauveria bassiana* at varied concentration were imposed as per protocol at 10 days interval whereas, for the chemical treatment imidacloprid was used at 0.025 % concentration. Totally four rounds of spray were given. The total number of fruits and fruits with scar damage were counted before treatment and seven days after the last spray. The data on the per cent fruit damage indicated that *Beauveria bassiana* at 10g/litre of water showed a maximum reduction of fruit damage (81.1%) closely followed by *Beauveria bassiana* at 5g /l which reduced the fruit damage of 79.69 per cent over control (Table 65). The insecticide spray of imidacloprid at 0.025% also had a reduction of 78.6 per cent fruit damage over control. The unsprayed tree recorded a fruit damage of 26.3 per cent during the same period of observation.

Table 65. Field evaluation of *Beauveria bassiana* WP formulation (IIHR) against tea mosquito bug in guava

Particulars	Mean per cent fruit damage by *Helopeltis antonii*		Per cent reduction over control
	Pre treatment count	One week after last spray	
T1- *B.bassiana* 1g / l	22.4[a]	9.32[b]	64.50
T2- *B.bassiana* 5g / l	24.6[a]	5.34[a]	79.69
T3- *B.bassiana* 10g / l	18.2[a]	4.96[a]	81.14
T4- Chemical check	23.5[a]	5.62[a]	78.63
T5 -Control	21.8[a]	26.3[c]	

Means followed by a common letter in a column are not significantly different by DMRT; *Mean of four replications

3.10 Biological control of Temperate Fruit Crop Pests

3.10.1 Survey for identification of suitable natural enemies of codling moth, *Cydia pomonella* (SKUAST)

In order to observe natural parasitism either egg parasitoids or larval/ pupal parasitoids of codling moth infesting apple, two approaches were made in Kargil, during 2016. Five sentinel cards with *Corcyra* eggs were installed in untreated orchards during ending 1st week of June and 1st week of July 2016. The sentinel cards were collected back after three days of exposure in the field, kept in laboratory at 26ºC and examined for egg parasitism. For observations on naturally occurring larval and pupal parasitism two approaches were made during 2016-17. During ending July 2016, the larvae preparing for taking shelter for overwintering were collected from six orchards and sample from each orchard kept separately in plastic jars and kept in farmers' house of respective village for observations on the emergence of parasitoids from larvae/ pupae. Other approach comprised collection of ten overwintered larvae from each of the ten trees from each village, during the month of October' 2015 and leaving the material as such till May 2016 for emergence of larval/ pupal parasitoids. During both the period a total of 600 larvae, one hundred each from the six villages were examined for per cent parasitism.

Out of a total of 600 larvae observed, average parasitism was worked out as 2.5 ranging 1.0 to 4.0 per cent (Table 66). Although the parasitoids were found to occur in all the villages, the presence was found almost negligible, being the minimum at Bagh-e-Khomini and maximum at Mingy. The reason for negligible occurrence of parasitism is probably due to large scale pesticide used on apple, in past, for the management of Codling moth.

Sentinel cards used in all the orchards during beginning May to July 2016 did not reveal occurrence of any indigenous *Trichogramma*.

Table 66. Larval parasitism of Codling moth, *Cydia pomonella* at Kargil during 2016

Location	Total No. of larvae observed	% parasitism
Shanigund	100	2
Mangmore	100	2
Bagh-e- Khomini	100	1
Kharrol	100	3
Mingy	100	4
Gond	100	3
	Total = 600	**Average parasitism= 2.5**

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

The experiment was repeated in six orchards during 2016, with similar technical programme as of 2015, except, one time release of *Trichogramma* spp. in treatments T1, T2 and T3, because of unfavorable conditions in the valley and disturbed National highway. The cultures of *Trichogramma* spp. were received from NBAIR, Bangalore which were later mass multiplied in Biocontrol laboratory of Division of Entomology, SKUAST-K and released in Kargil.

Orchards		Detail of treatments
Shani Gund	T1	Chlorpyriphos + *T. embryophagum*
Mangmore	T2	Chlorpyriphos + *T. cacoeciae*
Bagh-e-khomini	T3	Pheromone traps + *Trichogramma* spp.
Kharrol	T4	Trunk banding + disposal of infested fruits
Mingy	T5	Azadirachtin 1500 ppm + all the treatments (1-4)
Gond	T6	Untreated Check

Similar approaches of collecting data on fruit damage (on tree & dropped fruits), per cent reduction in damage over control, trapping of overwintering larvae through trunk bands and pheromone trapping of adult moths were made as during 2015.

Overall fruit damage (Plate 6) during 2016 in treated orchards varied from 45.07 to 63.49 per cent, when compared with untreated control (72.69) (Table 67). Differences among treatments in relation to fruit damage on tree ($F = 42.41^{**}$; d.f. = 5,45; $p = 0.00$), dropped fruits ($F = 5.99^{*}$, d.f. = 5,45; $p = 0.00$) as well as overall fruit damage ($F = 33.78^{**}$; d.f. = 5,45; $p = 0.00$) were found statistically significant, when data was analyzed through one way ANOVA. Per cent reduction in damage over control ranged 12.24 to 37.65, which was also worked out to be statistically significant for treatments ($F = 19.79^{**}$; d.f. = 4,36; $p = 0.00$). Average damage during 2016 was nevertheless comparatively more than in the year 2015, as indicated through Student's t- tests (Table 67). Overall difference in fruit damage during the two years was statistically significant ($t = -2.96$, $p = 0.0038$ d.f. = 103). Comparison of two years' data on overall per cent reduction in fruit damage over control also yielded statistically significant difference ($t = -6.00^{**}$, d.f. = 96, $p = 0.00$). Significant increase in damage causing observed decline in per cent reduction in control over damage, is attributable to lack of second sequential releases of *Trichogramma* in treatments T1- T3 as well as T5. An improvement in per cent reduction in fruit damage in treatments T1, T2 and T5 is mainly due to one spray of Chlorpyriphos @ 1.5 ml/ lit of water during May. Superiority of *Trichogramma cacoeciae* (T2) over *T. embryophagum* (T1) was again established during 2016. Treatment T5, that included all the approaches for the management of Codling moth, was found superior over all other treatments during 2016 (Table 67).

Overwintering larvae of Codling moth, *Cydia pomonella* in the trunk bands used during late August of 2016, ranged 20.7- 45.5 per tree (Table 68) differed statistically orchard wise ($F = 16.51^{**}$; d.f. = 5,45; $p = 0.00$). Difference in number of larvae trapped during 2016 however when compared with data of 2015 through Student's t- test, revealed statistically non-significant differences both orchard wise as well as in terms of overall larval trap.

Average catch of adult moths through pheromone traps (Plate 7) ranged 31.25 to 90.37 / trap in different orchards, differing significantly when analyzed through ANOVA ($F = 64.72^{**}$; d.f.= 5,15; $p = 0.00$) (Table 68). Average catch of adults when compared for 2015 and 2016 through Student's t- test however did not indicate significant difference, with similar observation orchard wise, except Kharrol and Mingy.

In view of heavy fruit damage, an integrated approach for the management of Codling moth is required. One sprays of insecticide either chlorpyriphos or dimethoate, however, is essential in addition to other practices for better yield (Plate 8).

Plate 6. IPM Technology against codling moth. 19 - Biocontrol staff isolating larvae from trunk band, 20 -.isolated mature larvae of codling moth, 21 - damaged fruit on tree, 22 - fruit cut open to show larva inside

Table 67. Effect of different treatments on apple against codling moth *Cydia pomonella* in Kargil, during 2016

Location	Damage on tree (%)	Dropped fruits (%)	Overall fruit damage (%)	% reduction in damage over control	average damage during 2015 & 2016 (t-test)	% reduction in damage over control during 2015 & 2016(t- test)
Shanigund (T1)	28.53 (32.01)^{c}	88.5 (70.39)^{b}	58.52 (49.91)^{b}	19.00 (25.34)^{b}	t = -4.15** P=0.0009 DF= 15	t= -4.11 P=0.0007 DF= 17
Mangmore (T2)	20.43 (26.52)^{b}	89.16 (71.12)^{b}	54.79 (47.75)^{b}	24.21 (29.24)^{c}	t= -3.77* P=0.0027 DF= 12	t= -4.30 P=0.0006 DF= 15
Bagh-e-Khomini (T3)	34.01 (35.60)^{cd}	92.98 (76. 33)^{bc}	63.49 (52.85)^{bc}	12.24 (19.53)^{a}	t= -1.94NS P=0.077 DF= 12	t= -2.78 P=0.015 DF= 14
Kharrol (T4)	32.07 (34.40)^{c}	91.38 (74.33)^{b}	61.72 (51.82)^{b}	14.71 (21.82)^{a}	t= -3.61* P=0.0023 DF= 16	t= -4.81 P=0.0002 DF= 17
Mingy (T5)	9.08 (17.37)^{a}	81.05 (65.22)^{a}	45.07 (42.12)^{a}	37.65 (37.74)^{d}	t= -2.70* P=0.015 DF= 17	t= -3.15 P=0.0058 DF= 17
Gond (T6) (Untreated check)	49.64 (44.75)^{d}	95.74 (78.96)^{bc}	72.69 (58.62)^{c}	--	t= -1.72 NS P=0.11 DF= 14	--
C.D.(0.05)	3.34	4.71	2.24	3.81	Over all t= -2.96 P=0.0038 DF= 103	Over all t= -6.00 P=0.0000 DF= 96
CV (0.05)	50.26	9.33	16.46	55.96	--	--

*Figures in each column represent mean of 10 observations; values in parentheses are arcsine transformations; similar alphabets in a column indicate values statistically on par; DF = Degree of freedom; NS = Non significant; * and ** significant at 5% and 1% respectively; Where T1= One spray of Chlorpyriphos +Two sequential releases of *T. embryophagum*; T2= one spray of Chlorpyriphos + Two sequential releases of *T. cacoeciae*; T3= Pheromone traps + *Trichogramma* spp.; T4= Trunk banding & destruction of larvae; T5= 2 sprays of Chlorpyriphos + Two sequential releases of Trichogramma + trunk banding + pheromone traps

Plate 7. IPM Technology against Codling moth. 23 - Distribution of pheromone traps among locals, 24 - Local boys involved for Preparing pheromone traps, 25 & 26 - Sticky liners showing adult catch of codling moth

Plate 8. IPM Technology against Codling moth. 27 - Biocontrol staff preparing Neem solution for spray, 28 - Orchard in Mingy with good crop during 2016

Table 68. Effect of trunk bands and pheromone traps against larvae and adults of codling moth, *Cydia pomonella* during 2016

Location	Av. Larvae/ burlap	Av. adults / trap during May' 2016	Av. adults / trap during July' 2016	Average moths/ trap during 2016	Comparison of data for 2015 & 2016 (t- test)	
					Average larval trap/ band	Average adult moths trapped/trap
Shanigund	28.0 (5.24)^{b}	23.25 (4.80)^{ab}	59.0 (7.66)^{b}	41.12 (6.40)^{b}	t= 0.48 NS, p=0.64, d.f.= 14	t= 1.97 NS, p =0.11, d.f. = 5
Mangmore	27.7 (5.19)^{b}	21.5 (4.63)^{a}	62.25 (7.88)^{b}	41.87 (6.46)^{b}	t= 1.47 NS, p =0.16, d.f. = 17	t= 1.26 NS, p =0.28 , d.f. = 4
Bagh-e-Khomini	43.7 (6.59)^{c}	51.5 (7.15)^{b}	91.0 (9.50)^{c}	71.25 (8.43)^{c}	t= 0.97 NS, p =0.35, d.f. = 14	t= 1.65 NS, p =0.16, d.f. = 5
Kharrol	37.9 (6.13)^{c}	45.75 (6.75)^{b}	103.0 (10.13)^{c}	74.4 (8.62)^{c}	t= 0.54 NS, p =0.60, d.f. = 17	t= 3.90*, p =0.018, d.f. = 4
Mingy	20.7 (4.53)^{a}	19.5 (4.39)^{a}	43.00 (6.54)^{a}	31.25 (5.58)^{a}	t= 1.70 NS, p =0.11, d.f. = 15	t= 2.36*, p =0.065, d.f. = 5
Gond	45.5 (6.69)^{cd}	78.0 (8.81)^{c}	102.75 (10.11)^{c}	90.37 (9.50)^{d}	t= -0.70 NS, p =0.49, d.f. = 17	t= -0.00 NS, p =1.0, d.f. = 3
CD(0.05)	0.50	0.58	0.84	0.48	Overall t= 1.10 NS, p =0.28, d.f. = 113	Overall t= 1.34 NS, p =0.19, d.f. = 45
CV(0.05)	35.17	55.87	34.21	38.44		

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

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

The experiment was conducted in high density apple orchard block of SKUAST-K, during the month of June' 2016. Two releases of 8-10 days old nymphs of anthocorid bugs, *Blaptostethus pallescens* were made on ten plants@ 100 and 200/ plant (Plate 7, Figs. 29 & 30). The two treatments were carried out in different blocks, each separated by 20-25 feet apart. Observations on the number of red mites/leaf for each treatment was recorded, on third and seventh days. For recording the observations, three leaves, each from top and middle portion of a plant were randomly selected and number of mites on the under surface of the leaves were recorded with the help of hand lens as well as portable binocular. A total of 24 leaves from a plant, six leaves from each of the four directions were examined after three and seven days. The data was replicated three times and compared with untreated check. The culture of anthocorid bugs, *B. pallescens* was received from NBAIR, Bangalore and mass multiplied in the biocontrol laboratory of Division of Entomology, SKUAST-K.

On an average, number of European red mites (only the motile stages) *P. ulmi* in untreated check were 9.95 and 15.52/leaf on 3rd and 7th days, respectively. Differences in number of mites among plants from all four directions were found statistically non significant on 3rd and 7th days, but significant for mean of the two periods when analyzed through one way ANOVA (F= 5.61**, d.f.= 3(18), p = 0.007).

In response to two releases of bugs @ 100/plant, average number motile mites were 8.26 which increased to 12.15 from 3rd to 7th day. The mean population was worked out as 10.21. Differences in mites' population among plants on 3rd, 7th and also for mean of the two observations were found statistically non significant when compared through ANOVA. Similar observations were also recorded for T2, *i.e.*, @ 200 bugs/plant.

Comparison of the three treatments however indicated a significant difference in mites' population on 3rd day (F= 5.45**, d.f.= 2(67), p = 0.006), 7th day (F= 10.73**, d.f.= 2(67), p = 0.000) and mean of the two periods (F= 17.17**, d.f.= 2(14), p = 0.000), when compared through one way ANOVA.

Data revealed treatments, T1 and T2 statistically different from check (T3) on 3rd day of the release of bugs, but statistically on par on 7th day. However, mean of the data indicated supremacy of T2 over T1 and check (T3) (Table 69). Per cent reduction in mites' population over check was worked out as 18.22 and 23.99 in T1 and T2, respectively being statistically on par when compared with Student's t- test (t= 0.99 NS, d. f. = 12, p = 0.33).

Present data confirms the field efficacy of *B. pallescens* against European red mites infesting apple in Kashmir. However, very low suppression of the pest indicates inadequate dosage as well as frequency of release of predators. Increase in dosage/plant probably can yield better result which will be done during current year, *i.e.*, 2017.

Laboratory evaluation of *B. pallescens* against European red mite, *P. ulmi* was also done at different predator: prey ratio. Total mortality (failure of hatching) of the eggs of the prey was worked out as 70.00, 92.22, 80.00 and 68.66 per cent in response to 1:10, 1:15, 1:20 and 1:25 predator: prey ratio, respectively (Table 70). Difference in per cent egg hatching of the prey in relation to observed predator: prey was found statistically non significant on 3rd day (F= 2.74 NS, d.f.= 4(8), p = 0.105) but, significant on 5th day (F= 13.96** NS, d.f.= 4(8), p = 0.001) when analyzed through one way ANOVA. Differences in per cent mortality of European red mite as indicated by the failure of egg hatch was found statistically significant (F= 15.77**, d.f.= 4(8), p

= 0.001) when compared for different predator: prey ratio. Overall performance of predator however at all predator: prey ratio was found statistically on par.

Table 69. Impact of field releases of *B. pallescens* against European red mites, *Panonychus ulmi* on apple in Shalimar, Kashmir during 2016

Treatment	No. of mites/ leaf		Mean	Per cent reduction over check
	3rd day	7th		
@100 bugs (T1)	8.26 (2.84)[a]	12.15 (3.95)[a]	10.21 (3.4)[a]	18.22 (27.34)[a]
@200 bugs (T2)	7.68 (2.73)[a]	11.16 (3.32)[a]	9.42 (3.03)[b]	23.99 (28.70)[a]
Check (T3)	9.95 (3.11)[b]	15.52 (3.91)[a]	12.74 (3.51)[a]	
CD (0.05)	0.18	0.71	0.29	20.36
CV (%)	31.17	35.63	27.14	--

*Each figure in the column represents mean of 72 observations; figures in parentheses except last column that represents arc sin transformations, are √n; similar superscripts indicate data statistically on par

Table 70. Laboratory evaluation of *B. pallescens* against European red mite, *Panonychus ulmi* on apple during 2016

Predator : prey	Predator used	No. of prey used	Effect of *B. pallescens* on average mortality of eggs of European red mite			
			% hatching 3rd day	% hatching 5th day	Total mortality (%)	Corr. Mortality (%)
1:10	1	10	10.00 (15.00) [a]	22.03 (27.56)[a]	70.00 (56.99)[b]	63.39
1:15	2	30	14.44 (21.87) [a]	19.61 (26.19) [a]	68.88 (56.22) [b]	62.03
1:20	3	60	20.00 (26.51) [a]	31.40 (34.01) [a]	55.00 (47.88)[b]	45.08
1:25	4	100	25.66 (30.33) [a]	38.65 (38.31)[a]	46.00 (42.64)[b]	34.11
Check	-	40, 60,100	29.94 (33.08) [b]	74.43 (59.91)[b]	18.05 (24.83)[a]	--
CD (0.01)			17.73	14.92	14.52	

Values in parentheses are a sin transformation; figures in columns 4-6 are mean of three replications; ; similar superscripts in a column indicate data statistically on par

3.10.4 Laboratory evaluation of feeding potential of *Chilocorus infernalis* against *Lecanium* scale on plum (SKUAST)

Lecanium scales along with grubs of *Chilocorus infernalis* on plum were collected from the orchard (Plate 9, Figs. 34 & 35) during the month of June' 2016 and brought to lab for evaluation of feeding propensity of the grubs. Counted number of scales on twigs, in fixed ratio of predator: prey of 1:10, 1:15 and 1:20 were exposed separately in glass test tubes (20 x 2.5cm.) for seven days. Scales consumed on 3rd, 5th and 7th day, as indicated by holes created in the scales and devoid of crawlers within, were recorded. A per cent consumption on given period was determined. The experiment was done in BOD (27±1°C, 65% Relative Humidity, 14L: 10D). The experiment was replicated thrice.

A third instar grub of *C. infernalis* was found to consume an average of 90.0, 86.66 and 66.65 per cent *Lecanium* scale, when 10, 15 and 20 prey was supplied to a single grub (Table 71). Average rate of consumption was found statistically similar in T1 and T2 i.e. when 10 and 15 hosts were supplied, which however declined in T3. However, comparison of data for average consumption revealed the difference among treatments statistically non significant when analyzed through one way ANOVA (F= 3.53NS, d.f. 2(4), $p = 0.131$). Rate of feeding was found to increase gradually with decrease in host number. On 3rd day however, it was found statistically identical at all the predator: prey ratio. On 5th and 7th day, rate of consumption was statistically similar in T1 and T2 but different from T3.

Table 71. Predatory potential of 3rd instar grubs of *Chilocorus infernalis* against *Lecanium* scales on plum

Predator : prey	Rate of consumption (%) of *Lecanium* scale			
	consumption 3rd day	consumption 5th day	consumption 7th day	Average consumption (%)
T1 (1:10)	33.33 (35.21)[a]	39.68 (39.01)[b]	75 (65.00)[b]	90.00 (75.00)[b]
T2 (1:15)	22.22 (27.74)[a]	42.60 (40.74)[b]	70.63 (57.56)[b]	86.66 (69.01)[b]
T3 (1:20)	25.0 (29.92)[a]	28.82 (32.46)[a]	37.87 (37.85)[a]	66.65 (54.83)[a]
CD (0.01)	8.89	4.93	26.79	16.63

Values in parentheses are arc sin transformation; each figure in columns represent mean of three replications; similar superscripts indicate the values statistically on par

3.10.5 Field evaluation of predatory bug, *Blaptostethus pallescens* against two spotted spider mite, *Tetranychus urticae* on apple (SKUAST)

The experiment was conducted in similar high density apple orchard block of SKUAST-K, as of European red mites, during the month of June 2016. Besides taking data on ERM, data on two spotted mites, *Tetranychus urticae* was also recorded. Similar approach for recording data was done as for ERM, discussed earlier.

On an average, number of two spotted spider mites (only the motile stages) was 10.5 and 18.5/leaf in untreated check, on third and seventh days respectively, with an average of 14.5

mites/leaf for both the periods (Table 72). Differences in number of mites among plants were found statistically significant on 3rd day (F= 4.35**, d.f.= 2(14), p = 0.034) but non significant on 7th day and also for mean of the two periods, when analyzed through one way ANOVA. Differences in mites on 3rd and 7th day was also significant (t= 12. 18**, d.f.= 45, p = 0.000) when compared through Student's t- test.

In response to two releases of bugs @ 100/plant, average number of two spotted mites was 7.43 which rose to 11.26 on 7th day. The mean population was worked out as 9.34. Among plants, differences in mites' population however was found statistically non significant on 3rd, 7th day and for mean of the two periods, when compared through ANOVA. Similar observations were also recorded for treatment T2, *i.e*., @ 200 bugs/plant.

Comparison of treatments for number of mites however, when indicated significant differences on 3rd day (F= 48.35**, d.f.= 2(67), p= 0.000), 7th day (F= 120.97**, d.f.= 2(67), p = 0.000) and also mean of the two periods (F= 153.75**, d.f.= 2(14), p = 0.000), when compared through one way ANOVA, which clearly indicated the efficacy of predatory bugs in the suppression of two spotted spider mites.

Comparison of data revealed treatments, T1and T2 significantly different than check (T3) both on 3rd and 7th day. Mean of two periods however in case of T1 and T2 were found statistically on par, but significant when compared with T3 (Check). Difference in mites' population on 3rd and 7th day was found statistically significant (t= 6.72**, d.f.= 126, p = 0.000) when compared using Student's t- test. Per cent reduction in mites' population over check was worked out as 34.56 and 43.23 in T1 and T2, respectively being statistically significant, when compared with one way ANOVA (F= 3.59**, d.f. = 5(35), p = 0.01)

Present data confirmed the field efficacy of *B. pallescens* against two spotted spider mite, *Tetranychus urticae* infesting apple in Kashmir. Significant rise in per cent reduction in mites' population in relation to increase in dosage argues well for future exploitation of this predator in valley. Further increase in reduction however can be realized if dosage as well as frequency of the predators is increased, in view of the role of bug both against eggs of European red mites, *Panonychus ulmi* as well as two spotted spider mites, *Tetranychus urticae*.

Table 72. Impact of field releases of *B. pallescens* against two spotted spider mite, *Tetranychus urticae* on apple in Shalimar, Kashmir during 2016

Treatment	No. of mites/ leaf		Mean	Per cent reduction over check
	3rd day	7th		
@100 bugs (T1)	7.43 (2.71) [a]	11.26 (3.34)[a]	9.34 (3.03) [a]	34.56 (35.69)[a]
@200 bugs (T2)	6.63 (2.57) [b]	9.61 (3.08)[b]	8.12 (2.82) [a]	43.23 (40.95)[b]
Check (T3)	10.5 (3.22)c	18.5 (4.29)[c]	14.5 (3.76)[b]	--
CD (0.05)	0.12	0.13	0.26	5.25
CV (%)	26.16	33.6	28.45	30.05

- Each figure in the column represents mean of 72 observations; figures in parentheses except last column which represent arc sin transformation, are √n; similar superscripts in a column indicate data statistically on par

Laboratory evaluation of *B. pallescens* against two spotted spider mite, *Tetranychus urticae* was also done at different predator: prey ratio. Total mortality (failure of hatching) of the eggs of the prey was worked out as 93.33, 86.66, 63.33 and 51.0 per cent in response to 1:10, 1:15, 1:20 and 1:25 predator: prey ratio, respectively (Table 73). Difference in per cent mortality in relation to observed predator: prey was found statistically significant (F= 89.64**, d.f.= 4(8), p = 0.000) when analyzed through one way ANOVA. Differences in per cent egg hatch on 3rd (F= 27.32**, d.f.= 4(8), p = 0.000) and 5th day (F= 217.09**, d.f.= 4(8), p = 0.000) were also found statistically significant when analyzed through one way ANOVA.

Table 73. Laboratory evaluation of *B. pallescens* against two spotted spider mite, *Tetranychus urticae* on apple during 2016

Predator : prey	Predator used	No. of prey used	Effect of *B. pallescens* on average mortality of eggs of two spotted spider mite			
			% hatching 3rd day	% hatching 5th day	Total mortality (%)	Corr. Mortality (%)
1:10	1	10	6.66 (13.95) [a]	0.00 (4.05) [a]	93.33 (77.71)[a]	92.96
1:15	2	30	7.77 (16.65) [a]	6.04 (14.67) [b]	86.66 (68.68) [a]	85.92
1:20	3	60	21.66 (28.00) [b]	19.13 (26.28) [c]	63.33 (52.74) [b]	61.31
1:25	4	100	26.00 (30.96) [b]	30.87 (33.91)[d]	51.00 (45.57)[b]	48.30
Check	-	40, 60,100	55.94 (48.72) [c]	88.15 (70.37)[e]	5.22 (13.14)[c]	--
CD (0.01)			10.8	7.05	10.75	

*Values in parentheses are a sin transformation; figures in columns 4-6 are mean of three replications; similar superscripts in a column indicate data statistically on par

3.10.6 Evaluation of entomopathogenic fungi and EPNs for the suppression of apple root borer, *Dorysthenes hugelii* under field conditions (YSPUHF)

Bio-pesticides namely *Metarhizium anisopliae, Beauveria bassiana* (10^6 conidia/ cm² each) *Steinernema carpocapsae* and *Heterorhabditis indica* (80IJ/ cm² each) were evaluated for the control of apple root borer, *Dorysthenes hugelii* and compared with standard insecticide, chlorpyriphos (0.06%) and untreated control. The experiment was conducted on fully grown bearing trees of apple (cv. Royal Delicious) in randomized block design with four replications at Rohru district Shimla. The treatments were applied during the month of August, 2016 and the observations were recorded during December, 2016 i.e. at the time of basin preparation. Among different treatments chlorpyriphos (0.06%) was the most effective resulting in 83.2 per cent mortality of the root borer grubs, however, *Metarhizium anisopliae* was on par with the chemical insecticide resulting in 68.3 per cent mortality of the pest (Table 74). Other treatments were only

moderately effective and killed the pest larvae to the tune of 39 to 50.9 per cent. Pest mortality in the control was 5.8 per cent.

Table 74. Evaluation of entomopathogenic fungi and EPNs for the suppression of apple root borer, *Dorysthenes hugelii* under field conditions

Sl. No.	Treatment	Larval mortality (%)
1	*Steinernema carpocapsae* (80 IJ/cm²)	39.0 (38.4)[b]
2	*Heterorhabditis indica* (80 IJ/cm²)	50.9 (45.5)[b]
3	*Beauveria bassiana* (10^6 conidia/cm^2)	47.7 (43.6)[b]
4	*Metarahizium anisopliae* (10^6 conidia/cm²)	68.3 (56.9)[ab]
5	Chlorpyriphos (0.06%)	83.2 (69.2)[a]
6	Control(Untreated)	5.8 (9.9)[c]
	CD (p = 0.05)	(15.6)
	CV (%)	24.6

Figures in parentheses are angular transformed values

3.11 Biological control of Vegetable Crop Pests

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

3.11.1.1 AAU, Anand

Survey for ascertaining the outbreak of *T. absoluta* was carried out in agriculture campus, AAU, Anand as well as in farmers' fields at Anand, Kheda, Vadodara, Chhota udepur and Sabarkantha districts during the year 2015-16. Percentage of plants infested with *T. absoluta* was be assessed by observing 10 randomly selected plants in every 100 sq. m crop area and leaves were observed for the presence of leaf mine caused by larva and fruits were also be observed for the presence of pin head sized holes. The incidence of *Tuta* in other crop fields, *viz*., potato, brinjal, chilli, and tobacco was also surveyed and observations were recorded.

The incidence and damage was noticed to the level of 8-90 %. The incidence and damage to the tune of 8-14% was recorded at MVRS farm, AAU, Anand and in farmers' fields at Runaj and Ajarpura. Highest damage (80-90%) was reported in farmer field at Idar, Sabarkantha District. In the year 2016-17 regular survey was conducted to assess the *T. absoluta* incidence and damage. Only the *T. absoluta* moth catches were recorded and no damage symptoms were noticed in all the fields surveyed.

3.11.1.2 AAU, Jorhat

Extensive surveys were conducted in different tomato growing pockets of Jorhat, Golaghat and Sivsagar districts. No Pinworm infestation was observed in the surveyed areas. The survey programme will be continued during 2017 -18.

3.11.1.3 IIVR, Varanasi

Extensive surveys were conducted in and around Varanasi to know the occurrence of American pin work, *Tuta absoluta* (Gelechiidae: Lepidoptera) on tomato, if any. Different plant parts *viz*., green leaves and fruits were observed for the incidence of pin worm. Occurrence of pin worm on leaf and fruit were first recorded during second week of January (2 SMW), 2017 at the experimental farm of the institute. Larvae of *T. absoluta* feed on the mesophyll of the leaf leaving only the epidermis intact. They cause conspicuous leaf blotches of irregular shape which later become necrotic. Tomato plants, from seedlings to mature stage, found to be attacked by this oligophagous pest. On fruits, small minute pin-sized holes are often visible. Damaged fruits with galleries representing open areas for invasion by secondary pathogens, leading to fruit rot.

3.11.1.4 MPKV, Pune

The tomato fields were surveyed to record the incidence of pinworm, *Tuta absoluta* Meyrick during the period from January, 2016 to March, 2017. The pest incidence was observed in Junnar and Ambegaon tahasil from Pune district. The leaf damage was ranged from 20 to 40 per cent, while the fruit damage was noticed to the extent of 18 to 29 per cent (Table 75). However, the pest incidence was not observed from June to December, 2016. The pest incidence was again noticed in Pune during January to March, 2017 to the extent of 18 to 40 per cent leaf

damage and 12 to 20 per cent fruit damage. The maximum incidence of this pest was noticed in the month of March during both the years.

Table 75. Survey and incidence of pin worm, *Tuta absoluta* on tomato

Month	Leaf damage (%)	Fruit damage (%)
January, 2016	24.00	20.00
February, 2016	36.00	24.00
March, 2016	40.00	29.00
April, 2016	32.00	23.00
May, 2016	20.00	18.00
June, 2016	0.0	0.0
July, 2016	0.0	0.0
August, 2016	0.0	0.0
September, 2016	0.0	0.0
October, 2016	0.0	0.0
November, 2016	0.0	0.0
December, 2016	0.0	0.0
January, 2017	18.00	12.00
February, 2017	26.00	16.00
March, 2017	40.00	20.00

3.11.1.5 KAU, Thrissur

The South American pin worm, *Tuta absoluta* was collected from brinjal plants in a homestead at Vadakkenchery in Palghat district. A pupal parasitoid of the South American pin worm, *Tuta absoluta* was collected from brinjal plants in a homestead and has been sent to ICAR-NBAIR for identification.

3.11.1.6 SKUAST, Srinagar

Extensive **s**urveys were conducted during vegetative and fruit ripening stages of tomato in four districts viz. Anantnag, Budgam, Ganderbal and Srinagar of Kashmir, for the presence of Pin Worm, *Tuta absoluta*. The experiment was however not conducted as per Technical Programme. The leaves were visually and thoroughly observed for the presence of leaf miners for indication of mining by *T. absoluta,* which was absolutely lacking in the observed fields. Although presence of tomato fruit borer, *Helicoverpa armigera* was noticed in the field, but no indication of the tomato pin worm could be traced out at any stage of the fruit, in the surveyed districts of the Kashmir province.

3.11.1.7 YSPUHF, Solan

A survey for the American pin worm, *Tuta absoluta* was conducted from May to November, 2016 covering 11 locations of districts Solan, Sirmour, Shimla and Bilaspur which are the major tomato growing areas of Himachal Pradesh (Table 76). The incidence of *Tuta absoluta* was also recorded under polyhouse conditions at two locations namely Nauni and

Subathu of district Solan (HP) on tomato, brinjal and potato (Table 77). Under open field conditions the pest was found to infest tomato and potato. The miner was present at eight (Nauni, Dharja, Nainatikkar, Deothi, Subathu, Kandaghat, Dharampur and Sarahan) out of the eleven surveyed locations. At these locations 42 to 89 per cent of the tomato plants were infested with *T. absoluta* with the number of mines/leaf/infested plant varying from 1-11 and fruit damage varying from 0-6 per cent at different locations. Under polyhouse conditions the pest was found to attack tomato, brinjal and potato (Table 77). The severity of the pest was more on tomato than on brinjal and potato. In tomato 78 to 100 per cent plants were infested with the pest resulting upto 100 per cent crop loss in one of the polyhouses. In brinjal and potato 84 and 92 per cent plants had leaf mines with their density varying from 6-16 and 3-8, respectively. Survey study revealed that the pest was more severe under polyhouse conditions than in open field conditions and prefers tomato over other host plants. During the survey a mirid predatory bug, *Nesidiocoris tenuis* was recorded preying on eggs and early instars of the leafminer. Besides, a parasitoid *Neochrysocharis formosa* was also associated with the pest.

Table 76. Infestation of *Tuta absoluta* on tomato under open field conditions at different locations

Sl. No.	Location	Plants infested (%)	Number of mines/leaf/infested plant	Fruit damage (%)
1	Nauni	54 - 71	3-6	0-4
2	Dharja	58 - 70	2-11	1-3
3	Kandaghat	51 - 63	4-7	2-4
4	Nainatikkar	59 - 77	1-9	0-5
5	Deothi	42 - 55	1-4	1-2
6	Subathu	64 - 89	5-9	0-6
7	Dharampur	65 - 82	3-9	0-4
8	Sarahan	60 - 76	3-8	0-3
9	Bhadrog (Bilaspur)	Nil	Nil	Nil
10	Kandraur	Nil	Nil	Nil
11	Duttnagar (Rampur)	Nil	Nil	Nil

Table 77. Infestation *Tuta absoluta* under polyhouse conditions

Sl. No.	Location	Crop	Infestation (%)	Mines/leaf	Fruit damage (%)
1	Nauni	Tomato	78	7-10	3-7
2	Subathu	Tomato	100	The crop was totally damaged	2-11
3	Subathu	Brinjal	84	5-16	Nil
4	Subathu	Potato	92	3-8	-

3.11.1.8 PAU, Ludhiana

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

3.11.1.9 PJTSAU, Hyderabad

Methodologies as prescribed by NBAIR were adopted for the collection of samples and surveys were concentrated in two districts of Telangana state, *viz*., Rangareddy and Nalgonda. The natural enemies were collected from the tomato plant parts affected by *Tuta absoluta.*The observations were also recorded on alternate host plants also. The vegetable growing areas of Telangana were surveyed for infestation and intensity of *Tuta absoluta* incidence. The overall scenario showed marginal incidence of the pest. The surveys are in progress and quantification of the incidence levels will be finalized after completion of surveys.

3.11.1.10 TNAU, Coimbatore

The occurrence of tomato pinworm, *Tuta absoluta* was monitored using water pan trap and sleeve trap loaded with sex pheromone lures in four tomato growing areas of Coimbatore district, *viz*., Thondamuthur, Thudiyalur, Madukkarai and Irugur. The moth collection of pinworm was maximum in October (3-23), November (5-25) and December (3-17) adult moths trap) as compared to rest of the cropping period. The leaf damage and fruit damage observed in the field was also high in October, November and December 2016 which coincides with the maximum adult catches. Among the four locations studied, Madhukkarai region harboured more incidence of pinworm followed by Thondamuthur than Thudiyalur and Irugur. The higher incidence in Madhukkarai and Thondamuthur might be due to more tomato cropping areas in this region. The occurrence of pinworm was not observed in other Solanaceous crops like potato, brinjal chilli and tobacco.

3.11.1.10 UAS, Raichur

The incidence of tomato pinworm, *T. absoluta* noticed during last week of October and continued till first week of April. The peak activity of moths was noticed during second week of January (1060.07 moths /trap) and later the decline in moth trap catches was observed (Table 78).

Table 78. Survey and surveillance of natural enemies of tomato pinworm, *Tuta absoluta* on tomato

Year **2016**	Std Week	No. of moths per trap (Average of 4 traps)
Oct 29-Nov 04	44	5.07
Nov 05-11	45	7.20
Nov 12-18	46	13.76
Nov 19-25	47	59.87

Nov 26-Dec 02	48	141.97
Dec 03-09	49	259.71
Dec 10-16	50	309.58
Dec 17-23	51	442.90
Dec 24-31	52	518.63
2017		
Jan 01-07	1	699.18
Jan 8-14	2	1000.43
Jan 15-21	3	1060.07
Jan 22-28	4	905.07
Jan 29-Feb 4	5	809.52
Feb 5 - 11	6	783.24
Feb12 - 18	7	572.89
Feb 19- 25	8	202.44
Feb 26- Mar 4	9	182.81
Mar 5-11	10	136.35
Mar 12-18	11	108.34
Mar 19-25	12	91.39
Mar 26-Apr 01	13	75.75
Apr 02-08	14	57.46

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

3.11.2.1 AAU-Anand

The treatments comprised of T1: *Trichogramma achaeae* @ 50000/ha release (6 releases), T2: *Trichogramma pretiosum* @ 50000 / ha release (6 releases), T3: *Metarhizium anisopliae* @ 4 g/ liter ($2x10^8$ cfu g^{-1}), T4: *Lecanicillium lecanii* @ 4 g/ liter ($2x10^8$ cfu g^{-1}), T5: *Beauveria bassiana* @ 4 g/ liter ($2x10^8$ cfu g^{-1}), T6: Azadirachtin 1500 ppm @ 2 ml/ liter, T7: Indoxacarb 15.8 EC 0.032% @ 2 ml/ liter (125 g a.i./ha) and T8: Untreated control. Each retreatment was replicated thrice. An isolation distance of 500 meters was maintained between *Trichogramma* treatments. Observations were recorded at fortnightly intervals from seedling to last harvest from 10 plants/ 100 m^2 crop area selected at random . The leaf and fruit damage was also recorded.

Results

Tuta absoluta infestation was observed to the tune of 8-12 %. Low leaf and fruit damage was observed in the treatment T6 - Azadirachtin 1500ppm @ 2ml/liter (2.67%, 0.58%) followed by the treatment T5 - *Beauveria bassiana* @ 4g/ liter (2x108cfu g-1) (4.00%, 0.69%) and T1 (*Trichogramma achaeae* @ 50000/ha release - 6 releases) (5.33%, 1.12%). However, the lowest leaf and fruit damage was recorded in chemical treatment T7- Indoxacarb @ 2ml/liter (1.33%, 0.34%). Among the biocontrol treatments T6 (28.33 t/ha) recorded highest yield followed by T5 (27 t/ha) and T1 (23.33 t/ha) (Table 79).

The experiment for the year 2016-17 is in progress in farmer's field at Runaj village. No pest incidence was recorded.

Table 79. Efficacy of biocontrol agents against *Tuta absoluta* in tomato

Treatment		Infestation of *T. absoluta*		Infestation of *H. armigera*		Fruit yield (t/ha)
		Leaf damage (%)	Fruit damage (%)	No. of larvae	Fruit damage (%)	
T1	*Trichogramma achaeae* @ 50000/ha release (6 releases)	2.41 (5.33)	1.27 (1.12)	1.33 (1.27)	2.52 (5.82)	23.33
T2	*Trichogramma pretiosum* @ 50000/ha release (6 releases)	2.91 (8.00)	1.65 (2.23)	1.42 (1.50)	2.73 (6.89)	20.33
T3	*Metarhizium anisopliae* @ 4 g/ liter ($2x10^8$ cfu g^{-1})	3.08 (8.67)	2.18 (4.24)	1.86 (3.00)	2.84 (7.54)	19.00
T4	*Lecanicillium lecanii* @ 4 g/ liter ($2x10^8$ cfu g^{-1})	2.68 (6.67)	1.52 (1.81)	1.64 (2.23)	2.43 (5.11)	21.00
T5	*Beauveria bassiana* @ 4 g/ liter ($2x10^8$ cfu g^{-1})	2.11 (4.00)	1.09 (0.69)	1.33 (1.27)	2.33 (4.93)	27.00
T6	Azadirachtin 1500 ppm @2 ml/ liter	1.77 (2.67)	1.02 (0.58)	1.25 (1.07)	2.24 (4.42)	28.33
T7	Indoxacarb 15.8 EC 0.032% @ 2 ml/ liter (125 g a.i./ha)	1.34 (1.33)	0.92 (0.34)	1.23 (1.00)	1.92 (3.47)	32.00
T8	Control (water spray)	3.63 (12.67)	2.92 (8.06)	2.20 (4.37)	3.29 (10.26)	16.33
SEM ±		0.09	0.07	0.08	0.16	2.14
CD at 5%		0.27	0.20	0.24	0.48	6.48
CV%		6.32	7.39	9.18	10.83	15.8

Note: Figures in parentheses are retransformed values; those outside are transformed value

3.11.2.2 MPKV, Pune

The experiment was laid out on the Research Farm of Agril. Entomology Section, College of Agriculture, Pune. The transplanting of tomato *var*. Abhinav was carried out on 22nd November, 2016 on ridges and furrows at 90x60 cm spacing in 3x2 m plots. The trial was laid out in RBD with eight treatments and three replications. Three sprays of biopesticides and chemical insecticide were given at fortnightly interval starting from 3rd February, 2017. Six release of bioagents *viz., Trichogramma achaeae* @ 50,000 and *T. pretiosum* @ 50,000 at weekly interval starting from 3rd February, 2017. The observations were recorded on ten randomley selected palnts from each treatment plots. All the leaves on each plant were observed for the presence of leaf mines and pin head sized holes on fruits per plant caused by the larvae recorded at weekly interval. The leaf and fruit damage were recorded a day before initiation of treatment application as pre-count and post counts at weekly interval till last picking of the tomato.

The data in Table 80 revealed that three sprays of indoxacarb @ 1 ml/lit. found significantly superior over other treatments in reducing the leaf damage (6.02%) and fruit infestation on number basis (4.10%) as well as on weight basis (6.84%) and gave maximum yield of marketable tomato (230.96 q/ha). However, the biological component consisting six releases of *Trichogramma achaeae* @ 50,000 per ha which recorded 8.12 per cent leaf damage, 8.16 per cent fruit damage on number basis and 10.12 per cent on weight basis with 219.67 q/ha yield of marketable fruits was the next best treatment, followed by *Metarhizium anisopliae* @ 10^8 conidia/ ml and Azadirachtin 1000 ppm @ 2 ml/lit, being on par with each other.

Table 80. Biological suppression of American pinworm, *Tuta absoluta* on tomato

Treatment	Leaf damage %		Fruit damage %		Yield (q/ha)
	Pre count	Post count	No. basis	Wt. basis	
T_1: *Trichogramma achaeae* @ 50,000 per ha- 6 release	21.13[a] (27.37)	8.12[b] (16.56)	8.16[b] (16.60)	10.12[b] (18.55)	219.67[b]
T_2: *Trichogramma pretiosum* @ 50,000 per ha-6 releases	21.89[a] (27.90)	12.97[c] (21.11)	15.87[c] (23.48)	16.98[c] (24.33)	192.30[c]
T_3: *Metarhizium anisopliae* @ 10^8 conidia/ ml	22.63[a] (28.41)	8.64[b] (17.09)	11.65[b] (19.96)	13.09[b] (21.21)	218.23[b]
T_4: *Lecanicillum lecanii* @ 10^8 conidia/ ml	20.58[a] (26.98)	29.62[d] (32.97)	19.52[d] (26.22)	22.19[d] (28.10)	163.59[d]
T_5: *Beauveria bassiana* @ 10^8 conidia/ ml	23.60[a] (29.06)	12.33[c] (20.56)	13.66[c] (21.69)	16.01[c] (23.59)	197.42[c]
T_6: Azadirachtin 1000 ppm @ 2 ml/lit.	19.65[a] (26.31)	10.19[b] (18.62)	12.22[b] (20.46)	13.36[b] (21.44)	211.65[b]
T_7: Indoxacarb @ 1 ml/lit.	20.81[a] (27.14)	6.02[a] (14.20)	4.10[a] (11.68)	6.84[a] (15.16)	230.96[a]
T_8: Untreated control	21.64[a] (27.72)	32.85[d] (34.97)	21.14[d] (27.37)	23.54[d] (29.02)	150.65[e]
CD ($P = 0.05$)	NS	2.21	3.97	3.23	10.91

NS= Non-significant; Figures in parentheses are arc sine transformed values

3.11.2.3 IIHR, Bangalore

Eperimental details not available.

3.11.2.4 YSPUHF, Solan

The experiment for the biological suppression of the American pin worm, *Tuta absoluta* was conducted at the experimental farm of the Department of Entomology, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during 2016. Bio-control agents/biopesticides, *viz*., *Trichogramma achaeae* (50000/ha), *Trichogramma pretiosum* Thelytokous) (50000/ha), *Metarhizium anisopliae* (4g/L), *Lecanicillium lecanii* (4g/L), *Beauveria bassiana* (4g/L), azadirachtin (1500ppm; 3ml/L) and *Bacillus thuringiensis* (Bt) (1L/ha) were evaluated against the pest and compared with indoxacarb (2ml/L) and untreated control. The treatments were applied in plots having an on par pest density of 9.7 to 12 larvae per

plant. Each treatment was applied twice at 15 days interval and the data on pest population were recorded before treatment as well as 7 and 15 days after first treatment, and 7 days after second treatment. The data recorded during the experiment was used to calculate the per cent reduction in pest population over control and is presented in Table 81. Results of the experiment revealed that indoxacarb (2ml/L) was the most effective treatment resulting in 87.4, 71.4 and 88.6 per cent reduction of the miner population over control after 7 and 15 days of first spray and 7 days of second spray, respectively. Among different bio-agents evaluated, azadirachtin (1500 ppm; 3ml/L), *T. achaeae, T. pretiosum* (each @ 50000/ha) and Bt (1L/Ha) were equally and more effective (56.8 - 69.6% reduction) than *M. anisopliae, L. lecanii* and *B. bassiana* (32.5 - 33.9% reduction), but, less effective than indoxacarb (2ml/L) seven days after the second treatment.

Table 81. Biological suppression of American pin worm, *Tuta absoluta* on tomato

Sl. No.	Treatment	Population reduction over control (%)		
		7 DAT	15 DAT	7DAST
1	*Trichogramma achaeae* (50000/ha)	26.9 (30.9)b	44.7 (41.9)bc	63.5 (52.9)b
2	*Trichogramma pretiosum* (50000/ha)	32.8 (33.4)b	52.9 (46.7)bc	56.8 (49.0)b
3	*Metarhizium anisopliae* (4g/L)	34.5 (34.3)b	31.0 (33.1)c	33.9 (35.4)c
4	*Lecanicillium lecanii* (4g/L)	34.4 (35.7)b	30.4 (33.2)c	32.5 (34.4)c
5	*Beauveria bassiana* (4g/L)	31.7 (33.9)b	37.9 (37.7)c	33.2 (34.8)c
6	Azadirachtin (1500 ppm; 3ml/L)	38.2 (37.7)b	59.1 (50.2)ab	69.6 (56.6)b
7	Bt (1L/ha)	41.2 (39.6)b	55.1 (47.9)b	57.7 (49.4)b
8	Indoxacarb (2ml/L)	87.4 (69.5)a	71.4 (57.6)a	88.6 (70.6)a
	CD	(18.2)	(9.3)	(12.0)
	CV (%)	37.6	17.9	20.1

Figures in parantheses are angular transformed values

3.11.2.5 PJTSAU, Hyderabad

Treatments

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

Methodology and observations

The trial was laid out in RBD with 3 replications. Plot size: 5 x 4 m^2; Treatment applications will be started at initial occurrence of American pin worm. In all, three sprays will be given during evening hours at fortnightly interval.

Status of the trial

The trial is in the field. Transplanting was done in February, 2017. Treatments are yet to be administered.

3.11.2.5 UAS, Raichur

The experiment was conducted with Mahyco 401 tomato variety in 100 sqm, design was RBD. The treatment details are T1: *Metarhizium anisopliae* ($1x10^8$ conidia/g), T2: *Lecanicillium lecanii* ($1x10^8$ conidia/g), T3: *Beauveria bassiana* - 14 ($1x10^8$ conidia/g), T4: Azadiractin (2 ml/lit.), T5: Indoxacarb 15EC, T6: Untreated control. Two sprays of each were given on 15-11-2016 and 29-11-2016.

Results

One day before spray, the number of tomato pinworm larvae ranged from 13.02 to 13.62 per top five leaves and it was statistically non significant. Maxiimum of 2.62 larvae per top five leaves was noticed in *Metarhizium anisopliae* @ 1.5 ml/l and it was followed by *Lecanicillium lecanii* @ 1.5 ml/l and *Beauveria bassiana* @ 1.5 ml/l which recorded 2.96 and 3.06 larvae per top five leaves, respectively. Per cent fruit damage indicated that *Metarhizium anisopliae* @ 1.5 ml/l recorded lowest damage of 4.18 per cent and it was followed by *Lecanicillium lecanii* @ 1.5 ml/l (5.62%) and *Beauveria bassiana* @ 1.5 ml/l (6.28%) fruit damage, respectively. *Metarhizium anisopliae* @ 1.5 ml/l recorded 26.92 t/ha fruit yield and it was followed by *Lecanicillium lecanii* @ 1.5 ml/l and *Beauveria bassiana* @ 1.5 ml/l which recorded 24.04 and 21.24 t/ha. Untreated control recorded minimum fruit yield of 17.92 t/ha (Table 82).

Table 82. Biological suppression of tomato pinworm, *Tuta absoluta* on tomato

Sl. No.	Particulars	Dosage (ml/l)	Number of larvae (Top 5 leaves)		Fruit damage (%)*	Fruit yield (t/ha)
			1 DBS	7 DAS		
1.	*Metarhizium anisopliae* ($1x10^8$ conidia/g)	1.50	12.36 (3.59)	2.62 (1.77)	4.18 (2.16)	26.92
2.	*Lecanicillium lecanii* ($1x10^8$ conidia/g)	1.50	12.02 (3.54)	2.98 (1.87)	5.62 (2.47)	24.04
3.	*Beauveria bassiana* - 14 ($1x10^8$ conidia/g)	1.50	13.18 (3.70)	3.06 (1.89)	6.28 (2.60)	21.24
4.	Azadiractin	2.0	13.62 (3.76)	2.36 (1.69)	3.92 (2.10)	28.06
5.	Indoxcarb 15EC	0.30	12.84 (3.65)	1.28 (1.33)	2.08 (1.61)	30.18
6.	Untreated control	--	12.92 (3.66)	13.14 (3.69)	17.32 (4.22)	17.92
S Em $\pm$			0.28	0.05	0.38	0.41
CD ($P = 0.05$)			NS	0.15	1.14	1.24
CV %			11.06	11.98	10.46	11.82

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

3.11.3 Demonstration of BIPM package for management of key pests of tomato (AAU-J, YSPUHF)

3.11.3.1 AAU, Jorhat

The trial was conducted at Farmers' Field (Alengmora, Jorhat) for the management of tomato fruit borer, *Helicoverpa armigera* on variety "*Arka Alok*" The treatments composed of T1: BIPM package (Seedling root dip treatment with *Pseudomonas* 2%solution , Installation of yellow sticky trap @ 50 no's/ha, Installation of bird perches @ 10 /ha, Spray of NSKE @ 5 % against sucking pests, Use of pheromone traps @ 15 /ha against *Helicoverpa armigera*, Six releases of *Trichogramma pretiosum* @ 1,00,000 /ha from flower initiation stage at weekly intervals, Need based spray of Bt @ 1 kg/ha (two rounds of spray) and regular collection and destruction of damage fruits)., T2 :Chemical control plots (Farmers' practice) and T3: Untreated control

The bio control based IPM package of tomato was evaluated in comparison with farmers' practice (chemical control) and untreated check. Application of bio agents, *viz*., releases of parasitoids, spraying of Bt and NSKE were made at 10 days interval starting from 35 days after transplanting. Four rounds of alternate spray with cypermethrin (50 g *a.i.)/* indoxacarb(75 g *a.i.)* per ha was sprayed in farmers practice plots.

The sucking pest (*Scirtothrips dorsalis*) was counted from 10 randomly selected plants at three leaves (top, middle and bottom) after each spray. As the population of *Bemisia tabaci* was negligible (0.3-0.5 per three leaves), the insect was not considered. Egg parasitism by *Trichogramma chilonis* / *T. pretiosum* was also recorded by placing sentinel egg cards of *Corcyra* at eight spots in each treatments block.

Results

The mean population of *H. armigera* / plants was 2.23 in BIPM, where as it was 2.90 in chemical control plot (Table 83). Maximum number of larval population (5.20/ plants) was recorded in untreated check..The mean population of *Scirtothrips dorsalis* at three leaves per plant was 2.08 and 3.87 in BIPM package and a chemical control plot, respectively whereas the mean population was 12.16 in untreated control plot after 65 DAT. However, BIPM package effectively reduced the fruit damage (9.87%) compared to 12.47% in chemical control plots. The yield of BIPM package recorded 242.83 q/h, compared to 234.7q/ha in chemical control. Highest fruit damage of 17.42% and minimum yield of 201.5q/ha was recorded in untreated control plot. Maximum number of coccinelids was noticed in BIPM in comparison to chemical control plot throughout the cropping season.

Table 83. Effect of BIPM package on incidence against *Helicoverpa armigera* on tomato

Treatment	Post treatments* (larval population / plants	% damage* fruit	% reduction over control	% parasitism	Yield (q/ha)
BIPM	2.32^{c}	9.87^{c} (2.50)	43.34	9.25	242.83^{a}
Chemical Control	2.90^{b}	12.47^{b} (2.82)	28.42		234.70^{a}

Untreated control	5.2[a]	17.42[a] (3.34)	0.00		196.01[b]
CD (=0.05)	0.60	0.13			23.19
CV %	16.10	3.52			9.61

*Mean of five observations, Figures in parenthesis are transformed square root value; means followed by the same letter in a column are not significantly different

3.11.3.1 YSPUHF, Solan

An experiment for bio-intensive management of insect pests of tomato was laid at the experimental farm of the Department of Entomology, Dr. Y. S. Parmar University of Horticulture and Forestry Nauni, Solan (HP). Since the incidence of tomato fruit borer was very low, the treatments were applied only for greenhouse whitefly, *Trialeurodes vaporariorum* and two spotted spider mite, *Tetranychus urticae.* For the management of the greenhouse whitefly, *Chrysoperla zastrowi sillemi* (1 larva/plant), *Lecanicillium lecanii* (NBAIR strain) at 5g/L of 10^8 conidia/g formulation, azadirachtin (1500ppm; 3ml/L) were evaluated in comparison with imidacloprid @ 0.0075% (chemical control) and untreated control. For the control of the *T. urticae*, predatory mite, *Neoseiulus longispinosus* (5 and 10 mites/plant) and azadirachtin (1500 ppm; 3ml/L) were evaluated and compared with fenazaquin (0.0025%) and untreated control. All the treatments were applied three times at ten days interval and the data on the whitefly population and the mite population density were recorded before first application and seven days after the final application of the treatments. The data were then converted to percent reduction in the pest population over pretreatment counts which were further converted to percent reduction over control by applying Abbott's correction and the results are presented in Tables 84 and 85. Against greenhouse whitefly, all the bio-pesticides viz, *Chrysoperla zastrowi sillemi* (1 larva/plant), *Lecanicillium lecanii* (5g/L of 10^8 conidia/g) and azadirachtin (1500 ppm; 3ml/L) were moderately and statistically equally effective resulting in 50.9 to 54.3 per cent reduction in the whitefly population over control (Table 84). None of these bio-agents could match the efficacy of imidacloprid (0.0075%) which reduced the whitefly population by 94.1 per cent over control. As for as the control of *T. urticae* is concerned, *Neoseiulus longispinosus* (10 mite/plant) was the best treatment among the bioagents which resulted in a reduction of 60.3 per cent in mite population over control. Azadirachtin, however, was on par with *Chrysoperla* (Table 85).

Table 84. Evaluation of some biocontrol agents against *T vaporariorum* on tomato under field conditions

Sl. No.	Treatment	Reduction (%) in whitefly population over control
1	*Chrysoperla* (1 larva/plant)	54.3 (47.4)[b]
2	*Lecanicillium lecanii* (5g/L of 10^8 conidia/g)	53.3 (46.9)[b]
3	Azadirachtin (1500 ppm;3ml/L)	50.9 (45.5)[b]
4	Imidacloprid (0.0075%)	90.8 (74.4)[a]
	CD(p = 0.05)	(10.2)
	CV (%)	14.5

Table 85. Evaluation of some biocontrol agents against *T urticae* on tomato under field conditions

Sl. No.	Treatment	Reduction (%) in mite population over control
1	*Neoseiulus longispinosus* (5 mite/plant)	49.1 (44.5)[c]
2	*Neoseiulus longispinosus* (10 mite/plant)	60.3 (51.1)[b]
3	Azadirachtin (1500 ppm;3ml/L)	51.2 (45.7)[bc]
4	Fenazaquin (0.0025%)	91.1 (74.6)[a]
	CD ($P = 0.05$)	(10.5)
	CV (%)	15.2

3.11.4 Demonstration of bio intensive package for the pests of tomato (AAU, Jorhat)

The experiment was conducted at Farmers' field, (Alengmora, Jorhat) on variety "Namdhari" against *Helicoverpa armigera*.

Remarks

As the mass production of *Chrysoperla* in the laboratory was failure, the experiments could not be done during 2016-17 also and *Chrysoperla,* one of the most important components of BIPM package, could not be prioduced in the laboratory during the period.

3.11.5 Bio-efficacy of microbial insecticides against *Spodoptera litura* in cabbage (AAU-A)

The studies were carried out at Agronomy farm, BACA, Anand Agricultural University, Anand, during *Rabi* 2016, on cabbage , S-92 Hybrid and the treatments comprised of T1: *Bacillus thuringiensis* ($2x10^8$ cfu g-1) 1.0 kg/ha, T2: *Bacillus thuringiensis* ($2x10^8$ cfu g-1) 2.0 kg/ha, T3: *Beauveria bassiana* ($2x10^8$ cfu g-1) @ 30 g /10 litres water , T4: *Metarhizium anisopliae* ($2x10^8$ cfu g-1) @ 30 g /10 litres water,. T5 *Metarhizium anisopliae* (2 x 108 cfu g-1) @ 40 g /10 litres water , T6: *Nomurea rileyi* ($2x10^8$ cfu g-1) @ 30 g /10 litres water , T7: *Nomurea rileyi* ($2x10^8$ cfu g-1) @ 40 g /10 litres water, T8: *SI*NPV $1x10^{10}$ POB/ha, T9: Recommended insecticide and T10: Control.

Results

Pest incidence was not observed in the experimental field since three years, hence the trial will be concluded during the next year by carrying out the work under laboratory conditions.

3.11.6 Role of habitat manipulation on natural enemies of cabbage pests (AAU-J)

The experiment was carried out in the organic plot, Department of Horticulture, AAU, Jorhat, during 2016 on variety "CV Drumhead". The following five modules were tested: T1: cabbage intercropped with mustard and cowpea, T2: cabbage intercropped with mustard and oats as border crop, T3: cabbage intercropped with cowpea and oats as border crop, T4: cabbage with oats as border crop and T5: cabbage as sole crop (untreated check).

Larval counts of lepidopteran pests, sucking pests and natural enemies were randomly collected from 5 plants from each treatment at 10 days interval starting from 20 DAP. Yield data of cabbage was recorded individually.

Results

T1 treatment (cabbage intercropped with mustard and cowpea) was found to be the best (1.03 larvae/plant) in reducing the larval population followed by treatment T3, T2 and T4 with a mean of 1.20, 1.41 and 1.50 larvae per plant, respectively at 95 DAP. T1 Treatment also contributed the lowest population of *Brevicoryne brassicae* (3.41/plant) and it was significantly different from T3 with 3.70 /plant (cabbage intercropped with cowpea and oats as border crop), T2 (3.95/plant) and T4 (4.15/plant). Relatively, more number of aphids with 4.40 adult per plant was observed in T5, where cabbage was the sole crop

Higher number of coccinellids (3.34/plant) and syrphid (3.01/plant) was recorded in T1 (Cabbage intercropped with mustard and cowpea) followed by T3 (cabbage intercropped with cowpea and oats as border crop) with 3.03 /plant. Lowest number of coccinellids (1.71 /plant) was observed in treatment T4 (cabbage with oats as border crop). Similarly, treatment T3 (2.63 larvae/plant) was second best treatment to control the aphid population by syrphids followed by T2 (2.09 larvae/plant), T5 (1.76 larvae/ plant) i.e. untreated control plots and T4 (1.36 larvae / plant), respectively (Table 86).

Maximum yield of 175.52 q/ha was obtained in T1 (Cabbage intercropped with mustard and cowpea) followed by 172.80 q/ha and 168.92 q/ha in treatment T2 (Cabbage intercropped with mustard and oats as border crop) and T4 (cabbage with oats as border crop) respectively. The lowest yield of 158.84 q/ha was recorded in T5 where cabbage was grown as sole crop (Table 86).

Table 86. Effect of habitat manipulation in cabbage on coccinelids, syrphids and yield

Treatment	Coccinelids / plant *	Syrphid/plant *	Yield(q/ha)
T1	3.34 [a]	3.01 [a]	175.52
T2	2.65 [c]	2.09 [c]	172.80
T3	3.03 [b]	2.63 [b]	163.36
T4	1.71 [e]	1.36 [e]	168.92
T5	2.26 [d]	1.76 [d]	158.84
S. Ed (±)	0.12	0.11	NS
CD(P=0.05)	0.27	0.24	

Column mean followed by same letter do not differ significantly at 5% level of probability; *Mean of two observation in between two sampling occasion

3.11.7 Field evaluation of IPM module against pests of cabbage (PAU)

The experiment on field evaluation of biocontrol based IPM module against pests of cabbage (*Plutella xylostella*, *Spodoptera litura*, *Pieris brassicae*) is being conducted at Entomological Research Farm PAU, Ludhiana. The crop of cabbage (commercial hybrid) was transplanted in the month of December 2016. *Pieris brassicae* and aphid *Brevicorynae brassicae*

have started appearing during mid March 2017. The pre-treatment data for these pests has been taken and following treatments on need basis are being applied for these pests. The experiment is in progress and the report will be submitted in May 2017.

Treatments

A. Biocontrol based IPM module

1) *Chrysoperla zastrowi sillemi* @ 5 larvae/ plant against aphids at weekly interval.
2) Planting of mustard crop to collect and destroy eggs of *P. xylostella*.
3) Neem oil (1%) against aphids at 15 days interval.
4) *Trichogramma pieridis* @ 1,00,000/ ha against *P. brassicae* at seven days interval.
5) Mechanical collection and destruction of *P. brassicae* eggs at weekly interval.
6) Delfin WG @ 300 gm/ acre against *Pieris* larvae at weekly interval.

B. Chemical control

Spinosad 2.5 SC @ 250 ml/ acre against *Pieris* larvae and Rogor @400 ml/ acre against aphid at 15 days interval.

C. Control (no treatment)

3.11.8 Development of Bio-control base IPM module against *Leucinodes orbanalis* of brinjal (AAU-J)

The experiment was conducted at Farmers' field, (Alengmora,Jorhat) on variety "JC-1" and the following treatments were imposed.

T1: Application of MOC @ 250 kg /ha 5 days before transplantation of crop**,** Use of Lucilure (Pheromone trap) @15 /ha for *L. orbanalis***,** Mechanical collection and destruction of infested shoots and fruits**,** Six releases of *Trichogramma chilonis* @ 100,000 /ha at 10 days interval**,** Spray of NSKE 5 % (three round of spray from vegetative stage at 15 days interval and two sprays of Bt @ 1kg /ha (before flowering and 10 days after flowering).
T2: Farmers practice (chemical module) with four alternate sprays of profenofos@ 750 g *a.i*/ha and lambda cyhalothrin @ 25 g a.i /ha.
T3: Untreated control

The observations were recorded for per cent infestation of shoot from 10 randomly selected plants from each subplot at weekly interval after 25 DAP and per cent fruit damage was recorded at the time of harvesting. Egg parasitism by *Trichogramma chilonis* / *T. pretiosum* was also recorded by placing sentinel egg cards of *Corcyra* at ten spots in each treatments block.

Results

The lowest per cent incidence of shoot (9.03) and fruit (16.43) damage was recorded in BIPM package as compared to farmers practice (chemical control) where it was 11.50 and 19.71, respectively. Insecticidal sprays with Lambda cyhalothrin @ 25 g a.i /ha and profenofos @ 750 gm a.i./ha at fortnightly interval were superior with maximum yield of 263.78 q/ha in BIPM

package followed by chemical control plot with 260.09 q/ha and both the treatments were on par with each other in their efficacies (Table 87).

Table 87. Effect of BIPM package against *Leucinodes orbanalis* on brinjal

Treatment	% shoot damage*	% fruit damage**	% parasitism	Yield (q/ha)
BIPM	9.03[c] (2.94)	16.43 [c] (4.04)	8.75	263.78 [b]
Farmers practice	11.50 [b] (3.38)	19.71 [b] (4.43)		260.09 [b]
Untreated check	14.00 [a] (3.73)	28.60 [a] (5.34)		137.9 [a]
CD	0.30	0.18		10.78
CV (%)	9.60	4.20		5.20

*Mean of three observations, **Mean of five observations, figures in parenthesis are transformed angular values, means followed by the same letter in a column are not significantly different

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

The brinjal *var*. Panchaganga seedlings were transplanted on 15/02/2016 at the Research Farm of Agril. Entomology Section, College of Agriculture, Pune at 90x60 cm spacing in 3x2 m plot. The trial was laid out in RBD with eight treatments and three replications. Three sprays of biopesticides and chemical insecticide were given at fortnightly interval on 25/04/2016, 11/05/2016 and 26/05/2016, whereas 15 releases of *T. chilonis* were carried out at weekly interval. The observations were recorded on five randomly selected plants per plot. Pre-treatment incidence on shoot infestation, post-counts of shoot and fruit infestation were recorded at weekly interval. The yield of healthy marketable fruits was registered per plot at each pickings.

The shoot and fruit damage due to *L. orbonalis* influenced by various treatments were recorded at weekly interval from initiation of treatment application and pooled means were worked out. The data in Table 88 revealed that three sprays of chlorpyriphos 0.04 per cent found significantly superior over other treatments in reducing the shoot (9.53%) and fruit infestation on number basis (8.85%) as well as on weight basis (6.32%) and gave maximum yield of marketable brinjal (237.13 q/ha). However, it was at par with the biocontrol agent consisting of *B. thuringiensis* @ 1 kg/ha which recorded 10.60 per cent shoot infestation, 10.34 per cent fruit damage on number basis and 8.02 per cent on weight basis with 230.03 q/ha yield of marketable fruits.

Table 88. Effect of of biocontrol agents against *L. orbonalis* and yield of brinjal

Treatment	Shoot damage (%)		Fruit damage (%)		Yield (q/ha)
	Pre-count	Post count	No. basis	Wt. basis	
T1: *N. rileyi* @ 10^8 conidia/ ml	21.63[a] (27.72)	15.87[c] (23.48)	19.87[c] (26.47)	18.06[c] (25.15)	199.78[c]
T2: *M. anisopliae* @ 10^8 conidia/ ml	20.50[a] (26.92)	17.52[c] (24.74)	22.68[d] (28.44)	20.77[c] (27.11)	193.27[c]

T3: *B. bassiana*@ 108 conidia/ ml	19.87[a] (26.47)	16.25[c] (23.77)	20.69[c] (27.06)	18.97[c] (25.82)	196.98[c]
T4: *T. chilonis* @ 50,000 parasitoids/ha/release	22.33[a] (28.20)	13.91[b] (21.90)	16.74[b] (24.15)	13.64[b] (21.67)	211.36[b]
T5: *B. thuringiensis* @ 1 kg/ha	19.20[a] (25.99)	10.60[a] (19.00)	10.34[a] (18.76)	8.02[a] (16.45)	230.03[a]
T6: NSE @ 5%	20.07[a] (26.62)	13.20[b] (21.30)	14.58[b] (22.45)	11.98[b] (20.25)	217.39[b]
T7: Chlorpyriphos 0.04%	21.60[a] (27.69)	9.53[a] (17.98)	8.85[a] (17.31)	6.32[a] (14.56)	237.13[a]
T8: Untreated control	20.87[a] (27.18)	34.96[d] (36.25)	48.23[e] (43.99)	45.54[d] (42.44)	180.89[d]
CD ($P = 0.05$)	(NS)	(1.30)	(1.93)	(2.18)	8.93

Figures in parentheses are arc sine transformed values; NS= Non-singificant

3.11.10 Effect of biopesticides for the management of sucking pests in Brinjal (KAU-Vellayani)

Crop : Brinjal

Experiment details

Design : RBD
Plot Size : 4X5m^2
Replication : 4
Treatments : 4

Treatments

T1 : *Beauveria bassiana* (ITCC 6063 KAU culture) 20gm/l
T 2 : Oxuron 5ml/l (botanical insecticide)
T 3 : Dimethoate 600gai/ha
T 4 : Check

Observation

Number of Jassids /20 randomly selected leaves
Yield (Kg/plot)

Result

Beauveria bassiana (ITCC KAU culture) 20gm/l was found superior in controlling the sucking pests with minimum pest population. The botanical Oxuron 5ml/l also found effective against the pest. The yield was also high in the plots treated with *Beauveria bassiana* 20gm/l compared to the check plot (Table 2).

Table 89. Efficacy of biopesticides for the management of sucking pests in brinjal

Treatments	Number of Jassids /20 leaves			Yield
	5DAS	10DAS	15DAS	t/ha
T1 : *Beauveria bassiana*	17.61 (4.32)	6.15 (3.01)	1.53 (1.67)	17.67
T2: Oxuron	19.69 (4.55)	7.86 (2.98)	2.98 (1.99)	14.97
T3 : Dimethoate	28.08 (5.39)	10.97 (3.46)	4.55 (2.35)	12.99
T4: Check	34.53 (5.96)	24.99 (5.09)	14.28 (3.91)	8.96
CD (0.05)	(0.324)	(0.485)	(0.55)	(0.278)

Values in parenthesis are values after √x+1 tarnsformation

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

Brinjal plants of var. Arka Anand were transplanted into pots and plants that were a month old after transplantation were used for the study. Early stage larvae that were reared on birnjal plants under controlled conditions were used for the study. Larvae were released before 2-3 days of initiation of the experiment to the potted plants to get habituated to the environment. The microbes used for the bio-efficacy studies were isolated from diseased larvae /adult. Six bacterial isolates and one fungal strain of *Beauveria* sp. that proved positive for Koch postulate were selected for the study. The experiment was carried out under laboratory conditions. Three spore concentrations 10^8, 10^7 and 10^6 cfu /ml were selected for the study. Equal volume of spore suspension was added to all plants enough to reach root zone. Each treatment was replicated thrice where each plant/pot was a replicate. This entire set up was placed undisturbed to check the mortality rate after 72 hrs. Observations on the number dead were recorded after 7a hours later converted to percent mortality. The data was subjected to determine the LD_{50} values.

Results

Among the different concentrations tested, 10^8 recorded highest mortality in all the treatments. It was observed that *Beauveria* sp. recorded 93% followed by *Pseudomonas* sp. SK3b recording 86% mortality after 72hours. The LD_{50} values indicated lowest value of 0.26 and 0.23 for *Beauveria sp*p followed by *Pseudomonas* sp. respectively. In other isolates it varied from 0.51 to 16.8. Further field experiments on the efficacy of these isolates are being initiated. The isolates are in the process of identification up to species level.

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

The field experiment to validate different BIPM modules against shoot and fruit borer, *Leucinodes orbonalis* in brinjal was conducted at Entomological Research Farm PAU, Ludhiana. The nursery of the brinjal (Var. Punjab Nagina) was sown in the second week of March 2016 and the plants were transplanted on May 14, 2016 with plant to plant spacing of 60 cm and row to

row spacing of 45 cm. Each block was further divided into sub-plots as replicates. The crop was grown as per PAU recommendations. The following different BIPM modules along with farmer's practice and untreated control were evaluated. Different BIPM sub-treatments were given at weekly interval.

Treatments

T1: *Trichogramma chilonis* (*Tc*) @ 50,000/ha, six releases (weekly interval)
T2: *Trichogramma chilonis* + Neem oil 1% (*Tc* + *Tc* + Nm + *Tc* + *Tc* + Nm)
T3: *Trichogramma chilonis* + *Bacillus thuringiensis* @ 1 Kg/ha (*Tc* + *Tc* + *Bt* + *Tc* + *Tc* + *Bt*)
T4: *Trichogramma chilonis* + Neem oil 1% + *Bacillus thuringiensis* @ 1 kg/ha (*Tc* + Nm + *Bt* + *Tc* + Nm + *Bt*)
T5: Neem oil 1% + *Bacillus thuringiensis* @ 1 Kg/ha (Nm + Nm + *Bt* + Nm + Nm + *Bt*)
T6: Farmer's practice (Three sprays at fortnightly interval: Quinalphos 25 EC @ 2000 ml/ha; Triazophos 40 EC @ 1250 ml/ha; Quinalphos 25 EC @ 2000 ml/ha)
T7: Untreated control

The observations were recorded on incidence of brinjal fruit and shoot borer in terms of shoot and fruit damage at weekly intervals. Total shoots, damaged shoot, total fruits and damaged fruits were counted from five randomly selected plants in each sub-plot at each observation and per cent incidence was worked out. The yield of marketable fruits per plot at each picking was pooled and has been expressed as quintals per ha.

The data in table 44 indicated that all the treatments except BIPM module (T1) were significantly better than control in reducing the incidence of brinjal fruit and shoot borer. The lowest incidence in terms of shoot (4.94 %) and fruit damage (5.89 %) was recorded in chemical control treatment. Among the BIPM modules, significantly lower shoot damage (7.03%) and fruit damage (8.48%) was recorded in T4 (BIPM *T. chilonis* + Neem oil + Bt). It was followed by T5 (BIPM with Neem + Bt) and T3 (BIPM with *T. chilonis* + Bt) which were at par with each other. The yield was also significantly higher in chemical control (328.3 q/ha) followed by T4 (262.1 q/ha), T5 (258.3 q/ha) and T3 (240.7 q/ha). However, significantly lower yield was recorded in untreated control (177.9 q/ha).

Table 90. Effect of different BIPM modules on infestation of fruit and shoot borer, *L. orbonalis* and yield of brinjal during 2016

Sl. no.	Treatments	Shoot damage (%)	% reduction over control	Fruit damage (%)	% reduction over control	Yield (q/ha)	% increase over control
T1	BIPM with *T. chilonis*	15.86^{e} (23.44)	5.99	24.11^{e} (29.34)	1.59	190.5^{d}	7.1
T2	BIPM with *T. chilonis* + Neem	11.26^{d} (19.58)	33.27	18.28^{d} (25.29)	25.38	201.5^{c}	13.2
T3	BIPM with *T. chilonis* + *Bt*	8.72^{c} (17.16)	48.33	12.72^{c} (20.84)	48.06	240.7^{bc}	35.2
T4	BIPM with *T. chilonis* + Neem + *Bt*	7.03^{b} (15.36)	58.35	8.48^{b} (16.89)	65.36	262.1^{b}	47.2

T5	BIPM with Neem + *Bt*	8.83[c] (17.28)	47.68	12.07[c] (20.23)	50.71	258.3[b]	45.0
T6	Chemical control	4.94[a] (12.82)	70.74	5.89[a] (13.44)	75.93	328.3[a]	84.2
T7	Untreated control	16.87[e] (24.23)	-	24.50[e] (29.64)	-	177.9[d]	-
	CD (5%)	(0.91)		(2.53)		45.1	

*Average of six observations at weekly interval; Mean followed by common letters in a column did not differ significantly at $P = 0.05$ (LSD test)

Pooled data of two years (2015 and 2016) revealed that all the treatments were significantly better than control in reducing the incidence of brinjal fruit and shoot borer (Table 91). The chemical control recorded lowest incidence in terms of shoot damage (5.08%) and fruit damage (6.51%). Treatment T4 (BIPM with *T. chilonis* + Neem oil + Bt) was found best among the BIPM modules, recording 7.26 and 11.06 per cent shoot and fruit damage, respectively. It was followed by T5 (BIPM with Neem + Bt) and T3 which were at par with each other. The yield was also significantly higher in chemical control (321.1 q/ha) followed by T4 (270.2 q/ha), T5 (265.1 q/ha) and T3 (253.4 q/ha). However, significantly lower yield was recorded in untreated control (191.8 q/ha).

Table 91. Effect of different BIPM modules on infestation of fruit and shoot borer, *L. orbonalis* and yield of brinjal (Pooled data of 2015 and 2016)

Sl. No.	Treatments	Shoot damage (%)	% reduction over control	Fruit damage (%)	% reduction over control	Yield (q/ha)	% increase over control
T1	BIPM with *T. chilonis*	13.54[e] (21.50)	8.45	23.33[e] (28.86)	5.62	204.8[cd]	6.5
T2	BIPM with *T. chilonis* + Neem	10.35[d] (18.74)	30.01	18.31[d] (25.32)	25.89	226.2[c]	17.2
T3	BIPM with *T. chilonis* + *Bt*	8.69[c] (17.14)	41.24	13.56[c] (21.58)	45.09	253.4[b]	30.8
T4	BIPM with *T. chilonis* + Neem + *Bt*	7.26[b] (15.62)	50.90	11.06[b] (19.29)	55.19	270.2[b]	39.2
T5	BIPM with Neem + *Bt*	8.52[c] (16.96)	42.39	13.04[c] (21.14)	47.19	265.1[b]	36.7
T6	Chemical control	5.08[a] (13.00)	65.64	6.51[a] (14.69)	73.57	321.1[a]	64.7
T7	Untreated control	14.79[f] (22.55)	-	24.72[e] (29.79)	-	191.8[d]	
	CD (5%)	(0.58)		(1.23)		22.2	

It was concluded that although chemical control was best, among different BIPM modules, BIPM module with *Trichogramma chilonis* + Neem oil 1% + *Bacillus thuringiensis* @ 1 Kg/ha was found effective in terms of low shoot and fruit damage and high yield of brinjal and

therefore, this module can be integrated with farmers practice for the management of fruit and shoot borer of brinjal.

3.11.13 Biological control of brinjal mealy bug *Coccidohystrix insolitus* (TNAU)

The details of the experiment are as follows.

Name of the farmer : Mr.M.Thangarasu
Location : Arasur
Variety : Rasi local
Date of planting : 10.6.16

Treatments

T1: Release of *Cryptolaemus* @ 1500/ha
T2: Release of *Scymnus*@ 1500/ha
T3: Release of *Brumus suturoides* @ 1500/ha
T4: *Verticillium lecanii* 108 cfu /ml
T5: *Chrysoperla* 50,000 first instar grubs/ha
T6: Profenphos 50 EC 2ml /l
T7: Control

Replication: Three

Plot size: 8x5m

No. of releases of predator/ insecticide treatment: Two

Observations

i. Observations on mealybug population in 3 leaves/plant.
ii. Number of predators /plant was noted.
iii. Yield data at harvest recorded

The occurrence of mealybug in brinjal was noted in the trial plot during June - October 2016 at Arasur. The population was assessed before treatment in different treatment plots which ranged from 41.8 to 64.2 per plant. The treatments were imposed at 15 days interval as per the treatment schedule (Table 92). The grubs of various coccinellids were released at 15 days interval at the rate of 1500/ha whereas the 1st instar grubs of *Chrysoperla zastrowi sillemi* was released at the rate of 50,000 /ha. Two rounds of spray with profenophos 50 EC at 0.1% was imposed after the pre treatment count. The population reduction of the mealybug and the establishment of natural enemies were assessed 15 days after the treatment imposture. Subsequently, the second round of treatments were imposed as earlier and the observation on the mealybug population and the level of released predator 15 days after the second round of treatment imposture was carried out. The results indicated that two releases of *Cryptolaemus* @1500 /ha was able to reduce the population upto 5.46 mealybugs per plant with 91.5 per cent reduction of mealybug population sustaining the predator population of 10.4 per 10 plants and realising the fruit yield of 63.4 t/ha. This treatment was superior to all other treatments involving biocontrol agents and untreated check except pesticide treatment with profenophos 50 EC at

0.1% which showed a population of 3.52 /plant after 15 days of second round of pesticide application with mealybug population reduction of 92.39 per cent with the least natural enemy population of 0.5 /10 plants and maximum yield of 65.6 t/ha.

Table 92. Biological control of brinjal mealybug, *Coccidohystrix insolitus*

TREATMENTS	Pre Treatment	15 days after I release /spray		15 days after II release /spray		Per cent reduction over control	Yield t/ha
	Mealybug /Plant	Mealybug/ Plant	Predator/ 10 Plants	Mealybug /Plant	Predator/ 10 Plants		
Release of *Cryptolaemus* @ 1500/ha	64.2[a] (54.84)	32.64[b] (28.32)	3.2	5.46[b] (11.72)	10.2	91.5	63.[b]
Release of *Scymnus*@ 1500/ha	55.8[a] (46.32)	35.28[bc] (30.28)	3.8	9.54[c] (14.34)	8.6	82.91	62.3[b]
Release of *Brumus suturoides* @ 1500/ha	48.36[a] (40.62)	36.82[c] (33.24)	2.7	15.36[d] (21.62)	5.4	68.23	60.8[b]
Verticillium lecanii10^8cfu /ml	52.7[a] (43.64)	42.64[e] (38.23)	1.6	31.62[f] (34.72)	4.6	40.01	58.4[c]
Chrysopa 50,000 first instar grubs/ha	42.34[a] (36.72)	38.54[d] (34.32)	2.4	22.46[e] (27.52)	5.8	46.95	60.2[c]
Profenophos 2 ml/l	46.26[a] (39.43)	14.62[a] (12.46)	0.0	3.52[a] (8.34)	0.5	92.39	65.60[a]
Control	41.8[2a] (35.6)	64.26[f] (51.36)	1.5	109.46[g] (71.52)	3.6	-	55.8[d]
CD (P = 0.05)		3.64	-	3.26	-		-

3.11.14 Bio-efficacy evaluation of EPN formulations of NBAIR against ash weevil in brinjal (TNAU)

Name of the Farmer : Th.Manikandan, Anaikatti
Variety : Purple local
Date of planting : 25.6.16

Treatments

T1: Soil application of EPN WP formulation of NBAIR – 20kg/ha
T2: Soil application of *Metarhizium anisopliae* NBAIR formulation @ 2.5kg+250kg FYM/ha
T3: Soil application of *Metarhizium anisopliae* TNAU formulation @ 2.5kg+250kg FYM/ha
T4: Soil application of EPN (20 kg/ha) + *Metarhizium anisopliae* NBAIR @ 2.5kg + 250kg FYM/ha

T5: Soil application of EPN (20 kg/ha) + *Metarhizium anisopliae* TNAU @ 2.5 kg + 250 kg FYM/ha
T6: Neem cake 100 kg/ acre as amendment in basal and one month after planting.
T7: Soil drenching with Chlorpyriphos 5ml /l of water
T8: Control

Replications and Plot Size

- No of replication- 3
- Plot size: 5×8 m

Field experiment to manage ashweevil in brinjal was carried out at Anaikatti in farmer holding with eight treatments and three replications. The field experiment was laid in RBD with plot size of $40m^2$. The treatments were applied in soil 45 days after transplanting. The entomofungal pathogen *Metarhizium anisopliae* was mixed with FYM and incubated for 30 days and applied in the treatment plot. The other treatments like EPN was applied as formulation in individual treatment schedule and mixed with *Metarhizium anisopliae* + FYM mixture in combination schedule. The leaf damage of ash weevil and its population were assessed before, 30 and 45 days after treatment application. The application of EPN (NBAIR formulation) along with *Metarhizium anisopliae* (NBAIR formulation) was superior which recorded 87.74 per cent reduction of ash weevil with minimum leaf damage of 8.37 per cent. But the treatment was found on par with treatments EPN (NBAIR) + *Metarhizium anisopliae* (IPL) formulation + 250 kg FYM and soil drenching of chlorpyriphos 0.1 per cent which recorded 88 per cent reduction in weevil population and less leaf damage of 8.62 per cent. The other bioagent treatments when applied alone were also effective with 64.31 to 73.16 per cent reduction of weevil population recording 9.52 to 10.38 per cent leaf damage. Neem cake application at 250 kg /ha could reduce a population up to 52 per cent with 13.64 per cent leaf damage as compared to 31.4 per cent leaf damage in control (Table 93).

Table 93. Efficacy of EPN formulations of NBAIR against ash weevil in brinjal

Treatments	Leaf damage (%)			Population of ash weevil / plant			
	Pre treatment	30 DAT	45 DAT	Pre treatment	30 DAT	45 DAT	Per cent reduction over control
T1- Soil application of EPN (NBAIR) @ 20 kg/ha	*12.34^{a}	16.60^{e}	10.38^{b}	3.24^{a}	2.63^{ab}	1.82^{b}	64.31
T2- Soil application of *Metarhizium* (NBAIR) @2.5kg + FYM 250kg/ha	10.68^{a}	8.90^{b}	10.16^{b}	5.54^{a}	3.26^{b}	2.34^{c}	73.16
T3 - Soil application of *Metarhizium* (IPL) @2.5kg + FYM 250kg/ha	10.46^{a}	11.56^{cd}	9.52^{ab}	4.52^{a}	3.18^{b}	2.36^{c}	66.83

T4 – T1 + T2	14.38[a]	10.64[c]	8.37 [a]	6.22[a]	3.16[b]	1.20[a]	87.74
T5 – T1+T3	18.46[a]	14.24[d]	10.25[b]	3.86[a]	2.40[a]	1.08[a]	82.25
T6 – Neem cake 250kg/ha	16.42[a]	18.12[ef]	13.64[c]	5.48[a]	3.84[c]	4.14[d]	52.00
T7 –Soil drenching chlorpyriphos 5 ml/l	11.82[a]	6.24[a]	8.62[a]	6.36[a]	2.74[a]	1.20[a]	88.00
T8 –control	15.58[a]	23.7[f]	31.4[d]	6.48[a]	6.43[d]	10.2[e]	-

Means followed by a common letter in a column are not significantly different by DMRT; *Mean of three replications

3.11.15 Evaluation of entomopathogenic fungi against sucking pests of *Bhut Jolokia* (*Capsicum sinensis*) (AAU, Jorhat)

The experiment was conducted at Horticultural farm , AAU, Jorhat on variety "Raja" against sucking pests *Aphis gossypi* and *Scirtothrips dorsalis* and the following treatments were imposed.

Treatments

T1: *Metarhizium anisopliae* (Biometa, AAU strain) ($1x10^8$ spores /g) @ 5g/ litre
T2: *Beauveria bassiana* (Biosona, AAU strain) ($1x10^8$ spores /g) @ 5g/ litre
T3: *Metarhizium anisopliae* (Ma-4) NBAIR strain ($1x10^8$ spores /g) @ 5g/ litre
T4: *Metarhizium anisopliae* (Ma-35) NBAIR strain ($1x10^8$ spores /g) @ 5g/ litre
T5: *Beauveria bassiana* (Bb-5a) NBAIR strain ($1x10^8$ spores /g) @ 5g/ litre
T6: *Beauveria bassiana* (Bb-23) NBAIR strain ($1x10^8$ spores /g) @ 5g/ litre
T7: Imidacloprid @ 20 g ai/ha
T8: Untreated control

Population of sucking pests (*Aphis gossypi* and *Scirtothrips dorsalis*) were recorded before treatment as well as 3,7 and 10 days after each spray on 5 randomly selected plants from each plot at 3 leaves (top, middle and bottom). Three rounds of microbial agents ($1x10^8$ spores /g) @ 5g/ litre and imidacloprid @ 20 gm a.i/ha (0.4ml/l) were given to the crop at 15 days interval. Spraying was initiated at 30 DAP. Yield data was recorded at each harvesting. Natural enemy activity was also recorded.

Results

Three spraying of imidacloprid @ 20 gm ai/ha at 15 days interval could significantly reduce the mean population of *A. gossypii* (3.00/3leaves) and *S.dorsalis* (2.13 /3 leaves) in Bhut Jolokia gave maximum yield (53.33 q/ha) after third spray. Among the different entomopathogenic fungi, Bb 5a (NBAIR strain) was the next best treatment in reducing the population of *A. gossypi* (5.10/ 3 leaves) and *S. dorsalis* (3.13/ 3 leaves) with next higher yield of 44.35 q/ha. However, the rest of the entomopathogenic fungi of NBAIR strains (Ma-4, Ma-35, Bb-23) and local strains (Bb-Biosona, Ma-Biometa) in reducing the sucking pests was equally effective after third spray and found to be significantly different from untreated check.. Maximum number of *A. Gossypii* (15.85 /3 leaves) and *S. Dorsalis* (13.60 /3 leaves) was recorded in untreated control plot with minimum yield of 29.45 q /ha.

3.11.16 Evaluation of fungal pathogens against sucking pests of chilli (IIVR; KAU-Vellayani; UBKV)

3.11.16.1 IIVR, Varanasi

Experimental details

Location – Experimental Farm of IIVR, Varanasi
Target pests – Yellow mites (*Polyphagotarsonemus latus*) and thrips (*Scirtothrips dorsalis*)
Plot size – 5 x 6mt
Variety – Kashi Anmol

Treatments

T1 = *Metarhizium anisopliae* (Ma-59) IIVR strain 1 x 10^8cfu/g @ 5 g /lit
T2 = *Beauveria bassiana* (Bb-83) IIVR strain 1 x 10^8cfu/g @ 5 g /lit
T3 = *Metarhizium anisopliae* (Ma-35) NBAIR strain 1 x 10^8cfu/g @ 5 g /lit
T4 = *Beauveria bassiana* (Bb-23) NBAIR strain 1 x 10^8cfu/g @ 5 g /lit
T5 = Imidacloprid 17.8 SL @ 1 ml/3 lit
T6 = Untreated control

Replication:	3
Round of application:	3 with 15 days intervals
Date of transplanting:	24/08/2016
Fertilizer dose:	120: 60: 60 (N: P: K)

The data on number of sucking pests in chilli *viz*., yellow mite (*Polyphagotarsonemus latus* (Banks)) and thrips (*Scirtothrips dorsalis* Hood) were recorded from five tagged plants selected randomly. Three leaves were plucked from bottom, middle and top of each of the randomly selected five plants to count the number of mites and thrips per leaf. The leaves were brought to the laboratory and observations were taken under stereo zoom binocular microscope. Such observations were recorded on one day before and 1, 3, 5, 7 and 10 days after spray (DAS). Three rounds of microbial agents at their respective doses and Imidacloprid 17.8 SL @ 1 ml/3 lit of water was applied. Triton X-100 @ 1 ml/lit was added as surfactant with microbial pesticides. Spraying was initiated at 35 days after transplanting (DAT). The aphids and whiteflies population were negligible during the entire cropping season, hence not considered.

From Table 94, it is evident that amongst all the entomofungalpathogens, *Beauveria bassiana* (Bb-83) IIVR strain was found most promising against the yellow mites in chilli with highest per cent reduction (56.57) over the control followed by *Metarhizium anisopliae* (Ma-35) NBAIR strain (53.60 PROC). However, amongst all the treatments, Imidacloprid was the best with highest PROC (66.52) and lowest mites population (1.58 / leaf). With regard to thrips, all the four tested entomofungal isolates were on par with each other and showed 54.21 – 65.42% reduction of thrips. However the insecticide treatment showed significantly higher percent reduction of thrips (71.03). A marked difference in green chilli yield was observed among the different treatments. *B. bassiana* (Bb-83) IIVR strain treated plots registered significantly highest yield (6175 kg/ha) as compared to other entomofungalpathogens including untreated control. *M.*

anisopliae (Ma-35) NBAIR strain (6100 kg/ha) and *M. anisopliae* (Ma-59) IIVR strain (5825 kg/ha) were the next in order in terms of yield and differed significantly with the untreated control (4425 kg/ha). However, Imidacloprid 17.8 SL, amongst the all treatments, registered significantly highest yield of 6900 kg/ha.

Table 94. Efficacy of different fungal pathogens against chilli yellow mites and thrips

Treatments	Pre-treatment count (per leaf)		Post-treatment* Number of Yellow mites/leaf					Post-treatment* Number of thrips /leaf					Yield (Kg/ha)
	Mites	Thrips	1st spray	2nd spray	3rd spray	Pooled mean	ROC# (%) (Avg)	1st spray	2nd spray	3rd spray	Pooled mean	ROC# (%) (Avg)	
T1	6.93^{b}	1.27^{a}	2.79^{b}	2.66^{a}	1.89^{b}	2.45^{ab}	48.09	0.57^{a}	0.48^{a}	0.36^{a}	0.47^{a}	56.08	5825^{c}
T2	6.87^{b}	1.40^{a}	2.12^{a}	2.23^{a}	1.79^{ab}	2.05^{a}	56.57	0.44 ^{a}	0.37^{a}	0.29^{a}	0.37^{a}	65.42	6175^{e}
T3	6.73^{c}	1.47^{a}	2.61^{ab}	2.35^{a}	1.60^{a}	2.19^{a}	53.60	0.53^{a}	0.45^{a}	0.33^{a}	0.44^{a}	58.88	6100^{d}
T4	7.27^{c}	1.40^{a}	3.09^{c}	2.85^{ab}	1.92^{b}	2.62^{b}	44.49	0.62^{a}	0.51^{a}	0.35^{a}	0.49^{a}	54.21	5704^{b}
T5	6.47^{a}	1.33^{a}	1.73^{a}	1.74^{a}	1.27^{a}	1.58^{a}	66.52	0.39^{a}	0.31^{a}	0.22^{a}	0.31^{a}	71.03	6900^{f}
T6	6.97^{b}	1.38^{a}	4.92^{d}	4.41^{c}	4.83^{c}	4.72^{c}	--	1.19^{b}	1.11^{b}	0.92^{b}	1.07^{b}	--	4425^{a}
SEm(±)	0.11	0.07	0.32	0.26	0.18	0.25	1.16	0.12	0.12	0.09	0.11	0.89	6.56
LSD (0.05)	0.29	0.18	0.71	0.63	0.43	0.61	2.66	0.41	0.29	0.23	0.26	2.37	18.45

*Means of five observations; #ROC= Reduction overcontrol; means followed by the same letters in a column are not significantly different

3.11.16.2 KAU, Vellayani

Crop: Chilli

Experiment details

Design : RBD
Plot Size : 4X5m^2
Replication : 4
Treatments : 4

Treatments

T1: *Beauveria bassiana (* ITCC 6063 KAU culture) 20gm/l
T2: Oxuron 5ml/l (botanical insecticide)
T3: Dimethoate 600g ai/ha
T4: Check

Observation

Number of mites, thrips and other sucking pests / six leaves randomly selected leaves

Result

Beauveria bassiana 20gm/l and Dimethoate 600g ai/ha found superior in controlling the sucking pests with minimum pest population. The botanical Oxuron 5ml/l also found effective against the pest. The yield was also high in the plots treated with *Beauveria bassiana* 20gm/l compared to the check plot (Table 95).

Table 95. Effect of biopesticides for the management of sucking pests in chilli

Treatments	Number of thrips /6 leaves			Yield kg/plot
	5 DAS	10 DAS	15 DAS	
T1: *Beauveria bassiana*	9.30 (3.21)	2.96 (1.99)	0.99 (1.41)	35.28(17.64t/ha)
T2: Oxuron	3.97 (2.23)	3.67 (2.16)	1.99 (1.73)	33.34(16.62t/ha)
T3: Dimethoate	5.66 (2.58)	2.65 (1.91)	1.66 (1.63)	25.11(12.55t/ha)
T4: Check	22.62 (4.86)	9.96 (3.31)	8.67 (3.11)	13.47(6.735t/ha)
CD (0.05)	(0.72)	(0.488)	(0.340)	(1.183)

3.11.16.3 UBKV, Pundibari

The target pests are: yellow mite (*Polyphagotarsonemus latus)* and chilli thrips (*Scirtothrips dorsalis*).

Variety: Akashi (Local)

Treatments
T1: *Beauveria bassiana* NBAIR strain @ 5gm/lit
T2: *Metarhizium anisopliae* NBAIR strain @5gm/lit
T3: *Lecanicillium lecanii* NBAIR strain @ 5gm/lit
T4: *Beauveria bassiana* (market product) @ 6gm/lit
T5: *Metarhizium anisopliae* (market product) @ 6gm/lit
T6: Imidacloprid 17.8 SL @ 5ml/lit
T7: Thiomethoxam 25% WG @ 0.25gm/lit
T8: Untreated control

Replication: 3
Design: RBD

Result: The field trial is under progress and the data is yet to be collected.

3.11.17 Development of bio-intensive IPM package for the suppression of insect pests of capsicum under field conditions (YSPUHF)

An experiment was conducted to evaluate C*hrysoperla zastrowi sillemi* (1 larva/plant), *Lecanicillium lecanii* (5g/L of 10^8 conidia/g), azadirachtin (1500ppm; 3ml/L) and imidacloprid (0.0075%) against the green peach aphid, *Myzus persicae* on capsicum (cv Solan Bharpur) at the experimental farm of the Department of Entomology, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan during 2016. The experiment was conducted in a randomized block design with each treatment replicated 4 times. Aphid population was counted before and 7 days after treatment. Data thus recorded were converted to per cent reduction in population over control which was further corrected through Abbott's formula to get per cent reduction over control. Results of the experiment revealed that imidacloprid (0.0075%) was the most effective treatment resulting in 87.2 per cent reduction of the aphid population over control (Table 96). *Chrysoperlazastrowi sillemi* (1 larva/plant), *Lecanicillium lecanii* (5g/L of 10^8 conidia/g) and azadirachtin (1500 ppm; 3ml/L) were statistically equally effective resulting in 54.8 to 61.2 per cent reduction of the aphid population over control.

Table 96. Evaluation of bio-control agents against *Myzus persicae*on capsicum under field conditions

SN	Treatment	Reduction (%) in aphid population over control
1	*Chrysoperla zastrowi sillemi* (1larva/plant)	56.4 (48.7)[b]
2	*Lecanicillium lecanii* (5g/L of 10^8 conidia/g)	54.8 (47.9)[b]
3	Azadiractin (1500 ppm;3ml/L)	61.2 (51.7)[b]
4	Imidacloprid (0.0075%)	87.2 (69.2)[a]
	CD(p=0.05)	9.4
	CV (%)	27.6

Figures in parentheses are angular transformed values

3.11.18 Biological suppression of fruit borer, *Earias vittella* in okra (MPKV; OUAT)

3.11.18.1 MPKV, Pune

The experiment was laid out on the Research Farm of Agril. Entomology Section, College of Agriculture, Pune. The seeds of okra *var*. Parbhani Kranti were dibbled at 75 x 15 cm spacing in 3.2x2.5 m plot size on 15/02/2016. The trial was laid out in RBD with eight treatments and three replications. Three sprays of biopesticides and chemical insecticide were given at fortnightly interval on 04/04/2016, 20/04/2016 and 05/05/2016. Fifteen releases of *T. chilonis* were carried out at weekly interval. The observations were recorded on five randomly selected plants per plot. The pre and post-treatment counts of shoot infestation and post counts of fruit damage were recorded at weekly interval. Yield of healthy marketable fruits were recorded per plot at each picking and converted into q/ha.

This experiment was also conducted during subsequent year 2016-17 with aforesaid variety, treatments and spray schedule as previous year. The shoot infestation and fruit damage due to *E. vitella* caterpillars recorded at weekly interval from initiation of treatment application till termination of treatment schedule and the means are presented in Table 97 (2015-16) and Table 98 (2016-17). The results indicated that the treatment with chlorpyriphos 0.04 per cent found significantly effective over all other tretments in reducing shoot infestation (6.43%), fruit damage on number basis (11.26%) and weight basis (13.87%). It was however, at par with *B. thuringiensis* @ 1 kg/ha which recorded 7.65 per cent shoot infestation, 13.91 per cent fruit damage on number and 15.58 per cent on weight basis. The marketable fruit yield recorded highest (194.58 q/ha) in chlorpyriphos 0.04 per cent treated plots and it was at par with *B. thuringiensis* @ 1 kg/ha (187.16 q/ha). The *B. bassiana, M. anisopliae* and NSE 5 per cent being at par with each other, were the next promosing treatments (Table 97).

Table 97. Efficacy of bioagents for management of fruit borer, *Earias vitella* on okra (2015-16)

Treatment	Shoot damage (%)		Fruit damage (%)		Yield (q/ha)
	Pre-count	Post count	No. basis	Weight basis	
T1: *L. lecanii* @ 10^8 conidia/ ml	12.13[a] ((20.38)	40.90[d] (39.76)	31.58[d] (34.19)	32.68[c] (34.87)	144.57[d]
T2: *M. anisopliae* @ 10^8 conidia/ ml	12.07[a] (20.33)	14.16[b] (22.10)	17.63[c] (24.83)	20.54[b] (26.95)	174.26[b]
T3: *B. bassiana* @ 10^8conidia/ ml	12.00[a] (20.27)	11.35[b] (19.69)	16.32[b] (23.83)	19.20[b] (25.99)	176.10[b]
T4: *T. chilonis* @ 50,000 parasitoids/ha	12.20[a] (20.44)	16.43[c] (23.91)	29.36[d] (32.81)	31.54[c] (34.17)	164.0[c]
T5: *B. thuringiensis* @ kg/ha	11.47[a] (19.80)	7.65[a] (16.06)	13.91[b] (21.90)	15.58[a] (23.25)	187.16[a]
T6: NSE 5%	11.60[a] (19.91)	14.89[c] (22.70)	18.60[c] (25.55)	22.48[b] (28.30)	168.50[b]
T7:Chlorpyriphos @ 0.04%	11.73[a] (20.03)	6.43[a] (14.69)	11.26[a] (19.61)	13.87[a] (21.87)	194.58[a]
T8: Untreated control	12.13[a] (20.38)	45.96[e] (42.68)	38.75[e] (38.50)	40.04[d] (39.25)	141.30[d]
CD (P = 0.05)	(NS)	(2.81)	(1.94)	(2.39)	7.98

Figures in parentheses are arc sine transformed values; NS= Non-significant

Similar results were also observed during 2016-17. The data in Table 98 revealed that the chemical insecticide chlorpyriphos 0.04 per cent found significantly superior over other treatments in suppressing the shoot damage (5.64 %), fruit damage on number basis (9.36%) as well as on weight basis (10.49%) of okra with maximum yield of marketable fruit (209.51 q/ha). However, it was at par with *B. thuringiensis* @ 1 kg/ha which recorded 6.23 per cent shoot damage, 11.41 per cent fruit damage on number and 12.64 on weight basis with 203.63 q per ha

yield of marketable fruits. Nevertheless, *B. bassiana, M. anisopliae* and NSE were the next best treatments in suppressing the shoot and fruit damage and recording yield of marketable fruits.

Table 98. Efficacy of biocontrol agents for management of fruit borer, *Earias vitella* on okra (2016-17)

Treatment	Shoot damage (%)		Fruit damage (%)		Yield (q/ha)
	Pre-count	Post count	No. basis	Wt. basis	
T1: *L. lecanii* @ 10^8 conidia/ ml	14.63[a] (22.49)	41.68[d] (40.21)	34.87[d] (36.19)	36.98[d] (37.45)	153.30[d]
T2: *M. anisopliae* @ 10^8 conidia/ ml	15.20[a] (22.95)	11.02[b] (19.39)	15.87[b] (23.48)	17.96[b] (25.07)	186.36[b]
T3: *B. bassiana* @ 10^8 conidia/ ml	15.00[a] (22.79)	9.54[b] (17.99)	14.67[b] (22.52)	16.58[b] (24.03)	192.68[b]
T4: *T. chilonis* @ 50,000 parasitoids/ha	15.53[a] (23.21)	20.63[c] (27.01)	23.61[c] (29.07)	25.88[c] (30.58)	177.98[c]
T5: *B. thuringiensis* @ 1 kg/ha	14.87[a] (22.68)	6.23[a] (14.45)	11.41[a] (19.74)	12.64[a] (20.83)	203.63[a]
T6: NSE 5%	14.93[a] (22.73)	11.93[b] (20.21)	17.02[b] (24.37)	19.11[b] (25.92)	183.47[c]
T7: Chlorpyriphos 0.4%	15.40[a] (23.11)	5.64[a] (13.74)	9.36[a] (17.81)	10.49[a] (18.90)	209.51[a]
T8: Untreated control	15.53[a] (23.21)	44.18[d] (41.66)	40.11[e] (39.30)	43.28[e] (41.14)	143.60[e]
CD ($P = 0.05$)	(NS)	(2.81)	(1.94)	(2.43)	7.98

Figures in parentheses are arc sin transformed values; NS= Non-significant

3.11.18.2 OUAT, Bhubaneswar

Treatments

T1: Application of *Beauveria bassiana* @ 1x108 cfu at 15 and 30 DAG (days after germination) followed by spray of Bt @ 1.5 kg/ha at 40 and 55 DAG
T2: Application of *Metarrhizium anisopliae* @ 1x108 cfu and Bt @ 1.5 kg/ha as in T1
T3: Application of *Lecaniicillium lecanii* @ 1x108 cfu and Bt @ 1.5 kg/ha as in T1.
T4: Application of Neemazal 4% at 15 and 30 DAG and Bt as in T1.
T5: Application of *Beauveria bassiana* @ 2x108 cfu at 15 and 30 DAG followed by Bt @ 1.0 kg/ha at 40 and 55 DAG.
T6: Application of *Metarrhizium anisopliae* @ 2x108 cfu and Bt @ 1.0 kg/ha as inT5.
T7: Application of *Lecaniicillium lecanii* @ 2x108 cfu and Bt @ 1.0kg/ha as in T5.
T8: Application of Neemazal 5% at 15 and 30 DAG and Bt @ 1.0 kg/ha as in T5.
T9: Application of Acetamiprid 0.025% and spinosad 0.4% as in T1.
T10: Untreated control.

Design:	RBD
No. of replications:	3 (three)
Date of sowing:	23.06.2016
Okra variety:	Arka anamika
Spacing:	50cm x 30cm
Plot size:	4m x 3m
Fertilizer dose:	N: P: K :: 200:100:100 kg/ha
Manuring:	10 tonnes/ha
No. of spraying:	3(Three) at 30,40 and 55 DAG
Harvesting period:	26.08.2016 to 19.09.2016

Results

The jassids population in different treatments one day before spraying and untreated control ranged from 4.27 to 11.39. There was significant reduction in jassids population due to the application of different biopesticides. All the tested fungal biopesticides at a dosage of 2×10^8 cfu and neemazal 5% are comparable to chemical pesticides acetamiprid and spinosad (Table 99). The aphid population ranged from 60.16 to 75.82 in different treatments in untreated control and one day before up to second spraying. The aphid population in almost all the treatments was nil during third spraying (Table 100). Thus, the pesticidal effect was noticed only up to second spraying in aphids. Like jassids the reduction in aphid population due to fungal biopesticides @2×10^8 cfu was next to the chemical pesticides acetamiprid and spinosad.

The average fruit borer infestation on weight and number basis in untreated control was 29.76 and 71.62%, respectively. Lowest fruit borer (2.35% by weight) damage was noticed in chemical insecticide treatment. Among the biopesticides significantly higher borer infestation was recorded in *B. bassiana* followed by *L. lecanii*. The borer infestation at both the doses of *M. anisopliae* remained at par. However, among the biopesticides, *M. anisopliae* at 2×10^8 cfu recorded the highest yield (8.38 t/ha) next to chemical insecticide application where the yield was 9.31 t/ha. Lowest yield (5.88 t/ha) was obtained in untreated control which was significantly lower than all other treatments (Table 101).

Table 99. Effect of biopesticides on jassids of okra (Arka anamika) during *kharif* 2016

Treatments	Jassid population/ leaf											
	1DBFS	3DAFS	5DAFS	7DAFS	1DBSS	3DASS	5DASS	7DASS	1DBTS	3DATS	5DATS	7DATS
T1: *Beauveria bassiana* @ 1×108 cfu followed by spray of Bt @ 1.5 kg/ha	5.19 (2.39)*	0.47 (0.99)	0.28 (0.88)	0.44 (0.97)	9.95 (3.23)	1.89 (1.55)	1.87 (1.54)	2.02 (1.59	5.17 (2.38)	1.67 (1.47)	1.58 (1.44)	1.81 (1.52)
T2 : *Metarrhizium anisopliae* @ 1×108 cfu followed by spray of Bt @ 1.5 kg/ha	6.94 (2.73)	0.61 (1.05)	0.46 (0.98)	0.42 (0.96)	11.39 (3.45)	1.76 (1.50)	1.72 (1.49)	1.89 (1.55	4.90 (2.32)	0.92 (1.19)	0.83 (1.15)	1.00 (1.22)
T3:*Lecanicilium lecanii* @ 1×108 cfu followed by spray of Bt @ 1.5 kg/ha	6.40 (2.63)	0.79 (1.13)	0.65 (1.07)	0.77 (1.13)	10.97 (3.39)	2.65 (1.77)	2.59 (1.76)	2.76 (1.81)	4.74 (2.29)	1.05 (1.25)	0.96 (1.21)	1.16 (1.29)
T4: Neemazal 4% followed by spray of Bt @ 1.5 kg/ha as in T1.	5.90 (2.53)	0.53 (1.02)	0.45 (0.97)	0.59 (1.04)	10.36 (3.30)	2.56 (1.75)	2.53 (1.74)	2.75 (1.80)	4.97 (2.34)	1.18 (1.30)	1.03 (1.24)	1.26 (1.33)
T5: *B. bassiana* @ 2×108 cfu followed by spray of Bt @ 1.0 kg/ha	7.20 (2.77)	0.17 (0.82)	0.10 (0.78)	0.31 (0.90)	9.85 (3.22)	0.98 (1.22)	0.95 (1.20)	1.05 (1.24)	5.04 (2.35)	0.97 (1.21)	0.87 (1.17)	1.05 (1.24)
T6: *M. anisopliae* @ 2×108 cfu followed by spray of Bt @ 1.0 kg/ha	5.85 (2.52)	0.26 (0.87)	0.15 (0.81)	0.12 (0.79)	10.48 (3.31)	1.18 (1.30)	1.14 (1.28)	1.29 (1.34)	4.51 (2.24)	0.61 (1.05)	0.53 (1.01)	0.71 (1.10)
T7: *L. lecanii* @ 2×108 cfu followed by spray of Bt @ 1.0 kg/ha as in T5.	7.06 (2.75)	0.25 (0.87)	0.20 (0.84)	0.31 (0.90)	11.32 (3.44)	1.36 (1.37)	1.34 (1.36)	1.53 (1.42)	4.41 (2.22)	0.90 (1.18)	0.79 (1.14)	1.03 (1.24)
T8: Neemazal 5% followed by spray of Bt @ 1.0 kg/ha as in T5.	6.80 (2.70)	0.27 (0.88)	0.21 (0.84)	0.31 (0.90)	11.31 (3.44)	1.08 (1.26)	1.02 (1.23)	1.21 (1.31)	4.27 (2.18)	0.83 (1.15)	0.77 (1.13)	0.94 (1.20)
T9: Acetamiprid 0.025 % and spinosad 0.4% as in T1.	5.52 (2.45)	0.32 (0.91)	0.27 (0.88)	0.34 (0.92)	10.63 (3.34)	0.74 (1.11)	0.70 (1.10)	0.94 (1.20)	4.97 (2.34)	0.70 (1.10)	0.64 (1.07)	0.88 (1.17)
T10: Untreated control	6.78 (2.70)	7.89 (2.90)	6.36 (2.62)	6.57 (2.66)	11.31 (3.44)	9.65 (3.19)	9.79 (3.21)	10.87 (3.37)	4.80 (2.30)	4.80 (2.30)	4.53 (2.24)	4.07 (2.14)
S.E.(m)±	(0.09)	(0.11)	(0.09)	(0.10)	(0.02)	(0.12)	(0.12)	(0.11)	(0.02)	(0.07)	(0.07)	(0.06)
C.D. (0.05)	(0.28)	(0.31)	(0.28)	(0.29)	(0.07)	(0.36)	(0.36)	(0.34)	(0.07)	(0.21)	(0.20)	(0.19)
C.V. (%)	(6.20)	(16.08)	(15.28)	(15.19)	(1.26)	(13.11)	(13.28)	(11.84)	(1.86)	(9.11)	(9.36)	(8.06)

*Figures in parentheses are $\sqrt{(x+0.5)}$ transformed values; DBFS- Day Before 1st Spraying; DAFS- Days After 1st Spraying; DBSS- Day Before 2nd Spraying; DASS- Days After 2nd Spraying; DBTS- Day Before 3rd Spraying; DATS- Days After 3rd spraying

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Table 100. Effect of biopesticides on aphids of okra (Arka anamika) during *kharif* 2016

Treatments	Aphid population/ leaf											
	1DBFS	3DAFS	5DAFS	7DAFS	1DBSS	3DASS	5DASS	7DASS	1DBTS	3DATS	5DATS	7DATS
T1: *Beauveria bassiana* @ 1×108 cfu followed by spray of Bt @ 1.5 kg/ha	72.48 (8.54)*	42.51 (6.56)	16.21 (4.09)	8.02 (2.92)	60.16 (7.79)	34.46 (5.91)	14.20 (3.83)	8.06 (2.93)	0.32 (0.88)	0.66 (1.05)	0.44 (0.96)	0.33 (0.90)
T2: *Metarrhizium anisopliae* @ 1×108 cfu followed by spray of Bt @ 1.5 kg/ha	74.78 (8.68)	39.20 (6.30)	13.15 (3.69)	3.22 (1.93)	64.95 (8.09)	22.40 (4.79)	12.38 (3.59)	6.78 (2.70)	0.66 (1.05)	0.21 (0.83)	0.10 (0.77)	0.18 (0.83)
T3: *Lecanicilium lecanii* @ 1×108 cfu followed by spray of Bt @ 1.5 kg/ha	75.82 (8.74)	38.18 (6.22)	15.95 (4.06)	5.65 (2.48)	64.94 (8.09)	38.80 (6.27)	17.15 (4.20)	9.70 (3.19)	0.66 (1.05)	0.15 (0.80)	0.10 (0.77)	0.18 (0.83)
T4: Neemazal 4% followed by spray of Bt @ 1.5 kg/ha as in T1.	75.58 (8.72)	29.16 (5.45)	13.73 (3.77)	7.48 (2.82)	62.38 (7.93)	40.79 (6.43)	19.19 (4.44)	11.05 (3.40)	0.31 (0.88)	0.21 (0.83)	0.11 (0.78)	0.00 (0.71)
T5: *B. bassiana* @ 2×108 cfu followed by spray of Bt @ 1.0 kg/ha	74.19 (8.64)	31.89 (5.69)	12.59 (3.62)	1.86 (1.54)	64.05 (8.03)	21.81 (4.72)	10.32 (3.29)	3.98 (2.12)	0.00 (0.71)	0.15 (0.81)	0.10 (0.77)	0.00 (0.71)
T6: *M. anisopliae* @ 2×108 cfu followed by spray of Bt @ 1.0 kg/ha	73.19 (8.58)	29.13 (5.44)	10.96 (3.39)	2.18 (1.64)	61.00 (7.84)	12.44 (3.60)	7.89 (2.90)	3.79 (2.07)	0.32 (0.88)	0.22 (0.83)	0.11 (0.78)	0.17 (0.81)
T7: *L. lecanii* @ 2×108 cfu followed by spray of Bt @ 1.0 kg/ha as in T5.	72.20 (8.53)	26.21 (5.17)	10.24 (3.28)	2.14 (1.62)	62.28 (7.92)	19.75 (4.50)	10.43 (3.31)	3.12 (1.90)	0.66 (1.05)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T8: Neemazal 5% followed by spray of Bt @ 1.0 kg/ha as in T5.	71.98 (8.51)	29.24 (5.45)	13.48 (3.74)	7.73 (2.87)	63.70 (8.01)	10.40 (3.30)	7.27 (2.79)	5.35 (2.42)	1.00 (1.17)	0.11 (0.78)	0.00 (0.71)	0.00 (0.71)
T9: Acetamiprid 0.025 % and spinosad 0.4% as in T1.	71.40 (8.48)	31.13 (5.62)	11.15 (3.41)	2.25 (1.66)	63.19 (7.98)	28.54 (5.39)	8.10 (2.93)	1.58 (1.44)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T10: Untreated control	74.22 (8.64)	73.74 (8.62)	71.66 (8.49)	69.83 (8.39)	64.22 (8.04)	63.22 (7.98)	61.64 (7.88)	63.04 (7.97)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
S.E.(m)±	(0.05)	(0.09)	(0.10)	(0.06)	(0.08)	(0.14)	(0.08)	(0.07)	(0.16)	(0.10)	(0.06)	(0.05)
C.D. (0.05)	(0.15)	(0.27)	(0.30)	(0.18)	(0.24)	(0.41)	(0.24)	(0.20)	(0.47)	(0.31)	(0.18)	(0.16)
C.V. (%)	(0.98)	(2.57)	(4.21)	(3.78)	(1.74)	(4.54)	(3.53)	(3.80)	(29.69)	(21.89)	(13.85)	(11.50)

*Figures in parentheses are $\sqrt{(x+0.5)}$ transformed values; DBFS- Day Before 1st Spraying; DAFS- Days After 1st Spraying; DBSS- Day Before 2nd Spraying; DASS- Days After 2nd Spraying; DBTS- Day Before 3rd Spraying; DATS- Days After 3rd spraying.

Table 101. Effect of biopesticides on fruit borer infestation and yield of okra (Arka anamika) during *kharif* 2016

Treatments	Wt. basis (%)	No. basis (%)	Marketable yield (t/ha)	B: C ratio
T1	28.49 (5.38)*	33.48 (5.83)	6.56	1.98
T2	7.91 (2.90)	13.80 (3.78)	8.21	2.47
T3	12.69 (3.63)	25.52 (5.10)	6.43	1.93
T4	9.55 (3.17)	13.54 (3.75)	7.81	2.25
T5	10.65 (3.34)	18.29 (4.34)	8.13	2.40
T6	7.83 (2.89)	12.67 (3.63)	8.38	2.45
T7	4.78 (2.30)	10.70 (3.35)	8.06	2.35
T8	5.24 (2.40)	7.87 (2.89)	8.01	2.26
T9	2.35 (1.69)	3.32 (1.95)	9.31	2.53
T10	29.76 (5.50)	71.62 (8.49)	5.88	2.04
S.E.(m)±	(0.08)	(0.05)	0.11	
C.D. 0.05	(0.24)	(0.14)	0.33	
C.V. (%)	(4.24)	(1.93)	2.49	

* Figures in parentheses are √(x+0.5) transformed values.

3.11.19 Effect of biopesticides for the management of shoot and fruit borer, *Earias vitella* in Bhindi (KAU, Vellayani)

Crop: Bhindi var. Varsha Upahar

Experiment details

Design: RBD
Plot Size: 2m x 2m
Replication: 4
Treatments: 5

Treatments

T1: *Beauveria bassiana* ITCC6063 (KAU culture)
T2: *Numurea rileyii* (NBAIR Culture)
T3: *Metarhizium anisopliae* (NBAIR Culture)

T4: Malathion 0.1% (KAU POP)
T5: Check

Observation

Number of borer infested fruit /plant and yield (Kg/plot)

Result

Damage caused by *Earias vitella* was reduced significantly in the plots treated with *Beauveria bassiana* @ 20gm/ l/ and *Metarhizium anisopliae* @ 5g/l .The treatment was on par with the effect of insecticide Malathion 50 EC@ 2m1/l. Higher yield was also obtained as 19, 18, 17 ton/ha from the plots treated with Malathion 0.1%, *M.anisopliae* @ 5g/l *and Beauveria bassiana* 20g/l respectively (Table 102).

Table 102. Efficacy of biopesticides for the management of shoot and fruit borer, *Earias vittella* in Bhindi

Treatments	Fruit damage						Yield t/ha
	3 DAS	7 DAS	10 DAS	14 DAS	17 DAS	21 DAS	
T1: *Beauveria bassiana*	15.06 (3.87)	11.67 (3.37)	9.48 (3.03)	6.40 (2.51)	4.35 (2.07)	4.18 (2.02)	17.46
T2: *N. rileyii*	13.09 (3.57)	7.53 (2.66)	9.170 (2.99)	9.52 (3.06)	8.31 (2.87)	8.18 (2.82)	16.50
T3 :*M.anisopliae*	10.31 (3.19)	11.26 (3.31)	9.41 (3.08)	8.75 (2.95)	7.48 (2.71)	7.27 (2.64)	18.5
T4: Malathion	8.63 (2.93)	11.10 (3.32)	10.52 (3.23)	9.52 (2.97)	6.66 (2.55)	5.52 (2.34)	19.21
T5: Untreated control	15.49 (3.91)	22.21 (4.69)	23.11 (4.79)	25.92 (5.02)	25.37 (5.02)	31.09 (5.56)	13.0
CD (0.05)	(0.620)	(0.837)	(0.639)	(1.096)	(0.49)	(0.707)	

Values in parenthesis are values after √x+1 tarnsformation

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

Name of the Farmer: Th.Gopalsamy, West Arasur
Variety: Salem local
Area: 1.0 acre

Evaluation of BIPM against *A. disperses* on cassava was carried out using the Salem local. The trial was conducted in the field of Mr.Gopalsamy, West Arasur, Irugur block. The BIPM treatments includes

- Installation of yellow sticky traps @ 12 per ha for monitoring
- Release of *Chrysoperla zastrowi sillemi* @ 1.0 lakh first instar grub/ ha
- Application of entomopathogen *L. lecanii* @ 2 x 10^9 conidia per ml

- Application of NSKE 5%

Farmer's practice

Application of triazophos 40%EC @2.5 ml per litre, acephate 75SP @ 1.5 g per litre.

Results

Tapioca crop which showed the occurrence of spiralling whitefly from 3rd month onwards was installed with yellow stick traps at 12 /ha. The spray application of NSKE 5% was carried initially at 3rd month where as *Lecanicillium lecanii* was sprayed at 5th month of crop age. Later on the 1st instar grubs of *Chrysoperla zastrowi sillemi* was released periodically for 3 times to attain the recommended dose of 1.0 lakh/ha. In farmers practice two pesticide sprays were given at 3 and 5th month of crop age. Subsequently the population of whitefly was assessed in both BIPM demonstrated field and field with farmers practice. The whitefly population was reduced to the tune of 80.83 per cent as against the farmers practice which had 25.9 per cent reduction of whitefly population. The plots imposed with BIPM was able to check the whitefly population effectively and found free from sooty mould where as the plots with insecticide sprays and untreated had severe incidence of sooty mould indicating the presence of whitefly population. The BIPM plots recorded a tuber yield of 32.84 t/ha whereas in farmer's practice the tuber harvested was 29.68 t/ha (Table 103). The untreated plot had recorded 26.62 t/ha. The cost benefit ratio realised in BIPM module was 1:3.18 as against cost benefit ratio of 1:2.23 in farmers practice with insecticide sprays alone.

Table 103. Effect of BIPM module on *A. disperses* population and yield on cassava

Treatments	Pre treatment count	*A. dispersus*/ plant*	Per cent reduction over control	Yield (t / ha)	BCR
BIPM module	268.40[a]	56.24[c] (14.32)	80.83	32.84	1 : 3.18
Farmer's practice	230.70[a]	186.8[b] (37.42)	25.92	29.68	1 : 2.23
Control	285.80[a]	312.41[a] (48.42)	0.00	26.62	1: 1.84
CD (*P* = 0.05)	NS	23.46			

*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)

3.11.21 Evaluation of BIPM against major pests of curryleaf (TNAU)

Name of the Farmer : Th.Nandakumar, Mangalakaraipudur, Karamadai blcok
Area : One acre

- Raising sorghum as border crop and cowpea as intercrop
- Installation of yellow sticky trap @ 12/ ha
- Treatment of curry leaf flush 15 Days After Pruning with neem seed extract 5%
- Three releases of T. *chilonis* 50000/ha @ 15 days interval from 30 DAP along with two releases of G. *nephanditis* @ 250nos./ha (45 and 60 DAP for controlling leaf roller *Psorosticha zizyphi*)

- three releases of *Chrysoperla zastrowi sillemi* 10000/ha at 15 days interval from 30 DAP (for controlling psyllid)

The BIPM module implemented in one acre curryleaf field at Mangalakaraipudur in which sorghum was raised as border crop and cowpea as inter crop with installation of yellow sticky poly sheet of size 1 x 3'. The treatments which included spraying of NSKE 5% at 15 DAP followed by release of *Trichogramma chilonis* at 15 days interval from 30 DAP up to 60 DAP along with two releases of G. *nephanditis* for managing the leaf roller. Likewise the first instar grub of *Chrysoperla zastrowi sillemi* was released three times at 15 days interval from 30 days after pruning. The initial population of leaf roller and psyllid was respectively assessed by counting the number of live leaf roll/plant and number of nymphs and adult psyllids in 5 cm long flush on 30 DAP. In the farmers practice, three rounds of spray was given with chlorpyriphos 0.1%, followed by imidacloprid 0.025 % and thiamethoxam 0.0125 % at 15, 30 and 60 DAP. The data on leaf roller and psyllid population clearly indicated that implementation of BIPM module could reduce the leaf roller population by 78.94 per cent and psyllid population upto 59 per cent, whereas the farmers practice recorded a reduction of 64.58 and 42.69 per cent leaf roller and psyllid population respectively. The leaf yield was high in BIPM plot 7.75 t/ha and the cost benefit ratio is 1:3.99, but in farmers practice the leaf yield is 7.02 t/ha with cost benefit ratio of 1:2.98. The control plot realised the lowest leaf yield of 3.35t/ha (Table 104).

Table 104. Field demonstration of BIPM package for the management of major pests of curry leaf

Treatments	Psyllid nymph / 5 cm flush / plant		Per cent reduction over control	Live leaf roll / plant		Per cent reduction over control	Leaf yield (t/ha)	Cost Benefit Ratio
	Pre treatment population 30 DAP	15 days after third release		Pre treatment population 30 DAP	15 days after third release			
BIPM	18.3[a]	7.5[a]	59.01	5.7[a]	1.2[a]	78.94	7.75	1:3.99
Farmers practice	17.8[a]	10.2[b]	42.69	4.8[a]	1.7[a]	64.58	7.02	1:2.98
Control	23.6[b]	36.5[c]	--	18.5[b]	12.6[b]	--	3.35	-

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

3.12 Biological control of Polyhouse Crop Pest

3.12.1 Evaluation of biocontrol agents against sap sucking insect pests of ornamental/vegetables in polyhouses (YSPUHF)

Biocontrol agents like *Beauveria bassiana, Metarhizium anisopliae, Lecanicillium lecanii* (each @ 5g/L of 10^8conidia/g)*, Hippodamyia variegate* (10 beetles/plant) and azadirachtin (1500 ppm; 3ml/L) were evaluated against the rose aphid, *Macrosiphum rosaeiformis* **(There is no species with the name *Mcrosiphum rosaeiformis*, it should be either *Macrosiphum rosae* or *Sitobion rosaeformis*)** on rose under polyhouse conditions at Nauni, Solan during November 2016. Imidacloprid (0.0075%) and water spray were included in the experiment as chemical control and absolute control, respectively. Aphid population was counted on 10 randomly selected plants before and 7 days after the application of treatment. Data on aphid count were converted to percent reduction in aphid population over pre-treatment count which was further corrected through Abbott's correction to get percent reduction over control. Data (Table 105) reveal that among bio-pesticides azadirachtin (1500 ppm;3ml/L), *Hippodamyia variegate* (10 beetles/plant) and *Lecanicillium lecanii* (5g/L of 10^8 conidia/g) were equally effective resulting in 50.8 to 69.1 per cent reduction in the aphid population over control. These bio-agents were, however, significantly less effective in managing the aphid than imidacloprid (0.0075%) which reduced the aphid population to the tune of 96.6 per cent over control. *Beauveria bassiana* and *Metarhizium anisopliae* (both @5g/L of 10^8 conidia/g) were the least effective resulting only 35.5 and 19.3 per cent reduction of the aphid population over control.

Table 105. Evaluation of bio-control agents against *Macrosiphum rosaeiformis*on rose under polyhouse conditions

Sl. No.	Treatment	Reduction (%) in aphid population over control
1	*Beauveria bassiana* (5g/L of 10^8 conidia/g)	35.1 (36.4)^{c}
2	*Metarrhizium anisopliae* (5g/L of 10^8 conidia/g)	19.3 (26.1)^{c}
3	*Lecanicillium lecanii* (5g/L of 10^8 conidia/g)	50.8 (45.6)^{bc}
4	*Hippodamyia variegata* (10/plant)	63.4 (52.7)^{b}
5	Azadirachtin (1500 ppm; 3ml/L)	69.1 (56.2)^{b}
6	Imidacloprid (0.0075%)	96.6 (79.3)^{a}
	CD (P = 0.05)	(12.1)
	CV (%)	21.5

Figures in parentheses are angular transformed values

3.12.2 Evaluation of microbial insecticides against cauliflower aphid, *Brevicoryne brassicae* in shade net house (DRYSRHU)

Experimental details

Season and year: *Rabi* 2016
Design: RBD
Plot size: 2 x 5m
Treatments: 6

Replications: 4
Target pest: Aphids

Treatments

T1: *Beauveria bassiana* @ 5 g/ L
T2: *Metarrhizium anisopliae* @5 g /L
T3: *Lecanicillium lecanii* @ 5 g /L
T4: Azadirachtin 1500 ppm @ 3 ml/L
T5: Dimethoate 2 ml/litre (chemical check)
T6: Untreated control

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

Observations to be recorded

i. No. of aphids/ 5 leaves before treatment
ii. No. of aphids/ 5 leaves after every treatment
iii. Per cent leaf infestation/ 5 plants
iv. Yield at harvest

Results

The results in Table 106 show that among biopesticides the spraying of *Lecanicillium lecanii* followed by *Metarhizium anisopliae* and *Beauveria bassiana* were effective against aphids. The chemical insecticide treatment dimethoate was the most effective treatment and was followed by *L. lecanii* treatment. The mean surviving population was recorded as160 and 50 aphids/5 leaves after imposing the sprays in *L. lecanii* treatment as against 180 and 21, 25 aphids/5 leaves in dimethoate treatment. In untreated control a high population of aphids was recorded consistently. However after two sprays a high incidence *Plutella xylostella* (DBM) and *Spodoptera litura* was recorded and complete defoliation of cauliflower leaves was observed with low yield realization.

Table 106. Evaluation of different bio pesticide formulations against *Brevicoryne brassicae* aphids on cauliflower in Andhra Pradesh

Treatments	Pre count		Post Count Post count after sprays			
	Aphid population / 5 leaves	Per cent leaf infestation/ 5 plants	aphid population / 5 leaves		Per cent leaf infestation/ 5 plants	
			1st spray	2nd spray	1st spray	2nd spray
T1 : *Beauveria bassiana* @ 5g/L	435 (20.74)*	53.44	252.5 (15.75)*	100 (10.02)*	40.29	-

T2: *Metarrhizium. anisopliae* @5 g/L	387.5 (19.62)	58.96	225 (14.99)	105 (10.21)	48.71	-
T3: *Lecanicillium lecanii* @ 5 g /L	423.75 (20.55)	49.50	160 (12.53)	50 (7.02)	49.51	-
T4: Azadirachtin 1500 ppm @ 3 ml/L	416.25 (20.29)	47.18	292.5 (17.10)	135 (11.51)	55.21	-
T5: Dimethoate 2 ml/litre (chemical check)	353.75 (18.76)	59.73	180 (13.23)	21.25 (4.52)	40.52	-
T6: Untreated control	395 (19.82)	63.03	412.5 (20.28)	395 (19.87)	77.30	-
SEM	-		0.91	0.66		
CD	NS		2.76	1.99		

Figures in parentheses; * are √x+0.5 transformed values

3.12.3 Monitoring diversity of pests and diseases of yard long bean (*Vigna unguiculata*) under polyhouse conditions and their management (KAU, RARS-Kumarakom)

a) Survey and documentation of pest and diseases of yard long bean

Survey work was conducted at 8 polyhouses of Kottayam district during the period from October to December 2016 for incidence of pests and diseases. Incidence of Tetranychid mite *Tetranychus truncatus* Ehara (population ranging from 2-5/cm^2) and white fly *Bemisia tabaci* (0-5/plant) were observed in 50 percent of polyhouses surveyed. Infestation of serpentine leaf miner, *Liriomyza trifolii* was recorded in 30 per cent of polyhouses surveyed with 30 to 40 percentages of infested leaves. At two locations infestation of *Spodoptera litura* could be seen. Incidence of powdery mildew (30 %), sooty mould (20%) and *Cercospora* leaf spot (10 %) were also recorded.

b) Evaluation of microbial agents for themanagement ofmajor pests of yard long bean

The experiment was laid out in RBD with 6 treatments and 5 replications (3 plants per replication) under protected condition at RARS, Kumarakom with KAU variety Lola. Three sprayings were given at an interval of 15 days and observations on pest incidence were recorded.

Treatments

1. *Lecanicillium lecani*i NBAIR 1%(10^8 spores/ml)
2. *Lecanicillium lecani*i NBAIR 1% (10^9 spores/ml)
3. *Beauveria bassiana*NBAIR 1% (10^8 spores/ml)
4. *Beauveria bassiana* NBAIR 1%(10^9 spores/ml)
5. Spiromesifen 22.9SC@ 96 g ai ha^{-1}
6. Untreated control

Incidence of aphids and leaf miner were observed in polyhouse. Data on population of aphids was insignificant to be analysed after first spraying. Observations recorded 5,7 and 9 days after second spraying (Table 107) showed *Beauveria bassiana* 1% (10^8 spores/ml and 10^9 spores/ml) and *Lecanicillium lecani*i 1% (10^9 spores/ml) to be to be on par with insecticide Spiromesifen@ 96 g ai ha^{-1} in reducuing aphid population. Observations recorded at 3, 5, 7 & 9 days after third spraying also showed the same trend where both the biopesticides at both doses were on par with the insecticide Spiromesifen@96 g ai ha^{-1} in reducing aphid incidence. Data on leaf miner *Liriomyza trifolii* was insignificant to be analysed.

Table 107. Evaluation of microbial agents for the management of major pests of yard long bean under protected conditions

Treatments	Mean no. of aphids / 5cm shoot length							
	After second spraying				After third spraying			
	3 days	5 days	7 days	9 days	3 days	5 days	7 days	9 days
Lecanicillium lecanii NBAIR 1% 10^8 spores/ml)	3.671^{ab} (1.916)	3.53^{bc} (1.877)	1.912 (1.383)	8.003^{ab} (2.809)	1.571^{d} (1.253)	4.364 (2.089)	6.610^{bc} (2.571)	7.312^{b} (2.704)
*Lecanicillium lecani*i NBAIR 1% (10^9 spores/ml)	2.657^{bc} (1.627)	2.442^{c} (1.563)	1.252 (1.119)	4.194^{bcd} (2.048)	3.675^{bcd} (1.917)	6.620 (2.576)	9.511^{b} (3.084)	8.696^{b} (2.949)
Beauveria bassiana NBAIR 1% (10^8 spores/ml)	2.631^{c} (1.622)	1.664^{b} (1.290)	2.474 (1.576)	$(1.943)^{d}$ 1.394	5.143^{bc} (2.268)	1.819 (1.649)	5.612^{bc} (2.369)	7.017^{bc} (2.649)
Beauveria bassiana NBAIR 1%(10^9 spores/ml)	3.136^{c} (1.771)	1.687^{c} (1.299)	1.438 (1.199)	5.29^{bc} (2.300)	1.583^{cd} (1.258)	6.569 (2.563)	7.371^{b} (2.715)	6.922^{b} (2.631)
Spiromesifen 22.9 SC@ 96 g ai ha^{-1}	3.034^{bc} (1.742)	2.08^{c} (1.438)	1.295 (1.138)	2.310^{cd} (1.520)	6.355^{ab} (2.521)	1.664 (1.290)	2.749^{c} (1.658)	3.489^{c} (1.868)
Untreated control	5.847^{a} (2.418)	5.26^{a} (2.294)	6.447 (2.539)	11.44^{a} (3.383)	11.102^{a} (3.332)	14.646^{a} (3.827)	15.848^{a} (3.981)	17.850^{a} (4.225)
CD (0.05)	NS	0.574	0.344	0.832	1.011	1.106	0.879	0.724
CV (%)	18.581	19.394	12.668	20.391	26.559	26.063	17.694	14.021

Figures in each column represents mean of 5 replications; values in parantheses are √n transformed values

3.12.4 Monitoring the diversity of pests and natural enemies in *Chrysanthemum* under polyhouse condition (TNAU)

The polyhouse Chrysanthemum available in Hosur, Kothagiri and Kodaikanal regions were surveyed for the incidence of pests. Whitefly *Bemisia tabaci*, leaf miner *Liriomyza trifolii, Chromatomyia* and two spotted spider mite, *Tetranychus urticae* were recorded. The whitefly population was maximum in Hosur 4.2 /plant whereas maximum incidence of leaf miner 14.6 nos/plant was noted in Kothagiri area followed by Hosur (10.2 no/plant). Regarding the mite incidence all the three locations showed a population range of 2.7 to 3.5 no./ 2 sq.m (Table 108).

Table 108. Pest incidence in *Chrysanthemum* under polyhouse condition

Locations	Period	Whitefly (No/plant)	Leaf miner damage (No /plant)	Mite incidence no. per 2 sq.cm
Hosur	August 2016	0.0-4.2	2.3 - 10.2	0.0 – 3.5
Kothagiri	December 2016	0.0 – 1.5	3.2 – 14.6	0.0 – 3.2
Kodaikanal	January 2017	0.0 – 0.6	0.8 – 2.4	0.0 – 2.7

3.13 Biological control of Flowering Crop Pest

3.13.1 Biological Suppression of budworm (*Hendecas*is sp.) and blossom midge (*Contarinia* sp) in Jasmine (TNAU)

Name of the Farmer: Th.Brammagiri, Chellapapalayam, Annur blcok
Variety: Ramnad local
Plot size: 8 x 5 m

Treatments

T1: NSKE 5 % three times starting from bud initiation stage at 10 days interval
T2: Release of *T. chilonis* @ 40,000/ acre at 10 days interval for two months from bud initiation based on light trap monitoring
T3: T2+ three rounds of spraying with *Beauveria bassiana* NBAIR formulation ($1x10^8$ spores/g) @ 5g / litre at 10 days interval
T4: T2+ three rounds of spraying with *Metarhizium anisopliae* NBAIR formulation ($1x10^8$ spores/g) @ 5g / litre at 10 days interval
T5: Soil drenching with *Metarhizium anisopliae* 10^9 spores/ha - two times at fifteen days interval
T6: Soil application of Neem cake @250 kg/ha two times per year
T7: Soil application of Carbofuran 3G @ 20 gm/plant
T8: Untreated control

Observations

- No. of plants per treatment: 10
- No. of Replications: 3
- 3 branches / plant / replication
- No. of infested buds/ flowers will be counted on 7 days after each application
- Per cent damage will be worked out

Results

The flower damage due to jasmine bud borer and blossom midge were assessed at the bud initiation stage before imposing treatment. The data on bud borer and blossom midge seven days after the III round of spray was recorded. Among all the treatments tested, application of *Beauveria bassiana* (NBAIR formulation) at 5g/ litre of water along with 6 releases of *Trichogramma chilonis* at 10 days interval from bud initiation stage was superior in checking the bud borer with minimum bud damage of 2.9 per cent and a reduction of 80.3 per cent bud damage as compared to other treatments which showed a bud damage reduction of 55.7 to 71.2 per cent including chemical treatment with carbofuran granule @20g/plant which recorded a bud damage of 5.4 per cent and a reduction of 66.8 per cent bud damage over control (Table 109).

The data recorded on blossom midge damage in treatment plots revealed that application of carbofuran at 20g/plant and spraying of NSKE 5% were on par with each other showing 7.2 per cent midge damage. Both these treatments were on par with other treatments *viz*., release of *Trichogramma chilonis* (6 times) + *Beauveria bassiana* application 5g/l, *Trichogramma chilonis*

(6 times) + *Metarhizium anisopliae* (NBAIR) 5g/l which recorded the low blossom midge damage of 8.2 to 8.6 per cent as compared to control which showed 25.7 per cent.

Table 109. Efficacy of biocontrol agents in suppression of bud borer and blossom midge in jasmine

Treatments	Pre Treatment		Per dent damage 7 days after I spray		Per cent damage 7 days after II spray		Per cent damage 7days after III spray		Per cent reduction over control	
	Bud borer	B.M	Bud borer	B.M	Bud borer	*B.M*	Bud borer	*B.M*	Bud borer	*B.M*
T1: NSKE 5%	9.6[a]	12.5[a]	8.2[a]	10.3[a]	6.9[a]	9.5[a]	5.8[b]	7.2[a]	57.00	56.90
T2: *T. chilonis* @40,000/acre	13.5[a]	17.4[a]	11.8[b]	18.2[e]	9.6[b]	16.8[d]	6.9[bc]	15.6[c]	63.63	33.02
T3: T2+ *B. bassiana* (NBAIR) @5g/l	10.5[a]	18.5[a]	8.4[a]	14.8[c]	6.7[a]	10.6[b]	2.9[a]	8.6[ab]	80.35	65.24
T4: T2+ *M. anisopliae* (NBAIR) @5g/l	15.6[a]	16.8[a]	12.1[bc]	13.6[c]	8.9[ab]	11.2[bc]	6.3[b]	8.5[ab]	71.26	62.20
T5: *Soil drenching M. anisopliae (NBAIR)*	17.2[a]	14.7[a]	14.6[c]	12.3[b]	12.8[c]	10.5[b]	10.7[d]	8.2[ab]	55.73	58.33
T6: Soil application of Neem cake @ 100 kg/acre	14.4[a]	23.4[a]	11.6[b]	18.3[d]	9.2[b]	15.6[c]	7.1[c]	12.4[b]	64.91	60.41
T7: Soil application of carbofuran @ 20g/plant	11.6[a]	14.7[a]	10.1[b]	11.4[a]	7.6[ab]	9.9[b]	5.4[b]	7.2[a]	66.87	63.41
Control	15.3[a]	19.2[a]	16.8[d]	21.3[e]	19.1[d]	23.4[d]	21.5[e]	25.7[f]	--	-

BM: blossom midge; means followed by a common letter in a column are not significantly different by DMRT;
*Mean of three replications

4. Enabling Large Scale Demonstrations

4.1 On Rice (AAU-J, KAU-Thrissur, OUAT, PAU)

4.1.1 AAU, Jorhat

The experiment was carried out Rajabahar, Moran gaon, and Gohain gaon on variety "Ranjit" during 2016. The treatments comprised of T 1 BIPM package compared with T2 Chemical control (farmers practice) and i per technical programme was evaluated in comparison with (chemical control).

T1: BIPM package

1. Seedling root dip treatment with *Pseudomonus fluorescens* @ 2 % solution, 2, Two sprays of *Beauveria bassiana* @ 10^{13} spores/ha against sucking pests, 3. Erection of bird perches @ 15 nos /ha, 4. Six releases of *T. japonicum* @ 100,000 /ha at ten days interval starting from 30 DAT against *Scirpophaga* spp. and *Cnaphalocrocis* spp, 5. Spray of Botanicals (Pestoneem @ 5ml/lit) against foliar as well as sucking pests and 6. Spray of *P. fluorescens* 2 % against foliar diseases

T2: Chemical control (Farmers' practice) where four alternate sprays with chlorpyrifos @ 250 g a.i./ha and quinalphos @ 325 g a.i./ha was applied at 35, 50 , 65 and 80 DAT.

Observations on the population of the pest and natural enemies were recorded before and after the release of bioagent and biopesticides.

Results

The mean per cent dead heart incidence in the three locations caused by *Scirpophaga sp* in BIPM plots were 4.01 and 2.60 at 45 and 65 DAT, respectively as against 3.93 and 2.62 per cent in farmers practice plots. The mean per cent WEH was significantly lower in BIPM plots (3.18%) compared to farmers practice (4.72%). Similarly, leaf folder damage due to *Cnaphalocrosis* sp. in BIPM plots was (2.70 %), which was significantly lower as against farmers' practice plots (3.85%).

The Population of skippers, case worm, hairy caterpillar was negligible. The population of natural enemies like spiders and coccinellids were significantly high in BIPM when compared to farmers' practice. Higher number of spider and coccinellids population of 1.20 /m^2 and 1.40/m^2 was recorded in BIPM plots as against 0.70/m^2 and 0.80/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

Maximum grain yield of 4383.93 Kg / ha was registered in BIPM plot, compared to 3996.85 kg/ha in farmers' practice (Table 110). The higher net returns of Rs. 53,025.00 /ha in BIPM package was recorded as compared to Rs. 47,941.00/ha in farmers' practices (Table 111).

Table 110. Observation on incidence of Dead heart, WEH, LFDL and grain yield of rice

Treatments	Dead heart (%)		WEH (%)	LFDL (%)		Grain yield (kg/ha)
	45 DAT	65 DAT	125 DAT	45 DAT	65 DAT	
BIPM Package	4.01	2.60	3.18	3.94	2.70	4383.93
Farmers practice	3.93	2.62	4.72	3.89	3.85	3996.85
"t" value	1.062	0.149	5.653	0.574	7.00	6.157
Remarks	NS	NS	S	NS	S	S

Table 111. 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	4383.93	387.08	61,375.00	8,350.00	53,025.00
Farmers' practice	3996.85		55,956.00	8,015.00	47,941.00

*Rs. 14/kg of rice grain

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4.1.2 KAU, Thrissur

Location: Vadakkencherry panchayath in Palghat District
Season: October 2016 to February 2017
Area: 13 ha
Variety: Kanchana

The practices followed in IPM were:

1. Seed treatment with *Pseudomonas fluorescens* @ 10g/kg of seeds
2. *Trichogramma japonicum* and *T. chilonis* @ 1 lakh/ha were released from 20 days after transplanting. Five releases were made at 10 days interval.
3. Sprayed *Pseudomonas* @ 2% against foliar diseases.

The practices followed in conventional farming included,

1. Seed treatment with *Pseudomonas* @ 10g/kg of seeds
2. Flubendiamide @ 50 ml/ha against rice stem borer and leaf folder
3. Malathion 0.05% against rice bug

Large scale validation of IPM practices in rice was carried out in an area of 13 ha at Pallaroad padasekharam in Vadekkenchery Panchayat of Palghat District. The adoption of IPM

practices led to substantial reduction in infestation by major pests as well as increase in the natural enemy population as well as net returns.

The pest incidence in IPM plots was markedly lower than that of plots subject to farmer's practices. The case worm, leaf folder and rice bug populations were 67, 41 and 80 per cent lower in the former as compared to non IPM plots. Population of minor pests was also substantially lower in IPM plots. Stem borer infestation was not observed in either of the fields. The IPM plots had markedly higher population of natural enemies as well. They harboured nearly 60 per cent more spiders and 85 per cent more carabid predators as compared to non IPM plots. The number of parasitoids, at a mean number of 97.6/m2 was three times greater than that of plots which adopted conventional practices.

Adoption of IPM practices led to also substantial increase in yield as well as net returns. Plots where IPM practices were adopted registered 40 per cent more yield than that obtained from non IPM plots. The cost of cultivation also was 10 per cent lower in the former. The increased yield as well as reduced cost resulted in an increase in profit by Rs 32,626/ha. The cost benefit ratio, at 2.15 was higher than the 1.45 obtained in case of non IPM fields (Table 112).

Table 112. Comparison between IPM and non IPM plots at Pallaroad, Vadekkenchery

Sl. No.	Particulars	IPM plot (No/m^2)	Non IPM plot(No/m^2)
1.	Case worm	7.2	21.6
2.	Leaf folder	40	68.5
3.	Stem borer	0	0
4.	Green leaf hoppers	26.4	31.68
5.	Grasshoppers	27.2	40.8
6.	Rice bugs	11.2	56
6.	Spiders	111.2	69.5
7.	*Ophionea nigrofasciata*	33.6	18.2
8.	Coccinellids	55.2	35.4
9.	Others	31.2	29.6
10	Parasitoids	97.6	32.53
11	Yield (kg/ha)	4375	3125
12	Returns per ha (@Rs.22.5/kg)	98438.00	70312.00
13.	Cost of cultivation (Rs/ha)	45837.00	50337.00
14	Net return per ha	52601.00	19975.00
15	Cost benefit ratio	2.15	1.4

4.1.3 OUAT, Bhubaneswar

Area covered: 100 acres
Location: Otarakera village of Puri district
Number of beneficiaries: 33

BIPM adopted

- Seed treatment with *Pseudomonas* @ 8 g/ kg of seed/seedlings.
- Spray of *Beauveria bassiana* 10^{13}spores/ha against sucking pests.

- Bird perches erected @ 10/ha.
- Release of *Trichogramma japonicum* @ 1 lakh/ ha when either the leaf folder or stem borer occurrence is noticed. Release initiated as soon as moth actively was noticed.
- Spray of Bt @ 2 kg/ha, 2 sprays given at 15 days interval.
- Spray of *Pseudomonas fluorescens* @ 1.5 kg/ ha against foliar diseases.
- Spray of neemazal @ 2.5 l/ha twice at 45 and 60 DAT.

Farmers practice

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

Results

The dead heart, white ear head, leaf folder and case worm incidence in BIPM demonstrated plots were recorded as 4.5, 5.9, 4.8 and 3.1 %, respectively whereas their incidence in non-BIPM farmers plots were 11.7, 15.8, 9.8 and 5.2 %, respectively. Population of other pests like hairy caterpillar, GLH and BPH were also less in BIPM plots (0.7, 1.7 and 2.3) as compared to non–BIPM plots (1.7, 7.6 and 8.6). The predatory spider and mired bug population per hill were 1.2 and 0.8 in BIPM plots as compared to 0.3 and 0.2 in non–BIPM plots. The yield and B: C ratio was also found higher in BIPM plots as compared to farmers practice (FP). The farmers obtained a net profit of Rs. 5,966.00 per hectare over their own traditional practice (Table 113).

Table 113. Large scale demonstration of BIPM in paddy (100 ac) during *kharif* 2016 at village Otarakera (Block Satyabadi) of Puri district

Treatments	Dead heart (%)	White ear head (%)	Leaf folder (%)	Case worm (%)	Hairy caterpillar (No./hill)	GLH (No./ hill)	BPH (No./ hill)	Spiders (No./hill)	Mirids (No./hill)	Yield (q/ha)	B:C Ratio	Net return over FP (Rs/ha)
BIPM	4.5	5.9	4.8	3.1	0.7	1.7	2.3	1.2	0.8	52.83	1.8	5,966.00
FP	11.7	15.8	9.8	5.2	1.7	7.6	8.6	0.3	0.2	48.12	1.6	-

4.1.4 PAU

A) Large scale demonstration of proven biocontrol technologies against pests of organic *Basmati* rice

Releases of *Trichogramma chilonis* and *T. japonicum* in organic *basmati* rice

Large scale demonstration of biocontrol of yellow stem borer, *Scirpophaga incertulas* and leaf folder, *Cnaphalocrocis medinalis* were conducted in Nabha (Patiala), Samrala (Ludhiana), Kheri (Barnala) in organic *basmati* rice (var. Pusa 1121) over an area of 66 ha. The demonstrations included six releases of *T. chilonis* and *T. japonicum* each @ 100,000 parasitoids/ha at weekly intervals starting from 30 days after transplanting (DAT) and was compared with untreated control. Tricho-cards each having approximately 1000 parasitized eggs

were cut into 100 strips and were stapled uniformly to the underside of the leaves in biocontrol treatment. The data were recorded on dead hearts due to stem borer and leaf damage due to leaf folder at vegetative stage (45 and 60 DAT). White ear incidence was recorded a week prior to harvest. Grain yield was recorded on plot basis and economics was worked out.

Based on the mean of all locations (Table 114), mean dead heart incidence in biocontrol fields was 1.70 and 2.80 per cent at 45 and 60 DAT, respectively. The corresponding figures in untreated control were 3.50 and 6.35 per cent. The mean reduction of dead heart incidence in release fields was 53.67 per cent over control. Similarly, leaf folder damage in release field was significantly lower in biocontrol fields as compared to untreated control. The damage was 2.00 and 2.40 per cent at 45 and 60 DAT, respectively as compared to 4.60 and 5.90 per cent in untreated control with a mean reduction of 57.92 per cent. The mean incidence of white ears was significantly lower in biocontrol field (3.38 %) as against untreated control (6.93 %) resulting in a reduction of 51.23 per cent (Table 115). Grain yield in biocontrol field (26.80 q/ha) was significantly better as compared to 22.40 q/ha in untreated control, respectively. The yield increase in release fields was 19.64 per cent more than untreated control. It can be concluded that 6 releases of *T. chilonis* and *T. japonicum* each @ 1, 00,000/ha resulted in lower incidence of rice insect pests and higher grain yield in organic *basmati* rice with an additional benefit of Rs. 9100/- per hectare.

Table 114. Large scale demonstration of biocontrol of stem borer in organic basmati rice during 2016

Treatments	Dead hearts (%)				Leaffolder damaged leaves (%)			
	45 DAT	60 DAT	Mean	% reduction over control	45 DAT	60 DAT	Mean	% reduction over control
Biocontrol*	1.70[a]	2.80[a]	2.25[a]	53.67	2.00[a]	2.40[a]	2.20[a]	57.92
Untreated control	3.50[b]	6.35[b]	4.93[b]	-	4.60[b]	5.90[b]	5.25[b]	-

DAT – days after transplanting; *6 releases of *T. chilonis* and *T. japonicum* each @ 1,00,000/ha at weekly interval starting from 30 DAT

Table 115. Large scale demonstration of biocontrol of stem borer in organic basmati rice during 2016

Treatments	White ears incidence (%)	% reduction over control	Paddy yield (q/ha)	% increase over control	Net returns over control (Rs./ha)
Biocontrol*	3.38[a]	51.23	26.80[a]	19.64	9100.00
Untreated control	6.93[b]	-	22.40[b]	-	

DAT – days after transplanting; * 6 releases of *T. chilonis* and *T. japonicum* each @ 1,00,000/ha at weekly interval starting from 30 DAT

B) BIPM in *basmati* rice

The BIPM practices involving regular pest surveillance and monitoring, cultural control, biological control and bio-rational approaches were compared with farmer's practices (chemical control) and untreated control in *basmati* rice variety *Pusa Basmati* 1121 at village Sahauli (Patiala). The area was divided into three blocks representing three treatments, i.e. T1 – BIPM (1 ha), T2 - farmers' practice (1 ha) and T3 - untreated control (500 m^2). The treatments are given in Table 116. Each block was divided into three equal sub-blocks representing replications. All the observations were recorded from randomly selected 20 hills. The observations on stem borers infestation (dead hearts), leaf folder damage leaves (at least $1/3^{rd}$ leaf area damaged) and plant hopper population were recorded at weekly intervals starting from 30 DAT. White ears incidence by stem borers was recorded one week before the harvest of the crop. The population of predators was recorded on whole plant basis as well as through sweep nets. Grain yield was recorded on whole plot basis.

Table 116. Treatments followed in different modules

Particular	BIPM	Farmers' practices (Non-IPM)	Untreated control
Host plant resistance	Recommended variety (Pusa 1121)	Recommended variety (Pusa 1121)	Recommended variety (Pusa 1121)
Cultural control			
Fertilizers	Green manuring with *dhaincha*	Excessive use of chemical fertilizers	Green manuring with *dhaincha*
Plant Population	Optimum plant spacing (33 hills / m^2)	20-22 hills /m^2	33 hills / m^2
Water Management	Alternate wetting and drying for hoppers	-	-
Alleyways	Alleyways of 30 cm after every 2 m	-	-
Bio-rational approach			
Pheromone traps	Installation of pheromone traps for yellow stem borer @ 20 / ha	-	-
Biological control			
Augmentative releases	Six releases of *Trichogramma chilonis and T. japonicum* each @ 1,00,000/ha at weekly intervals starting from 30 DAT	-	-
Predation	Bird perches @ 10/ha		-
Conservation of natural enemies	Delaying sprays on basis of ETH level	Indiscriminate use of insecticides for insect pests	-

Monitoring and Surveillance	For insect pests at regular intervals to determine ETH level	-	-
Chemical control			
Seed treatment	Seed treatment with fungicide (*Trichoderma harzianum* @ 15 g/kg seed)	No seed treatment	-
Insecticidal Sprays	Spray on basis of ETH level (Botanical/ Microbials) Dipel 8L @ 750 ml/ha	Blanket application of Padan @ 15 kg/ha, Bifenthrin 500 ml/ha, Lambda cyhalothrin 5EC @ 200ml/ha, Buprofezin 25 SC @ 800 ml/ha	-

The overall incidence of rice stem borer and leaf folder was less in BIPM as well as farmers' practice (non-IPM) fields as compared to untreated control (Table 117). The mean dead heart incidence was 2.23, 1.95 and 6.79 per cent in IPM, farmer's practice and untreated control, respectively. The mean incidence of white ears was 2.86, 2.04 and 7.15 per cent in IPM, farmer's practice and untreated control, respectively. Similarly, leaf folder damage in IPM fields was1.67 as compared to 1.08 per cent in farmer's fields. The incidence of leaf folder in untreated control was 4.73 per cent. The population of plant hoppers was 3.92/hill in IPM and 5.14/hill in farmer's practice fields. The hoppers' population in untreated control was 10.82 per hill. Highest grain yield was recorded in farmers' practiced fields (31.05 q/ha) followed by yield in IPM fields (29.38 q/ha). These yields were significantly better as compared to untreated control (24.94 q/ha).

Table 117. Mean incidence of insect pests, natural enemy count and grain yield in BIPM, farmers' practice and untreated control during 2016

Particulars	BIPM	Farmers' practices (Non-IPM)	Untreated control
Dead hearts (%)	2.23	1.95	6.79
White ears (%)	2.86	2.04	7.15
Leaf folder damaged leaves (%)	1.67	1.08	4.73
Plant hoppers (no./hill)	3.92	5.14	10.82
Spiders (no./hill)	1.26	0.39	0.85
Grain yield (q/ha)	29.38	31.05	24.94

*Average of weekly observations; White ears one week before the harvest of the crop; grain yield at harvest

The data on pheromone trap catches for rice yellow stem borer revealed moth population ranging from 2.08 to 12.50 moths per trap per week during the entire season (Table 118). The maximum population (12.50 moths/ trap/ week) was recorded during 38th SMW (3rd week of September).

Table 118. Moth catch of rice yellow stem borer from sex pheromone traps in IPM plots at village *Sahauli* during 2016

Standard Meteorological Week	No. of moths/trap/week
34	2.72
35	9.11
36	4.34
37	2.63
38	12.50
39	6.87
40	2.08

The population of natural enemies was high in IPM fields than in non-IPM and untreated control fields. The population of spiders on whole plant basis was 1.26, 0.39 and 0.85 spiders per hill cent in IPM, non-IPM and untreated control, respectively. Similarly, in sweep net collection, the mean population of spiders (5.50/plot), dragonflies (2.25/plot) and damselflies (3.42/plot) was significantly higher in BIPM practiced plots. In farmer's practice plots, the mean population of spiders, dragonflies and damselflies was 2.71, 1.00 and 0.67 per plot, respectively. The corresponding figures for the untreated control were 5.28, 2.84 and 3.09 per plot, respectively (Table 119).

Table 119. Diversity of natural enemies in sweep net in BIPM and conventional plots at village Sahauli during 2016

Natural enemies	Mean* no. of natural enemies/plot		
	BIPM	Farmers' practices (Non-IPM)	Untreated control
Spiders	5.50	2.71	5.28
Dragonflies	2.25	1.00	2.84
Damselflies	3.42	0.67	3.09

*Mean of 8 weekly observations

Pooled (2015 and 2016)

The pooled analysis of two years (2015 & 2016) revealed that dead hearts, white ears, per cent leaves folded and plant hoppers' population was significantly lower in farmer's practice than in BIPM practices (Table 120). Both the treatments were significantly better than untreated control. Higher populations of natural enemies were observed in BIPM plots than farmer's practice fields (Table 121). The observations on the grain yield revealed significantly higher yield in farmer's practiced fields (30.84 q/ha) followed by BIPM fields (28.73 q/ha). However, yield in both treatments was significantly better than untreated control (25.06 q/ha).

Table 120. Mean incidence of insect pests in BIPM, farmers' practice and untreated control in *basmati* rice during 2015 & 2016 (pooled)

Treatment	Dead hearts (%)	White ears (%)	Leaf folder damaged leaves (%)	Plant hoppers (No./ hill)
BIPM	2.35[b]	3.08[b]	2.40[b]	1.96[b]
Farmers' practices	1.55[a]	1.91[a]	1.49[a]	2.57[a]
Untreated control	5.55[c]	6.10[c]	5.07[c]	5.95[c]

Table 121. Impact of different management practices on the natural enemies and grain yield in *basmati* rice during 2015 & 2016 (pooled)

Treatment	Mean* no. of natural enemies/plot			Grain yield (q/ha)
	Spider	Dragonfly	Damselfly	
BIPM	4.88[a]	1.50[b]	3.96[b]	28.73[b]
Farmers' practices	3.17[b]	0.69[c]	2.28[c]	30.84[a]
Untreated control	4.82[a]	1.79[a]	3.85[a]	25.06[c]

*Mean of weekly observations

4.2 On Sugarcane

4.2.1 OUAT, Bhubaneswar

Area covered: 105 ac of sugarcane (87A-298 and CO-86032) among 37 beneficiaries
Location: Barada village of Dhenkanal district

BIPM adopted

- Release of *Trichogramma chilonis* @ 1 lakh parasitoids/ha against early shoot borer (ESB) and internode borer (IB) and *T. japonicum* against top shoot borer (TSB) at 10 days interval.
-

Farmers practice

- Application of granular and sprayable insecticides as per availability

Results

The crop was planted in the month of November-December 2015. First release of *T. chilonis* was done in the month of January (20.1.2016) after taking pre-release ESB infestation which ranged from 11.8 to 15.3%. Release of T. *chilonis* continued and observation on incidence of ESB was noted at weekly interval. The mean incidence of ESB was 6.8% in *T. chilonis* released plants. On the contrary, the average incidence of ESB was 22.3% in the fields where no parasitoids have been released and the farmers took their own control measures of pesticide

application. The IB incidence was also lower (10.2%) in parasitoid released plots as compared to 26.8 % in farmers practice (Table 122).

The top shoot borer incidence appeared in the month of March 2016. Release of *T. japonicum* was done to control the TSB and observation on the incidence of TSB was noted at weekly interval. The pre-release TSB incidence ranged from 4.3-4.9%. The mean incidence of TSB was 2.1% in *T. japonicum* released plots as against 4.1% in farmers own practice. The yield of BIPM plots was also higher (128.7 t/ha) as compared to non–BIPM plots where the yield was 102.6 t/ha (Table 122). The farmers obtained a net profit of ₹15647.00 per hectare over their own practice.

Table 122. Incidence of borer pests of sugarcane in BIPM and fields at village Barada (Block Barada) of Dhenkanal district

Treatments	Early shoot borer (%)		Internode borer		Top shoot borer (%)		Yield (t/ha)
	Pre-release	Post-release	Pre-release	Post-release	Pre-release	Post-release	
BIPM	11.8	6.8	4.8	10.2	4.3	2.1	128.7
FP	15.3	22.3	4.6	26.8	4.9	4.1	102.6

4.2.2 PAU, Ludhiana

4.2.2.1 In collaboration with six sugar mills

Large scale demonstration of effectiveness of *T. chilonis* against stalk borer, *Chilo auricilius* over an area of **3164 ha** was carried out in collaboration with six sugar mills of the state (Table 123). 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 Nawanshahr, Morinda, Amloh, Buttar Seviyan, Paniar and Fazilka in IPM fields was 3.7, 2.2, 3.3, 3.0, 3.4 and 2.6 per cent, respectively. The corresponding figures in control (non-adopted) fields were 7.9, 5.0, 7.9, 6.7, 8.2 and 6.2 per cent. The reduction in damage over control in these mills was 53.2, 56.0, 58.2, 55.2, 58.5 and 58.1 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 56.6 per cent.

Table 123. Large-scale demonstration of biocontrol based IPM on sugarcane in six sugarcane mills of Punjab during 2016

Mill area	Area covered (ha)	Incidence of *Chilo auricilius*		
		IPM*	Non- Adopted	Per cent reduction over control
Doaba Co-op Sugar Mills Ltd, Nawanshahr (SBS nagar)	800	3.7	7.9	53.2
Morinda Co-op sugar Mills Ltd, Morinda (Roop Nagar)	1000	2.2	5.0	56.0
Nahar Sugar Mills Pvt. Ltd, Amloh (Fatehgarh Sahib)	980	3.3	7.9	58.2
Rana Sugar Mills Ltd, Buttar Seviyan (Amritsar)	200	3.0	6.7	55.2

Gurdaspur Cooperative Sugar Mills, Paniar (Gurdaspur)	104	3.4	8.2	58.5
Fazilka Cooperative Sugar Mills (Fazilka)	80	2.6	6.2	58.1
Total/ Mean	3164	3.03	6.98	56.6

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

4.2.2.2 Large-scale demonstrations against stalk borer

Large-scale demonstrations of effectiveness of *T. chilonis* against stalk borer, *C. auricilius* were carried out on an area of 182.4 ha at villages Paddi Khalsa (Jalandhar), Rawalpindi (Hoshiarpur), Karni Khera (Fazilka), Khuban (Fazilka), Bararwal (Sangrur), Sahauli (Patiala), Gunike (Patiala), Kariha (Nawashahr). 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 (3.1 %) was significantly lower than untreated control (7.7 %). The reduction in incidence over control was 59.7 per cent. The mean parasitism of eggs of *C. auricilius* in release fields was 50.1 per cent as compared to 4.8 percent in control (Table 124). 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.

Table 124. Demonstration of *T. chilonis* against *C. auricilius* by PAU, Ludhiana during 2016

Treatments	Incidence (%)	Per cent reduction over control	Per cent parasitism
T. chilonis @ 50,000 per ha*	3.1[a]	59.7	50.1[a]
Control	7.7[b]	-	4.8[b]

* 12 releases at 10 days interval; 8 locations (**182.4 ha**)

4.2.2.3 Large scale demonstrations against early shoot borer

A) In collaboration with sugar mills

Large scale demonstration of effectiveness of *T. chilonis* against early shoot borer, *Chilo infuscatellus* over an area of **620 ha** was carried out in collaboration with three sugar mills of the state. 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 Nawanshahr, Morinda and Amloh in release fields was 2.0, 1.6 and 1.7 per cent, respectively (Table 125). The corresponding figures in control (non-adopted) fields were 4.4, 3.4 and 3.8 per cent. The reduction in damage over control in these three mill area were 54.6, 52.9 and 55.3 per cent, respectively. It can be concluded that in large-scale demonstration, eight releases of *T. chilonis* @ 50,000 per ha at 10 days interval during mid-April to end-June reduced the incidence of early shoot borer by 54.3 per cent.

Table 125. Demonstration of *T. chilonis* against *Chilo infuscatellus* in collaboration with three sugar mills of Punjab during 2016

Mill area	Area covered (ha)	Incidence of *Chilo infuscatellus*		
		IPM*	Non- Adopted	Per cent reduction over control
Doaba Co-op Sugar Mills Ltd, Nawanshahr	200	2.0	4.4	54.6
Morinda Co-op sugar Mills Ltd, Morinda	200	1.6	3.4	52.9
Nahar Sugar Mills Pvt. Ltd, Amloh	220	1.7	3.8	55.3
Total/ Mean	620	1.77	3.87	54.3

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

B) PAU, LUDHIANA

Large-scale demonstrations on the effectiveness of *T. chilonis* against early shoot borer, *C. infuscatellus* were carried out on an area of **146 hectares** at villages Paddi Khalsa (Jalandhar), Rawalpindi (Hoshiarpur), Karni Khera (Fazilka), Khuban (Fazilka), Bararwal (Sangrur), Sahauli (Patiala), Gunike (Patiala), Kariha (Nawashahr). 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. coragen @ 375 ml/ha applied 45 days after planting and untreated control. The incidence of early shoot borer in release fields (2.24 %) and chemical control (0.70 %) and was significantly better than untreated control (5.20 %). The reduction in incidence over control was 56.9 and 86.5 per cent in release fields and chemical control, respectively. The mean parasitism of eggs of *C. infuscatellus* in release fields was 46.4 per cent as compared to 5.2 percent in chemical control and 7.0 per cent in control (Table 126). The yield in control (656.0 q/ha) was significantly lower than release fields (720.0 q/ha) and chemical control (842.5 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: 17.88) was high in biocontrol as compared to chemical control (1: 9.48) (Table 127).

Table 126. Demonstration of *T. chilonis* against *C. infuscatellus* by PAU, Ludhiana during 2016

Treatments	Incidence (%)	Per cent reduction over control	Per cent parasitism	Yield (q/ha)
T. chilonis @ 50,000 per ha*	2.24^{b}	56.9	46.4^{a}	720.0^{b}
Chlorantraniliprole 18.5 SC @ 375 ml/ ha	0.70^{a}	86.5	5.2^{b}	842.5^{a}
Control	5.20^{c}		7.0^{b}	656.0^{c}

***** 8 releases at 10 days interval

Table 127. Cost Benefit analysis (2016)

Treatments	Yield (q/ha)	Additional yield over control (kg/ha)	Gross returns over control (Rs)	Cost of treatment* (Rs/ha)	Net return over control (Rs/ha)	Cost benefit ratio
T. chilonis @ 50,000 per ha	720.0	64.0	18880.00	1000.00	17880.00	1: 17.88
Chlorantraniliprole 18.5 SC @ 375 ml/ ha	842.5	186.50	55017.50	5250.00	49767.50	1:9.48
Control	656.0	-	-	-	-	-

Price of sugarcane: Rs. 295/- per quintal during 2016; * includes trichocard/insecticide + labour cost; Price of Coragen 18.5 SC @ Rs. 1700/- per 150 ml

4.2.2.4 Large scale demonstration top borer, *Scirpophaga excerptalis*

A) In collaboration with sugarmills

Large scale demonstration of effectiveness of *T. japonicum* against top borer, *Scirpophaga excerptalis* over an area of **40 hectares** was carried out in collaboration with Doaba Co-operative Sugar Mills Ltd. Nawanshahr. 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 Nawanshahr in release fields was 3.1 as compared to 6.4 per cent in control fields. The reduction in damage over control was 53.4 percent. 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 53.4 per cent.

B) PAU, Ludhiana

Large-scale demonstrations of effectiveness of *T. japonicum* against top borer, *S. excerptalis* were carried over an area of **78 ha** at villages Paddi Khalsa (Jalandhar), Rawalpindi (Hoshiarpur), Karni Khera (Fazilka), Sahauli (Patiala), Gunike (Patiala), Kariha (Nawashahr). 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 (Chlorantraniliprole 0.4 GR @ 25 kg/ha applied during last week of June). The egg masses of *S. excerptalis* were collected to record per cent parasitization. The incidence of top borer in release and chemical control fields was 3.1 and 1.5 per cent, respectively. However, both the treatments were significantly better that untreated control (7.0%). The reduction in incidence over control was 55.7 and 78.6 per cent in release fields and chemical control, respectively. The mean parasitism of eggs of *S. excerptalis* in release field was 35.0 per cent as compared to 2.0 per cent in chemical control and 4.2 per cent in control (Table 128). The yield in control (650.0 q/ha) was significantly lower than release fields (716.0 q/ha) and chemical control (830.0 q/ha). 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 129) was high in biocontrol (1: 18.47) as against chemical control (1: 10.61).

Table 128. Large scale demonstration of *T. japonicum* against *Scirpophaga excerptalis* during 2016

Treatments	Incidence (%)	Per cent reduction over control	Per cent parasitism	Yield (q/ha)
T. japonicum @ 50,000 per ha	3.1[b]	55.7	35.0[a]	716.0[a]
Chlorantraniliprole 0.4 GR @ 25 kg/ha	1.5[a]	78.6	2.0[b]	830.0[b]
Control	7.00[c]	-	4.2[b]	650.0[c]

*8 releases at 10 days interval

Table 129. Cost Benefit analysis (2016)

Treatments	Yield (q/ha)	Additional yield over control (kg/ha)	Gross returns over control (Rs)	Cost of treatment * (Rs/ha)	Net return over control (Rs/ha)	Cost benefit ratio
T. japonicum @ 50,000 per ha	716.0	66.0	19470.00	1000.00	18470.00	1: 18.47
Chlorantraniliprole 0.4 GR @ 25 kg/ha	830.0	180.0	53100.00	4575.00	48525.00	1:10.61
Control	650.0	-	-	-	-	-

Price of sugarcane: Rs. 295/- per quintal during 2016; * include trichocard/insecticide + labour cost; Price of Ferterra 0.4 GR @ Rs 175/ kg

4.3 On Maize

4.3.1 PAU, Ludhiana

The demonstrations on the biological control of maize stem borer, C*hilo partellus* using *Trichogramma chilonis* releases were conducted at farmer's fields on an area of 142 ha in Hoshiarpur, Nawanshahr, Roop Nagar and Pathankot districts of Punjab in collaboration with Maize Section, Department of Plant Breeding & Genetics, KVK Pathankot, KVK Ropar, FASS Hoshiarpur and KVK Hoshiarpur.

A) Single release: The demonstration area was divided into three blocks representing three treatments, *viz*., one release of *T. chilonis* @ 100,000 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, deltamethrin 2.8 EC @ 200 ml/ha was sprayed using 150 litres of water per ha. The observations were recorded on dead heart incidence and the yield was recorded at harvest on whole plot basis.

Based on the mean of all locations (Table 130), mean dead heart incidence in fields with the release of *T. chilonis* was 5.14 per cent and in deltamethrin 2.8 EC @ 200 ml/ha was 3.52 per cent. However, both the treatments were significantly better than untreated control (10.14 %). The reduction in incidence over control was 52.51 and 69.24 per cent in biocontrol and chemical control, respectively. Similarly, yield in release (42.00 q/ha) and chemical control (44.50 q/ha) fields were significantly more than in untreated control (38.01 q/ha). The yield increase over control was 10.57 per cent in biocontrol as compared to 17.19 per cent in chemical control. The net return over control in biocontrol package was Rs. 5036.75/- as against Rs.8239.25/- in chemical control (Table 131).

Table 130. Effect of *T. chilonis* releases on incidence of *C. partellus* and yield in *Kharif* maize during 2016

Treatments	Dead hearts (%)	% reduction in incidence over control	Yield (q/ha)	% yield increase over control
T. chilonis @ 1,00,000 per ha*	5.14[b]	52.51	42.00[b]	10.57
Deltamethrin 2.8 EC @ 200 ml/ha	3.52[a]	69.24	44.50[a]	17.19
Untreated control	10.14[c]	-	38.01[c]	-

Table 131. Cost Benefit analysis (2016)

Treatments	Yield (q/ha)	Additional yield over control (kg/ha)	Gross returns (Rs)	Cost of treatment* (Rs/ha)	Net return over control (Rs/ha)
Biocontrol (release of *T. chilonis*)	42.00	3.99	5286.75	250.00	5036.75
Deltamethrin 2.8 EC @ 200 ml/ha	44.50	6.49	8599.25	360.00	8239.25
Untreated control	38.01				

Price of maize Rs. 1325/- per quintal; * includes trichocard/insecticide + labour cost; Price of Deltamethrin 2.8 EC Rs 550/ litre

B) Double release: Experiments were conducted at farmers' fields in Hoshiarpur, Shaheed Bhagat Singh Nagar and Ropar districts during 2015 and 2016 over an area of 21.2 (no. of trials-21) and 28.4 (no. of trials -32) hectares, respectively. Each field was divided into four blocks representing four treatments, viz. one release of *Trichogramma chilonis* @ 1,00,000 per ha on 10-15 days old crop, two releases of *T. chilonis* @ 1,00,000 per ha on 10 day old crop and one week after, chemical control (deltamethrin 2.8 EC @ 200 ml/ha) and untreated control. Each block was further divided into three replications. The observations were recorded on dead heart incidence due to *C. partellus* from 100 randomly selected plants at 30 days after germination in each plot. The grain yield was recorded at harvest.

Based on the pooled means of two year data (Table 132), the dead heart incidence was significantly lower in chemical control (3.51%). Between the biological control treatments, double release of *T. chilonis* rendered significantly lesser dead heart incidence (4.27%) as compared to single release (5.44%). However, all the treatments were significantly better than untreated control (10.52% incidence). The per cent reduction in incidence of maize stem borer over untreated control was 48.29, 59.41 and 66.63 in single release, double release and chemical control, respectively. The yield was significantly better in chemical control (49.15 q/ha) followed by double release (47.48 q/ha), which in turn was significantly higher than single release (45.89 q/ha). Lowest yield was recorded in untreated control (41.74 q/ha). The per cent increase in yield over control was 9.94, 13.75 and 17.75 in single release, double release and chemical control, respectively. The net returns over control in single release, double release and chemical control were Rs. 5285.75, 7105.50 and 9458.25, respectively.

It can be concluded that two releases of *Trichogramma chilonis* @ 1,00,000/ha; first release on 10 day old crop and second release one week thereafter rendered effective control of maize stem borer, *C. partellus* and has been approved **by Research Evaluation Committee, PAU Ludhiana for inclusion in package of practices for *Kharif* crops, 2017.**

Table 132. Effect of different treatments on the incidence of *Chilo partellus* and yield of *kharif* maize during 2015 and 2016 (pooled mean)

Treatments	Dead hearts (%)	% reduction in incidence over control	Yield (q/ha)	% yield increase over control	Net return over control (Rs/ha)
One release of *T. chilonis* @ 1,00,000 per ha	5.44[c]	48.29	45.89[c]	9.94	5248.75
Two releases of *T. chilonis* @ 1,00,000 per ha	4.27[b]	59.41	47.48[b]	13.75	7105.50
Deltamethrin 2.8 EC @ 200 ml/ha	3.51[a]	66.63	49.15[a]	17.75	9458.25
Untreated control	10.52[d]	-	41.74[d]	-	-

Price of maize Rs. 1325/- per quintal; * include trichocard/insecticide + labour cost; Price of Decis Rs 550/ litre

4.4 On Brinjal

4.4.1 OUAT, Bhubaneswar

Area covered: 58 acre (Tarini)

Location: Dhanagharapada, Sumandi, Barda and Murugakul village of Cuttack district

Number of beneficiaries:

- Dhanagharapada: 28 (29.5 ac)
- Sumandi: 17 (22.0 ac)

- Barda: 4(3.0 ac)
- Murugakul: 7 (3.5 ac)

Total: **56 (58 ac)**

BIPM adopted

- Pheromone traps erected @ 25/ha after 15 DAP(days after planting)
- Weekly release of egg parasitoid *Trichogramma chilonis* @ 50,000/ha/week after 20 DAP (total of 15 releases) (released till the final harvest)
- Two sprays of Bt (Dipel) @ 2ml/l at 10 days interval at peak flowering.

Farmers' practice

- Rynaxypyr (Coragen) @ 0.3 ml/l at fortnightly interval or other insecticidal application as per availability.

Results: Data indicates that the infestation in shoots (10.2-12.1%) and fruits (14.6-17.1%) in BIPM plots were lower as compared to 23.6-26.4% shoot and 35.8-39.1% fruit borer infestation in non-BIPM plots. The consequent yiled (19.98-20.31 ton/ha) and B:C ratio (4.2-4.8) were also higher in BIPM plots as compared to farmers own practice , where it ranged for 15.74-16.11 ton/ha and 3.1–3.5, respectively. Further, the BIPM package produced higher net return per hectare ranging from Rs. 60,060.00 to Rs. 64,545.00 over conventional practice. The number of moths caught per trap per week ranged from 7 to 46 during December 2016 to February 2017.

4.5 Tomato

4.5.1 AAU, Anand

In the year 2016-17 (*Kharif*) demonstration experiment was carried out at Sarangpur Goshala Trust, Sarangpur, on variety "Abhinav". There were three treatments, *viz*., BIPM module, Chemical Control/Farmers' practice and absolute control.
The BIPM Module comprised of 1. Use of pheromone traps @ 40/ha, 2. Release of *Trichogramma chilonis* @ 50000/ha - 6 releases; 3. Sequential spray of *Azadirachtin* 1500 ppm @ 2ml / liter, *Bt* @ 4 g / liter ($2x10^8$ spores g^{-1}), *Beauveria bassiana* @ 4 g/liter ($2x10^8$ cfu g^{-1})

Results

Lowest number of *H. armigera* / plant and fruit damage was recorded in BIPM module (1.15, 10.25%) followed by farmers practice (1.51, 12.74%). he Highest yield was recorded in BIMP module (16.84t/ha) followed by farmers practice (15.06 t/ha) treatment and found at par with each other (Table 133).

Table 133. Effect of different modules on incidence of *H. armigera* and yield of tomato

Modules	*H. armigera* larvae / plant	Fruit damage (%)	Fruit yield (t/ha)
BIPM	1.15* (0.82)	10.25** (2.34)	16.84
Farmer's practices	1.51 (1.78)	12.74 (4.03)	15.06
Absolute control	1.80 (2.74)	14.83 (5.72)	12.03
S. Em. ± T	0.06	0.62	0.70
P	-	-	-
T x P	-	-	-
C. D. at 5 % T	0.18	1.79	2.02
P	-	-	-
T x P	-	-	-
C. V. %	13.25	15.44	15.06

Mean of four observations; * √x + 0.5 transformed values; ** Arc sin transformed values, Figures in parentheses are retransformed values

5. Biological suppression of Tea mosquito bug in Tea

5.1.1 Evaluation of *Beauveria bassiana* (IIHR isolate) against Tea mosquito bug in Tea (AAU-J)

The experiment was carried out at Kachagaral, Jorhat during 2016-17 on variety TV-23 and the treatments imposed 1. Thiamethoxam @30 g ai/ha, 2. Neem Product @5 ml/lit, 3. *Beauveria bassiana* (Commercial product) @ 5 ml/ lit, 4. *Beauveria bassiana* (IIHR strain) @ 5 ml/ lit and 5. Untreated Control.

Two rounds of sprays were given against *H. theivora* maintaining an interval of 30 days in between the sprays based on maximum abundance of pests. Observations on treatment count, adults/ 10 plants were made at 15 and 30 days interval respectively, after each spray. Eggs of *H. theivora* and predatory spiders were collected from treated plots and observed for emergence of natural enemies in the laboratory.

Results

The treatment with Thiomethoxam @ 30 g *a.i.* / ha was the most effective (22.25 adults/ 10 plants) and was found significantly superior to *Beauveria bassiana,* IIHR strain (30.25 adults / plant) in reducing the *H. theivora* population in tea after 30 days of second spray.

However, no significant difference was observed in reducing the *H. theivora* population with commercial formulation of *B. bassiana* (35.25 adults/ 10 plants) and Neem product with 37.25 adults/ 10 plants. The highest population of 61.50 adults /10 plants was recorded in untreated control plot (Table 134).

Table 134. 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 1st spray	30 days after 1st spray	15 days after 2nd spray	30 days after 2nd spray
Thiamethoxam @ 30g ai/ha	50.75	36.50^{c}	32.00^{c}	26.50^{c}	22.25^{d}
Neem Products	50.25	46.00^{b}	40.25^{b}	39.75^{b}	37.25^{b}
Beauveria bassiana (Commercial formulation)	53.50	41.50^{bc}	38.75^{bc}	39.75^{b}	35.25^{b}
B.b (IIHR strain)	56.00	39.25^{c}	35.00^{bc}	34.50^{b}	30.25^{b}
Control	52.00	56.50^{a}	55.00^{a}	59.50^{a}	61.50^{a}
CV %	--	10.36	12.58	10.29	8.40
CD ($P = 0.05$)	NS	7.02	7.79	6.24	4.83

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

6. Tribal Sub Plan Report

6.1 AAU, Anand

6.1.1 Biocontrol technologies for the management of *Fusarium* wilt and pod borer (*H. armigera*) in pigeon pea during *kharif* 2016

Selection of Tribal Farmers

In *Kharif* (2016) season, 50 tribal farmers (Pigeon pea growers) were selected from Dahod district. Area covered (~1 acre/farmer)

Khedut Shibir and training programmes

In association with Tribal Research and Training Centre, Devagadhbariya, Dahod District, a khedut shibir and training programme was organized on 23-08-2016 on use of biocontrol inputs and strategies in pigeon pea crop to achieve sustainable crop production.

Distribution of bio-inputs

In khedut shibir, bio-inputs were distributed to tribal famers and gave demonstration and training on use of bio-inputs in farming. The following bio-inputs were distributed to farmers.

1. *Trichoderma* - 1kg / farmer
2. *Beauveria* - 1kg / farmer
3. *Bt* - 1kg / farmer
4. *Pseudomonas*-1kg / farmer
5. Azadirachtin- 1 lt / farmer
6. Pheromone trap and lures (*Helicoverpa*) - 10 Nos. / farmer

Field visits to record bio-efficacy and on-farm interactions with the farmers

Field visits (two) were made to record the use of bio-inputs by the farmers and bio-efficacy of inputs. Good crop stand with fewer incidences on *Helicoverpa* and *Fusarium* wilt was observed. With the use of biocontrol inputs there was a significant control in *Fusarium* wilt and *Helicoverpa armigera* to the tune of 60-65% and 10-15% increase in yield was observed compared to untreated plots.

6.1.2 Biocontrol technologies for the management of *Fusarium* wilt and pod borer (*H. armigera*) in Chickpea during *rabi* 2016-17

Selection of Tribal Farmers

For *Rabi* (2016) season, 50 tribal farmers (chickpea growers) were selected from Dahod district. Area covered (~1 acre/farmer)

Khedut Shibir and training programmes

In association with Tribal Research and Training Centre, Devagadhbariya, Dahod District, khedut shibir a training programme was organized on 23-1-2017 to train the farmers on use of biocontrol inputs and strategies in chick pea crop to tackle *Helicoverpa* and *Fusarium* wilt and to achieve highest production in a sustainable manner.

Distribution of bio-inputs

The following bio-inputs were distributed to farmers.

1. *Trichoderma* - 1kg / farmer
2. *Beauveria* - 1kg / farmer
3. *Bt* - 1kg / farmer
4. *Pseudomonas*-1kg / farmer
5. Azadirachtin- 1 lt / farmer
6. Pheromone trap and lures (*Helicoverpa*) - 10 Nos / farmer

Field visits to record bio-efficacy and on-farm interactions with the farmers

Regular field visits were made to record the use of bio-inputs by the farmers and bio-efficacy of inputs. Good observations were made with respect to use of inputs and the efficacy of the inputs as well. There was a significant reduction in the disease and insect pests' damage and higher yield (12-15%) was recorded in the treated fields compared to untreated.

6.1.3 Biological interventions to enhance the production and productivity of okra in tribal areas of Tapi district in Gujarat during *rabi* 2016-17

Selection of Tribal Farmers.

For *Rabi* season of 2016-17, 200 tribal farmers (okra growers) have been selected from Tapi district. Area covered (~1 acre/farmer)

Khedut Shibir and training programmes

In association with Krishi Vigyan Kendra (KVK), Vyara, Navsari Agricultural University, khedut shibir, a training programme was organised in the month of December 2016 and January 2017, to train the farmers on use of biocontrol inputs and strategies in okra crop to tackle key pests and diseases and to achieve sustainable production

Distribution of bio-inputs

The following bio-inputs were distributed to farmers (200 numbers in two phases).

1. *Trichoderma* - 1kg / farmer
2. *Beauveria* - 1kg / farmer
3. *Bt* - 1kg farmer
4. *Pochonia/Paecilomyces*-1kg / farmer
5. Biofertilizers - 2 lit / farmer
6. Tricho cards - 5 Nos / farmer
7. Azadirachtin- 1 l t/ farmer

8. Pheromone trap and lures (*Earias*) - 10 Nos / farmer

Field visits to record bio-efficacy and on-farm interactions with the farmers

Field visits were made to record the use of bio-inputs by the farmers and bio-efficacy of inputs. Good crop stand was observed in the fields with fewer incidences of pests and diseases.

Plate 9. TSP Programme on Biological interventions to enhance the production and productivity of okra in tribal areas of Tapi district in Gujarat

6.2 ANGRAU, Anakapalle

Details of Locations of TSP

Tribal dominating areas of Araku valley and Chinthapalli regions in Visakhapatnam district were selected for TSP demontration. The following villages were selected Naduguda, Ramguda, Gunjariguda, Kothavalasa of Araku valley and Idulabailu, Asarada of Chinthapalli areas are selected for implementation of TSP.

Survey was conducted in paddy, rajmah and ginger crops and interacted with farmers. The constraint identified in different crops was as listed, for paddy: low yielding varieties, poor tillering, stem borer, leaf folder, sheath blight and storage pests; for rajmah: low plant population, poor plant growth, stem rot and storage pests and for ginger: low plant population, poor plant growth, rhizome rot, rhizome weevil, shoot borer and termites.

Technologies adopted

1. Organic farming in Paddy
2. Organic farming in Rajmah
3. Organic farming in Ginger
4. *Trichogramma chilonis* production using Eri silk worm eggs in Tribal areas

Interventions

Front line demonstrations (FLD's), training programme at Rythusadassu.

Locations

Nine villages in Araku valley and Chinthapalli areas of Visakhapatnam district

Area Covered

143 acres of paddy, rajmah, ginger crops in Araku valley and Chinthapalli areas in Visakhapatnam district.

Number of farmers benefited

- 162 farmers through FLDs'.
- 168 farmers benefitted through trainings.

Inputs supplied to FLD farmers

- Paddy seed : MTU 1075, RNR 15048
- Biopesticides: *Pseudomonas flourescens* for seed treatment and foliar spraying in paddy *Metarhizium anisopliae* for soil application in ginger.
- Liquid Biofertilizers : *Azospirillum* and *Phosphobacteria* each @ 500 ml/ acre for paddy; *Azospirillum* and *Phosphobacteria* each @ 500 ml/ acre for rajmah and *Azatobacter* and *Phosphobacteria* each @ 500 ml/ acre for ginger crops.
- Biocontrol agents: Trichocards (*Trichogramma japanicum* and *Trichogramma chilonis*) for management of stem borer and leaf folder in paddy.

- Hand Sprayers, Polysheets, Sickels, Seed bins and Kurpas for paddy, rajma and ginger farmers.
- Trichocard production unit for tribal youth farmers.

A. Front line demonstrations organised

Organic farming in paddy, rajmah, ginger in 143 acres of Araku valley and Chinthapalli areas, Visakhapatnam district. Inputs distributed to 45 paddy farmers; 50 Rajma farmers and 67 ginger farmers.

1. Organic farming in Paddy

A front line demonstration trial was conducted in **o**rganic farming paddy in three villages, *i.e*., Naduguda, Ramguda of Araku valley and Idulabailu of Chinthapalli areas. Paddy seed, MTU 1075, RNR 15048 were provided to paddy farmers with biopesticides, *Pseudomonas flourescens* for seed treatment and foliar spraying in paddy against blast and sheath blight. *Azospirillum* and *Phosphobacteria* each @ 500 ml/ acre mixed with 25 kg FYM and broadcasted at the time of transplanting paddy. Biocontrol agents, Tricho cards of *Trichogramma japanicum* and *Trichogramma chilonis* released @ 100,000 egg parasitoids /ha/release from 30 Days after transplanting, 6 times at 7-10 days interval for management of stem borer and leaf folder in paddy.

- About 45 farmers successfully cultivated paddy and obtained good yields by adopting organic farming practices.
- Organic farming paddy FLD farmers recorded higher yields (4500 kg/ ha) compared to traditional tribal farmers (2300 kg / ha) without any fertilizer application and plant protection measures.
- Enhancement of yield levels by 95% with improved quality benefitting 45 paddy farmers covering 43 acres.

2. Organic farming in Rajmah

- Survey was conducted in Rajmah growing tribal areas and constraint for low yields by tribal farmers was assessed.
- Organic farming Rajmah in two villages, *i.e*., Gunjariguda (Araku valley) and Asarada (Chinthapalli).
- *Azospirillum* and *Phosphobacteria* each @500 ml/ acre mixed with 25 kg FYM and broadcasted at the time of sowing rajmah.
- *Trichoderma viridae* soil drenching for stem rot control.
- Around 20-30% of yield increment along with improved quality suitable for export benefiting 50 tribal farmers covering around 50 acres of tribal agricultural acreage**.**

3. Organic farming in Ginger

- Survey was conducted in ginger growing tribal areas and constraint for low yields by tribal farmers was assessed.

- Organic farming in Ginger in three villages, *i.e*, Gunjariguda, Kothavalasa (Araku valley) and Asarada (Chinthapalli).
- Biopesticides, *Metarhizium anisopliae* @5 kg / ha mixed with 25 kg FYM for 15 days enrichment before soil application against termites in Ginger.
- Liquid biofertilizers, *Azatobacter* and *Phosphobacteria* each @500 ml / acre mixed with 25 kg FYM and applied in ginger.
- Around 15-20% of yield increment with export oriented quality produces benefiting 67 tribal farmers covering around 50 acres of tribal agricultural acreage.

4. *Trichogramma chilonis* production using Eri silk worm eggs in Tribal areas

- Adoption of eco-friendly low cost biocontrol agent, *Trichogramma chilonis* production system by tribal farmers through establishment of eri silk worm based tricho card production unit.
- Training 25 tribal youth farmers *on Trichogramma chilonis* production.
- 12 tribal youth of Idulabailu village, Chinthapalli area gave site for constrtuction of semi permanent structure in 120 feet area with Earthwork Excavation for building foundation; Sand filling under foundation, plain cement concrete for building basement, building walls with door, windows, electrification and sunshades, slab 100 mm thick building and other accessories for Tricho card production with budget of Rs. 2 lakh is in progress.

B. Training programmes

- Five Training programme were conducted in Naduguda, Gunjariguda, Asadrada, Idulabailu villages and imparted training on organic farming practices in Paddy, Rajmah and ginger on 24. 6.16, 18.10.16, 25.10.16 and 30.11.16 and one training programme on *Trichogramma chilonis* production using Eri silkworm eggs at Chinthapalli on 28.2.17.
- Total of 168 farmers of Araku valley & Chintapalli areas were benefitted.

C. Method demonstrations

- Conducted at Naduguda, Araku valley and Idulabailu, Chinthapalli on paddy & at Gunjariguda, korai kothavalasa, Asarada on rajmah and ginger on seed treatment in paddy with *Pseudomonas flourescens*, rajmah with *Trichoderma viridae*, biofertilizer application in paddy, rajmah and ginger, Tricho card usage in paddy, spraying biopesticide, *Pseudomonas flourescens* in paddy , *Trichoderma viridae* soil drenching rajmah, soil application of *Metarhizium anisopliae* against termites in ginger, seed drying, seed storage in paddy, rajamah, ginger with neem leaves in seed bins.

D. Rythusadassu and Field day

Rythusadassu and field day organised at koraai kothavalasa, Arakuvalley of Dumbriguda mandal of Araku valley on 14th December 2016. Distributed the inputs to the tribal farmers.

Farmers' feedback

- Mr. Apparao, a tribal youth from Nandiguda village said that paddy cultivation became profitable with the assistance of AICRP on Biological control, ANGRAU technologies by way of employing organic production inputs such as bio fertilizers and plant protection measures like Trichocards. He also said that they were benefited through the regular field visits and interaction with the scientists.
- Mrs. Seedari tribal women farmer from Bonduguda expressed that after using yellow cards (Trichocards) in paddy they didn't observed any dead hearts, white ears and leaf damage and happy to use trichocards for pest control as it is easy technique compared to severe incidence of dead hearts and white ears and leaf folding symptoms in traditional rice cultivation.
- Mrs. Killo Bhimala, tribal women farmer from Korrai Kothavalasa said that application of bio-fertilizers in paddy gave good tillering without zinc deficiency symptoms and healthy vigorous crop thus they got higher paddy yields over traditional paddy cultivation.
- Mr. B. Krishna, tribal farmer from Gunjariguda village said that crop growth and plant stand was goo due to seed treatment in rajmah and control of termites in ginger. Recorded good yields in rajmah and ginger crops with the application of bio-fertilizers.

Expenditure

Total amount allocated for the year: Rs. 700,000/-
Amount spent: Rs. 700,000/-

Head wise breakup of the expenditure

1. Organic farming in paddy: 3 lakhs
2. Organic farming in rajmah: 1 lakh
3. Organic farming in ginger: 1 lakh
4. *Trichogramma chilonis* production using Eri silk worm eggs in Tribal areas: 2 lakhs

6.3 MPKV, Pune

1. Management of insect pests of fruit crops in tribal area

Details of locations of tribal areas/STS where TSP is implemented

The village Dalpatpur and Harsul in Trimbakeshwar Tahasil of Nashik district is a Tribal (ST) dominating areas in Maharashtra. The TSP was implemented in collaboration with Bharatiya Agro Industries Foundation (BAIF), Maharashtra Institute of Technology Transfer for Rural Areas (MITTRA), Nashik.

Table 1. Number of villages/ No. of farmers/area covered in TSP project

Sl. No.	Year	No. of farmers	Area in Horticultural crops covered under TSP
1	2015-16	50	50 acres
2	2016-17	50	50 acres
Total	2 years	100	100 acres

Selection of village

The village Dalpatpur and Harsul, Tahasil Trimbakeshwar, Dist. Nashik is a Tribal (ST) dominating area in Maharashtra selected for implementation of TSP.

Fruit orchard and Plantation crops

Fifty fruit orchards (*Wadis*) of tribal farmers established by BAIF, MITTRA at Dalpatpur and Harsul villages were selected for carrying out operation under TSP. The *wadi* of 0.40 ha consisting 9-10 years old plantation of fruit crops of 40 mango trees, 30 Cashew nut trees, 10 plants of Amla, 5 plants of Drumstick and forest species, *i.e*., *Teak* and *Bamboo* planted on border.

Survey

Survey was carried out to find to locate insect pests problems in fruit orchards. The infestation of mango stem borer, fruit fly, mango hopper and leaf webber, cashew nut tea mosquito bug and bark eating caterpillar was noticed in the plantation crops.

Training programme

One-day training programme on IPM of fruit crops to tribal youth and tribal farmers was organized on 19/02/2016 and 07/06/2016 at Dalpatpur, Dist. Nashik. In IPM training, pests of mango and cashew nut and their management strategies were presented to 25 tribal youth farmers. Similarly IPM training was organized to 50 tribal farmers on 07/06/2016. Thereafter, demonstration was organized for enrichment of FYM with biofertilizer and biopesticdes. The information on 3 P Mission programme was illustrated to protect parasitoids, predators and pollinators in ecosystem.

Crops covered under TSP

Horticultural crops	Major Insect pests
Mango	Mango hoppers, Stem borer, Leaf webber, fruit fly, gall fly
Cashew nut	Tea mosquito bug, Stem borer,Leaf webber Jassids and Bark eating caterpillar
Amla	Stem borer, Bark eating caterpillar
Forest trees	Stem borer, Bark eating caterpillar
French bean	Aphids,Pod borer
Rain fed tomato	Fruit borer,Leaf miner

Biocontrol / IPM technologies implemented for pest management under TSP

Enrichment of FYM:

The FYM (250 Kg) enriched with *Trichoderma* plus *Paecilomyces* + *Metarhizium anisopliae* + Phosphorus solubalizing bactria (PSB) @ 1 litre + Potash solubalizing bacteria (KSB) @ 1 litre + *Pseudomonas fluorescens* @ 1 kg each was mixed thoroughly by adding water to moist and covered with plastic or gunny bags for 15 days for enrichment. Then, it was applied near the root zone in July and September in two split dosages. The population of beneficial microbes was built-up in monsoon during high humidity.

Application of biopesticides for management of pests

For the control of pests and diseases, two preventive sprays of biopesticides were given during flowering at 10 days interval as detailed: i) spraying of *Lecanicillum lecanii* @5 g + *Metarhizium anisopliae* @ 5 g + *Pseudomonas fluorescens* @ 5 g per litre of water, ii) for the control of mango stem borers after cleaning the hole prepared by the grub, inject *Metarhizium anisopliae* @10 ml per tunnel and plug the hole with wet soil/mud, iii) curative spraying on demand if infestation of pests or diseases were followed.

Supply of input

The grant allotted under TSP is Rs. 1.00 Lakh for the year 2015-16 and 2016-17. Following bio pesticides and biofertilizer were supplied to fifty selected tribal farmers during the year 2015-16 to each *wadi* (orchard) owner.

1. Phule *Trichoderma* + *Paecilomyces lilacinus* : 1 kg
2. Phule *Pseudomonas fluorescens* : 2 kg
3. Phule *Metarhizium anisopliae* : 2 kg
4. Phule *lecaniicillium lecanii* : 2 kg
5. *Beauveria bassiana* : 2 kg
6. Phosphorus Solubalizing Bacteria (PSB) : 1 litre
7. Potash Solubalizing Bacteria (KSB) : 1 litre

Other inputs supplied to *wadi* owners are

1. Mango harvester : 50
2. Krushi darshani (MPKV, Rahuri publication) : 50
3. Fruit fly trap : 20 traps
4. Fruit fly lures : 120 lures

Biopesticides, Biofertilizer and other inputs supplied during the year 2016-17 for each tribal farmers

1. Phule *Trichoderma* + *Paecilomyces lilacinus* : 2 kg
2. Phule *Metarhizium anisopliae* : 2 kg
3. Phule *Lecaniicillium lecanii* : 2 kg
4. Phosphorus Solubalizing Bacteria (PSB) : 1 litre
5. Potash Solubalizing Bacteria (KSB) : 1 litre
6. Flight – T- traps : 2 no.
7. Bador lure : 2 nos
8. Yellow sticky trap : 1 no.
9. Krushi darshani (MPKV, Rahuri) : 90

The material supplied to the TSP farmers with financial details

Sl. No	Components	Cost of compo-nent (Rs.)	Quantity (litre/Kg/ No)	No. of farmers	Area covered/ (Acres) Persons covered	Total expenditure (Rs.)
II year (2015-16)						
1	Biofertilizers	200	100	50	50	20,000/
2	Phule *Trichoderma* +	150	50	50	50	7,500/
3	Biopesticides	120*	400	50	50	46,000/
4	Mango Harvester	200	50	50	50	10,000/
5	Krushi darshani	130	50	50	50	6500/
6	Fruit fly Trap	115	20	20	20	2300/
7	Lures for fruit fly	26	120	60	60	3120/
8	Training Expenses	-	-	50	-	2570/
Total Rs. :						97,990
III Year (2016-17)						100,000/=
1.	Biopesticides	160	300	50	50	48,000/=
2.	Biofertilizer	200	100	50	50	20,000/=
3.	Flight – T. traps	115	100	50	50	11,500/=
4.	Bador lure	30	100	50	50	3,000/=
5.	Yellow sticky trap	46	50	50	50	2,300/=
6.	Krushidarshani	130	90	90	90	11,700/=
7.	POL	-	-	-	-	3500/=
Total Rs. :						100,000/=
Total for 2 Years				100 acres Rs.		197,990/=

Achievements of TSP

1. Tribal farmers understand the insect pest problem of *Wadi* (Fruit orchard) and IPM practices.
2. Tribal farmers can identify the nature of damage of pests and remedies to be adopted.
3. They learn how to control mango stem borer and bark eating caterpillar by following the demonstration with PRA techniques.
4. Use of biopesticides is increased instead of chemical pesticides.
5. Tribal farmers are able to identify the pest as well as natural enemies.
6. Due to preventive sprays of biopesticides, fruit drops in mango and cashew nut were reduced thereby the fruit setting was increased. The tribal farmers are convinced with effectiveness of biopesticides in spite of unfavourable conditions.
7. Increased the beneficial fauna near the rhizosphere of the fruit tree to reduce the pest and diseases.
8. The cost of plant protection in horticulture crops is reduced by eco-friendly pest management.
9. Income of the farmers has been increased due to creation of irrigation facilities and by taking intercrops, *viz*., onion, groundnut and wheat in fruit orchards

Impact of TSP Project on economic improvement of the tribal people and wealth creation in tribal areas

During the year 2016, fruit setting was good because of timely management of pests that reflected increase in the yield of mango by 25 per cent and 25 to 30 per cent in cashew nut as compared to previous year. The tribal farmers showed satisfaction and supported the project with more additional demands.

Results

Due to proper and timely application of enriched FYM and spraying of entomopathogenic fungi (EPF) to control mango hopper and tea mosquito bug, the yield of mango and cashew nut was increased. Ultimately tribal farmers are satisfied with TSP project.

6.4 SKUAST, Srinagar

Tribal Sub Plan on Integrated Pest Management of Codling moth in Ladakh

Since the budget for TSP was released in ending October' 2016., the programme could not be initiated during 2016 as the National Highway from Srinagar to Laddakh remains closed from November to 1st week of May. The programme will, therefore, be implemented after reopening of the National Highway. Ground work for carrying out the work has already been done. Six tribal areas of Kargil have been selected for benefiting the farmers with IPM technologies of Management of Codling moth. Six core groups of literate orchardists have been made to implement the programme and help a total of 150 farmers under 10 groups. Each core group will be provided basic training related to IPM of Codling moth, including timing of chemical spray, use of Tricho cards and pheromone traps, trunk banding of apple for trapping and killing of larvae, debarking of old trees and disposal of infested fruits etc. Instructions and guide lines for IPM of Codling moth will be distributed to farmers in their local language. Following items purchased under the programme will be distributed to farmers during upcoming season.

Sl. No.	Name of equipment/ items for distribution	Quantity/ Nos.
1.	Dimethoate 30 EC	20.0 lit.
2.	Chlorpyriphos 20EC	20.0 lit.
3.	*Beauveria bassiana*	30.0 Kg
4.	Azadirachtin (Achook) Nimarin Neem Gold	5.0 Kg. 2.0 lit 2.0 lit.
5.	Foot sprayer (Maruti)	15.0 Nos.
6.	Pheromone traps + liner	500 Nos.
7.	Tubs	15.0 Nos.
8.	Apron	15.0 Nos.
9.	Mask	50.0 Nos.
10.	Hat	50.0 Nos.
11.	Goggle	50.0 Nos.

12	*Trichogramma* spp.	1.0 million
13.	Gunny bags	1000 meters

6.5 TNAU, Coimbatore

TSP trainings conducted during 2016-2017

Date	Location	District	No. of farmers trained	Inputs supplied
19.01.2017	Nammiampattu Panchayat, Jawathu hills	Tiruvannamalai	60	5 kg of samai seeds, *Azospirillum*, *Phosphobacteria* (1kg each), Panchakavya (1 lit) drought tolerance pink pigmented facultative methylotrap PPFM (350ml), *Pseudomonas* (1 kg), *Beauveria bassiana* (250 g), nimbicidine (100 ml), yellow polythene sticky trap, bhendi, amaranthus and snake gourd
02.03.2017	Manjavadi village, Pappireddipatti block.	Dharmapuri	60	Paddy seeds (Co 50 4 kg), horse gram (3kg),mango graft, *Azospirillum* (1kg) ,*Phosphobacteria* (1kg), drought tolerance inducing PPFM(850ml), *Pseudomonas flourences* (1kg) *Trichoderma* (1kg) *Beauveria bassiana* (250 gm) , nimbicidine (100ml) and yellow sticky tarp
28.03.2017	Sembukarai and Thumanoor villages of Periyanaickkan palayam block	Coimbatore	60	Seeds of sorghum, cowpea, field lab lab, bhendi, greens, multicut fodder sorghum (COFS 29) and Cumbu Napier (Co5) slips along with Sapota grafts , *Azospirillum* (1 kg), phosphobacteria (1 kg), drought tolerance inducing PPFM (500 ml), panchakavya (1 lit), pulse booster (500gm), *Beauveria bassiana* (250 gm), *Trichoderma* (1kg), neem oil formulation (100 ml) and yellow sticky trap

TSP Training 1 – Nammiampattu, Tiruvannamalai district

Sixty tribal farmers of Nammiampattu Panchayat, Jawathu hills, Polur block, Tiruvannamalai district were trained on 19.01.2017 about the organic cultivation of samai and homestead cultivation of vegetables for enhancement of their livelihood and nutritional security. The training programme was organized by the Department of Agrl.Entomology, TNAU, Coimbatore, with funds of ICAR-AICRP on Biological Control of Crop Pests under Tribal Sub Plan. Under the training programme, the tribal farmers were enriched with knowledge on organic cultivation using biofertilizers, growth regulators, antagonists, biopesticides, entomofungal agents and entomophages and establishment of homestead vegetable cultivation.

Each tribal farmer was supplied (at free of cost) 5 kg of samai seeds, biofertilizers like *Azospirillum*, *Phosphobacteria* (1kg each), growth promoters like Panchakavya (1 lit) drought tolerance pink pigmented facultative methylotrap PPFM (350ml), antagonists like *Pseudomonas* (1 kg) to control diseases, *Beauveria bassiana* (250 g), and nimbicidine (100 ml), yellow polythene sticky trap to control insect pests and vegetable seeds like, bhendi, amaranthus and snake gourd to raise homestead garden for nutritional security.

In addition, demonstrations on the use of nimbicidine, egg parasitoid *Trichogramma* spp. predators like green lace wing, *Chrysoperla* and *Cryptolaemus* were also conducted. Further an interactive session to exchange the ideas and to clarify the doubts was carried out. The training programme was organized by Dr.S.Sridharan, Professor and Dr P.A.Saravanan, Asst. Professor, Dept. of Agricultural Entomology, TNAU, Coimbatore and facilitated by Thiru. P. Vadamalai, ADA, Polur and Dr.N.Ramakrishnan, SCO, Polur block. At present the farmers are growing samai, ragi, horse gram, niger, chilly, tomato, brinjal, bhendi, papaya and banana. The tribal farmers opined that the training programme and the bioinputs provided are useful and timely.

TSP Training 2 – Manjavadi, Dharmapuri district

Tribal farmers of Manjavadi village, Pappireddipatti block of Dharmapuri district were offered motivational training on 02.03.2017 for the production of pesticide residue free crop produce by the Department of Agrl. Entomology, Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore in collaboration with KVK, Paparapatti, Dharmapuri district where in the beneficiaries were supplied paddy seeds (Co 50 4 kg), horse gram (3kg),mango graft, biofertilizers, *viz*., Azospirillum (1kg) ,Phosphobacteria (1kg), drought tolerance inducing PPFM(850ml) ,*Pseudomonas flourences* (1kg) Trichoderma (1kg) *Beauveria bassiana* (250 gm) , nimbicidine (100ml) and yellow sticky tarp on the cost free basis with financial assistance with ICAR AICRP BCCPW.

Dr.P.S.Shanmugam, Programme Co ordinator, KVK, Dharmapuri district welcomed the participants discussed the use of bio fertilizer and PPFM in crop production. Dr. S. Sridharan, Professor of Agrl. Entomology explained the objectives of the tribal farmers training programme and imparted the technical know how on the use of bio-pesticides for the ecofriendly crop protection while Dr.P.A.Saravanan, Assistant Professor (Agrl.Entomology) elaborated the use of the natural enemies and microbial pesticides to check the crop pest and the ways to integrate them in pest management and demonstrated the use of yellow sticky trap, release of egg parasitoids and green lace wing predator. Dr. Indhumathi, Assistant Professor (Horticulture) explained the technologies related to growing of vegetables in kitchen garden and the establishment of mango grafts. Thiru M. Anand, Horticultural Officer, Pappireddipatti created

awareness on the schemes of the Horticultural Department, Government of Tamil Nadu including drip Irrigation. Dr.P.A.Saravanan proposed the vote of thanks.

TSP Training 3- Sembukarai, Coimbatore district

Sixty tribal farmers of Sembukarai and Thumanoor villages of Periyanaickkan palayam block , Coimbatore district got exposed for one day training on 28.3.2017 about the production of pesticide residue free crop produce organized by the Department of Agrl. Entomology, Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore in coordination with Department of Horticulture, Periyanaikenpalayam block, Government of Tamil Nadu. Beneficiary tribal farmers were supplied with seeds of sorghum, cowpea, field lab lab, bhendi, greens, multicut fodder sorghum (COFS 29) and Cumbu Napier (Co5) slips along with Sapota grafts besides biofertilizers like *Azospirillum* (1 kg), phosphobacteria (1 kg), drought tolerance inducing PPFM (500 ml), panchakavya (1 lit), pulse booster (500gm), entomofungal pathogen *Beauveria bassiana* (250 gm), fungal antagonist, *Trichoderma* (1kg), neem oil formulation (100 ml) and yellow sticky trap on free of cost through the financial support of ICAR AICRP BCCPW.

Thiru P.Sekar, Horticultural Officer, Periyanaikenpalayam welcomed the participants while Dr.S.Sridharan, Professor of Agrl. Entomology explained the prime objectives of the tribal farmers training programme and delivered the technologies on the use of bio-inoculants including neem based pesticides to manage the crop pest in an eco friendly manner. Dr. P.A.Saravanan, Asst. Professor (Agri. Entomology) explained the potential benefits of predators, parasitoids and microbial pesticides in containing the crop pests besides their integration in bio intensive pest management demonstrating the field release of egg parasitoid, green lace wing predator, microbial pesticides and the use of yellow sticky traps. Mrs. Vasanthi Gnanasekar, ADH i/c, Periyanaickenpalayam block spoke on drip irrigation schemes of the Dept. of Horticulture and explained the technologies to grow sapota fruit trees. Dr. P.A.Saravanan proposed the vote of thanks.

6.6 YSPUHF, Solan

Eco-friendly management of pests of apple, almond, peas, beans, cauliflower and cabbage.

Details of the location of tribal area where TSP was implemented

District Kinnaur, Himachal Pradesh

No of village covered: 4 and number of farmers benefitted: 200

Sl. No.	Village	Date of training/demonstration	No. of farmers
1	Moorang	17-11-2016	50
2	Akpa	18-11-2016	50
3	Nichar	27-03-2017	50
4	Sungra	28-03-2017	50
	Total		200

Crops covered

Apple, almond, peas, beans, cauliflower and cabbage

Area covered

Crop	Area (ha)
Apple	100
almond	20
Peas	30
Beans	20
Cauliflower & cabbage	30
Total	200

IPM technologies demonstrated/ implemented

i) Use of *Metarhizium anisopliae*, *Beauveria bassiana*and azadirachtin for the management of apple root borer and apple stem borer.
ii) Use of *Trichoderma* and *Pseudomonas* far the management of diseases in apple vegetable nursery.
iii) Use of yellow and blue sticky traps for the management of thrips, whiteflies and leaf miner in apple, beans and peas.
iv) Use of azadirachtin in cabbage and cauliflower for the management of caterpillars.
v) Need based and safe use of insecticides for the conservation of parasitoids of apple woolly aphid and other natural enemies.
vi) Use/conservation of predatory mites in beans and apple against phytophagous mites.

Inputs supplied to the farmers

Sl. No.	Material	Number/ quantity
1	*Metarhizium anisopliae*	20 Kg
2	*Beauveria bassiana*	100 Kg
2	Yellow sticky traps	200 nos.
3	Blue sticky traps	200 nos.
4	Neem Baan	100 liter
5	*Trichodermaviridae*	100 Kg
6	*Pseudomonas*	100 Kg
7	Literature (Package of practices for fruit crops)	300

Training/ demonstration conducted

Trainings and demonstrations were organized at Moorang, Akpa, Nichar and Sungra villages of Kinnaur district of Himachal Pradesh in which 200 farmers participated. Farmers

were trained and demonstrated regarding the use of above said bio-pesticides for the management of insect and mite pests of apple, almond, peas, beans,c auliflower and cabbage. The farmers of the area were exposed to the use of bio-pesticides for the management of crop pests for the first time.

Expenditure

Total amount allocated for the year:	Rs. 270,000/=
Amount received till date:	Rs. 270,000/=
Amount spent till date:	Rs. 270,000/=

Outcome of the project

Two hundred farmers of Moorang, Akpa, Nichar and Sungra villages of Kinnaur district of Himachal Pradesh were benefited from the trainings/demonstrations. These farmerswere exposed to the use of bio-pesticides for pest management for the first time. In peas, beans, cauliflower and cabbage there was a reduction of 2-3 sprays of chemical pesticides. In case of apple, farmers saved about Rs. 15000/= per hectare by avoiding chemical treatment for the control of apple root borer.

Photographs TSP activities

View of village Nichar, District Kinnaur, Himachal Pradesh

Farmers taking part in a training camp

Farmers learning about the use of bio-pesticides and sticky traps

Farmers learning about apple root borer and apple crown gall

7. General Information

7. Functioning of the co-ordinated project

7.1 Staff position

Sl. No.	Name	Designation	Date Of joining ICAR/SAUS	Date of joining present position
1	Dr. Chandish R. Ballal	Director	06.02.1985	18.07.2016
2	Dr. Prashanth Mohanraj	HOD, Insect Systematics	24.05.1986	17.07.2013
3	Dr. S. K. Jalali	HOD, Mol. Entomology	06.02.1985	30.09.2014
4	Dr. N. Bakthavatsalam	Pl. Scientist (Agri. Ento.)	21.03.1985	21.03.2006
5	Dr. B. Ramanujam	Pl. Scientist (Pl. Patho.)	16.04.1986	28.09.2006
6	Dr. K. Veena Kumari	Pl. Scientist (Agri. Ento.)	05.12.1989	05.12.2006
7	Dr. A. N. Shylesha	Pl. Scientist (Agri. Ento.)	21.01.1992	09.12.2007
8	Dr. T. Venkatesan	Pl. Scientist (Agri. Ento.)	10.11.1993	01.01.2009
9	Dr. P. Sreerama Kumar	Pl. Scientist (Pl. Patho.)	25.07.1994	25.07.2009
10	Dr. K. Srinivasa Murthy	Pl. Scientist (Agri. Ento.)	25.07.1994	25.07.2009
11	Dr. T. M. Shivalingaswamy	Pl. Scientist (Agri. Ento.)	25.07.1994	01.01.2009
12	Dr. M. Nagesh	Pl. Scientist (Nemato.)	09.10.1990	09.10.2007
13	Dr. Sunil Joshi	Pl. Scientist (Agri. Ento.)	21.07.1993	22.07.2010
14	Dr. R. Rangeshwaran	Pl. Scientist (Microbiol.)	21.07.1993	24.07.2011
15	Dr. Kesavan Subaharan	Pl. Scientist (Agri. Ento.)	03.07.1998	03.07.2013
16	Dr. M. Pratheepa	Sr. Scientist (Com. App.)	21.04.1997	21.07.2012
17	Dr. Deepa Bhagat	Sr. Scientist (Or. Chem.)	18.11.1999	24.08.2013
18	Dr. G. Sivakumar	Pl. Scientist (Microbiol.)	30.12.2008	30.12.2014
19	Dr. R. Gandhi Gracy	Scientist (Agri. Ento.)	08.01.2007	08.01.2012
20	Dr. Ankita Gupta	Scientist (Agri. Ento.)	15.12.2009	15.12.2013
21	Dr. K. J. David	Scientist (Agri. Ento.)	21.04.2009	21.04.2014
22	Dr. S. Salini	Scientist (Agri. Ento.)	21.04.2009	21.04.2014
23	Dr. M. Mohan	Pl. Scientist (Agri. Ento.)	16.04.2003	30.08.2014
24	Dr. Mahesh Yandigeri	Sr. Scientist (Microbiol.)	29.06.2006	30.12.2013
25	Dr. Jagadeesh Patil	Scientist (Nemato.)	20.04.2010	20.04.2014
26.	Dr. Richa Varshney	Scientist (Agri. Ento.)	01.01.2015	01.01.2015
27	Ms. Rachana R R	Scientist (Agri. Ento.)	01.01.2015	01.01.2015
28	Dr. R. S. Ramya	Scientist (Agri. Ento.)	01.01.2016	01.01.2016
29	Dr. N. S. Omprakash	Scientist (Agri. Ento.)	01.01.2016	01.01.2016
30	Ms. Daliyamol	Scientist (Pl. Patho.)	01.01.2016	01.01.2016
31	Dr. M. Sampath Kumar	Scientist (Agri. Ento.)	11.05.2010	11.05.2014
32	Dr. Amala U	Scientist (Agri. Ento.)	15.09.2011	15.09.2011
33	Dr. K. Selvaraj	Scientist (Agri. Ento.)	27.04.2011	27.04.2015
34	Dr. G. M. Mahendiran	Scientist (Agri. Ento.)	04.11.2009	04.11.2013
Central Tobacco Research Institute, Research Station, Guntur				
1.	Dr. P. Venkateswarulu	Pl. Scientist (Nem.)	2015	Continuing
Central Plantation Crops Research Institute, Regional Station, Kayangulam				

1	Dr. Chandrika Mohan	Pl. Scientist (Ento.)	01.04.1996	Continuing
Indian Agricultural Research Institute, New Delhi				
1	Dr. B. Paul	Senior Scientist (Ent.)	2012	Continuing
2	Dr. Shankar Ganesh	Scientist (Ent)	2015	Continuing
Indian Institute of Sugarcane Research, Lucknow				
1	Dr. Arun Baitha	Sr. Scientist (Ento.)	01.10.2006	Continuing
Indian Institute of Horticultural Research, Bangalore				
1	Dr. P. N. G. Visalakshy	Pl. Scientist (Ento.)	1987	Continuing
2	Ms. Jayanthi Mala	Scientist (Ento.)	2016	Continuing
3	Dr. N.R. Prasannakumar	Scientist (Ento.)	2016	Continuing
Directorate of Weed Science Research, Jabalpur				
1	Dr. Sushil Kumar	Pl. Scientist (Ento.)	2006	Continuing
National Centre for Integrated Pest Management, New Delhi				
1	Dr. O.P. Sharma	Pl. Scientist (Pathology)	1984	Continuing
Indian Institute of Millet Research, Hyderabad				
1	Dr. V.R. Bhagwat	Princ. Scientist (Ent.)	2013	Continuing
Directorate of Seed Research, Mau				
1	Dr. Raghavendra	Scientist (Ent.)	2013	Continuing
Central Institute of Sub-Tropical Horticulture, Lucknow				
1	Mr. Balaji Rajkumar	Scientist (Ent)	2016	Continuing
2	Dr. Gundappa	Scientist (Ent.)	2013	Continuing
Indian Institute of Rice Research, Hyderabad				
1	Dr. Chitra Shanker	Princ. Scientist (Ent.)	2013	Continuing
Indian Institute of Vegetable Research, Varanasi				
1	Dr. Jaydeep Halder	Scientist (Ent.)	21.04.2009	24.05.2013
Anand Agricultural University, Anand				
1	Dr. D. M. Mehta	Principal Res. Scientist	July 2012	Continuing
2	Dr.P. H. Godhani	Asso. Res. Scientist	Sep. 2012	2017
3	Dr. B.L. Raghunandan	Asso. Res. Scientist	@015	Continuing
Acharya N. G. Ranga Agricultural University, RARS, Anakapalle				
1	Dr. M. Visalakshi	Sr. Scientist (Ent.)	Apriul 2015	Continuing
Assam Agricultural University, Jorhat				
1	Dr. D. K.Saikia	Principal Scientist (Ent.)	23.03.2001	Continuing
2.	Dr.R. Borkakati	Scientist (Ent.)	22.08.2014	Continuing
Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar				
1	Dr. Anand Kumar Tewari	Professor, Pl. Pathology		Continuing
2	Dr. Roopali Sharma	Junior Research Officer	12.01.2006	Continuing
Kerala Agricultural University, Thrissur				
1.	Dr. Madhu Subramanian	Professor (Ent.)	2015	Continuing
Mahatma Phule Krishi Vidyapeeth, Pune				
1	Dr. D.S. Pokharkar	Associate Entomologist	21.07.2016	Continuing
2	Dr. S.M. Galande	Asst. Entomologist	01.08.2013	Continuing
Professor Jayashankar Telangana State Agricultural University, (PJTSAU) Hyderabad				
1	Dr. S.J Rahman	Professor & Head	Feb. 2007	Continuing
Punjab Agricultural University, Ludhiana				

1.	Dr. K.S. Sangha	Senior Entomologist	31.08.1995	13.11.2014
2.	Dr Neelam Joshi	Senior Microbiologist	08.05.1997	08.05.1997
3.	Dr Rabinder Kaur	Asstt. Entomologist	20.12.2004	20.12.2004
4.	Dr. Sudhendu Sharma	Asstt. Entomologist	18.07.2005	01.01.2009
5.	Dr Parminder Singh Shera	Asstt. Entomologist	09.05.2003	07.03.2014
Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar				
1.	Dr. Jamal Ahmad	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	12.06.2014	continuing
2.	Dr. P.A. Saravanan	Assistant Professor Ent.	11.06.2014	continuing
Dr. Y.S. Parmar University of Horticulture and Forestry, Solan				
1	Dr. P. L. Sharma	Principal Scientist (Ent.)	21.11.1995	05.2008
2	Dr. S. C. verma	Principal Scientist (Ent.)	30.11.1995	01.2016
Central Agricultural University, Pasighat				
1	Dr. Raghubir K Patidar	Asso. Prof. (Ent.)	2015	Continuing
Maharana Pratap University of Agriculture & Technology, Udaipur				
1	Dr. B. S. Rana	Asso. Prof. (Ent.)	2007	Continuing
Orissa University of Agriculture & Technology, Bhubaneshwar				
1	Dr. Bhagaban Patro	Prof. (Ent.)	12.08.1985	29.06.2015
University of Agriculture Sciences, Raichur (Voluntary Centre)				
1	Dr. Arunkumar Hosmani	Asso. Prof. (Ent.)	2015	Continuing

7.2 Budget of AICRP for 2016-17

AICRP on Biocontrol, NBAIR, Bangalore

Head	Plan (Rs. in lakhs)	Non-Plan	Total (Rs. in lakhs)
Pay & Allowances	0.00	0.00	0.00
Recurring Contingencies	11.14	0.00	11.14
TA	4.00	0.00	4.00
Other charges including Equipment	0.00	0.00	0.00
TSP	0.00	0.00	0.00
Total	**15.14**	**0.00**	**15.14**

All centres

Item of Expenditure	Sanctioned and allotted grants (Rs. in lakh)	Grants released during 2016-17 from ICAR (Rs. in lakh)	Total expenditure (Rs.)
Pay and allowances	361.74	361.74	361.74
Rec. Contingencies	47.48	47.48	47.48
T.A	11.68	11.68	11.68
TOTAL	**420.90**	**420.90**	**420.90**

7.3 Problem encountered during the year

AAU, Anand

1. As there is a demand for the bio-pesticides from the farming community, KVKs and Co-operatives, the allocation of fund for the purchase of equipments (fermentors) and miscellaneous instruments will help to meet the huge demand of the biocontrol inputs.

AAU, Jorhat

1. A High quality microscope with digital photography is very much important to take photographs of tiny parasitoids.
2. For biodiversity study of the bio-agents and field trials in farmers' field, vehicle is highly essential. In many situation university is not in a position to provide vehicle at due time. Therefore, separate provision may be made in the budget for hiring the vehicle.
3. The budget allocation under recurring and TA head should be increased.
4. A fund has to be allocated for contractual worker for mass production of trichogrammatids.

MPKV, Pune

1. Survey and collection of natural enemies from different agro-ecological zones and the 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 the budget for hiring the vehicle. The labour wages are increased during this year, and hence the provisions of additional recurring contingent grants are required for conducting the trials. Besides, two large scale demonstrations are proposed on farmers fields in the commencing year 2017-18 for which the additional funds be provided to meet the expenses for mass production of parasitoids and entomopathogenic fungi.

TNAU, Coimbatore

1. Coconut black headed occurred in severe form in Dharmapuri district during June to September. The farmers were supplied both *Bracon brevicornis* and *Goniozus nephantidis.* The pest infestation subsided subsequently.
2. Occurrence of Rugose whitefly in coconut was noted from second week of August 2016. Further the whitefly population was collected and sent to NBAIR for identification in October 2016. The whitefly was identified as *Aleurodicus rugioperculatus.* The problem was severe from December to February 2017. The infestation declined in the month of March 2017. The natural enemies like *Encarsia* spp collected given in person to the scientists of NBAIR (24.01.2017) for the identification. The natural enemies recorded were *Mallada, Chrysoperla, Apochrys, Cryptolaemus, Cybocephalus* and other.

YSPUHF, Solan

1. Tribal area of the state is high mountainous region and remains covered with snow during winter; hence for effective and timely utilization, all the funds under TSP may kindly be released by September-October.

8. General

8.1 Meteorological Data (2016-17)

8.1.1 AAU, Anand

Month	Temperature (C)		RH (%)		Total rainfall	Evaporation (mm)	Wind speed	BSSH	Rainy days
	Max.	Min.	Morn.	Even.					
April 2016	38.3	23.8	65.3	28.2	0.0	8.0	4.7	9.8	0.0
May	40.7	27.1	73.7	34.4	10.3	9.5	7.0	10.5	1.0
June	39.0	27.8	77.6	44.2	41.8	8.5	7.8	8.2	2.0
July	33.4	25.8	90.5	72.0	80.6	3.8	6.1	2.8	9.0
August	30.9	24.9	95.3	81.0	231.4	2.8	5.6	2.4	15.0
September	33.0	24.2	93.3	64.0	178.4	4.6	5.0	7.4	7.0
October	33.6	20.9	92.9	50.1	44.2	3.7	2.7	7.0	2.0
November	33.3	13.1	91.3	29.1	0.0	3.4	1.8	9.4	0.0
December	30.6	11.5	91.7	35.7	0.0	3.1	2.1	9.4	0.0
January 2017	28.7	11.2	90	40	0.0	3.1	2.8	8.7	0.0
February	32.0	13.2	81	32	0.0	4.5	3.1	9.8	0.0
March	36.2	16.4	70	20	0.0	6.9	3.7	9.9	0.0

8.1.2 AAU, Jorhat

Month	Temperature (°C)		R/H (%)		Total rainfall	Wind speed (km/hr)	BSSH	Rainy days
	Max	Min.	Morn	Even.				
April	27.4	20.0	93	76	40.1	3.4	87.6	16
May	29.5	22.2	93	77	363.5	2.6	75.0	16
June	32.6	25.4	94	78	389.8	2.7	96.2	18
July	31.6	25.2	94	80	380.1	2.4	54.0	18
August	34.3	26.2	92	72	149.3	0.7	18.8	10
September	32.2	25.1	96	79	249.2	1.4	60.3	16
October	31.8	22.7	96	71	78.5	1.3	129.2	4
November	28.8	16.5	97	67	16.5	0.9	164.4	3
December	26.3	11.9	99	62	43.5	1.7	218.8	2
January	25.2	9.4	98	57	0.1	1.0	232.7	0
February	26.8	13.0	95	55	39.4	1.5	157.6	3
March	26.3	15.5	93	63	148.8	2.5	137.8	10

8.1.3 MPKV, Pune

Met.week (MW)	Tmax^{0}C	Tmin$_0$C	RH-I (%)	RH-II (%)	Rain (mm)	Rainy days	BSS (hrs)
1	31.3	11.0	93	29	0.0	0	9.2
2	30.1	11.3	93	27	0.0	0	8.2
3	28.5	10.8	94	39	0.0	0	9.2
4	29.5	10.4	93	30	0.0	0	9.4
5	33.7	11.7	91	22	0.0	0	9.8
6	32.0	13.3	87	31	0.0	0	9.3
7	31.6	14.6	86	32	0.0	0	8.7
8	34.7	16.8	79	27	0.0	0	8.8
9	34.8	17.6	82	31	9.3	1	7.5
10	33.7	16.4	82	26	3.0	1	8.2
11	34.8	16.4	75	22	0.0	0	9.7
12	37.0	16.6	69	17	0.0	0	9.8
13	38.6	19.3	65	16	0.0	0	8.7
14	38.7	20.4	61	18	2.2	0	8.1
15	38.5	19.5	52	16	0.0	0	9.6
16	39.8	21.7	55	18	0.2	0	9.4
17	38.2	20.5	61	20	0.0	0	10.4
18	39.8	21.0	44	17	0.0	0	10.3
19	38.2	22.5	70	21	5.5	0	8.9
20	39.6	25.1	56	27	1.0	0	8.4
21	36.7	25.7	69	36	0.0	0	10.5
22	36.7	24.6	71	35	4.0	1	10.7
23	34.6	23.7	76	49	31.2	2	5.3
24	33.4	25.5	71	51	0.0	0	6.4
25	32.4	23.9	78	57	6.0	0	4.8
26	28.1	23.3	86	75	17.8	3	1.6
27	28.0	22.9	91	81	79.4	5	1.0
28	26.4	22.3	90	83	63.1	6	0.6
29	27.3	22.1	89	78	5.5	0	2.2
30	28.6	22.3	86	67	3.1	0	2.4
31	26.8	21.7	89	84	141.0	5	0.7
32	26.4	21.9	91	83	79.3	6	2.4
33	28.3	22.1	85	70	2.3	0	6.7
34	28.7	21.8	311	71	12.6	2	5.4
35	28.1	22.2	87	77	0.7	0	2.6
36	28.6	20.4	86	63	1.9	0	6.4
37	29.3	21.0	84	66	4.5	1	14.9
38	26.5	21.9	93	83	40.1	6	0.9
39	29.5	21.3	92	73	10.1	2	3.4
40	27.0	20.4	88	79	34.4	1	2.3
41	29.6	20.2	92	55	46.0	3	8.3
42	31.1	19.6	91	39	0.0	0	7.0

43	31.2	17.1	92	37	0.0	0	8.8
44	30.9	13.7	91	36	0.0	0	8.9
45	30.2	11.5	93	30	0.0	0	9.0
46	30.3	13.4	95	38	0.0	0	8.0
47	29.8	10.7	93	26	0.0	0	8.2
48	31.7	10.4	95	25	0.0	0	9.3
49	30.7	14.4	92	37	0.0	0	8.8
50	32.2	16.1	91	35	0.0	0	9.2
51	31.5	14.2	95	42	0.0	0	8.7
52	28.4	8.7	92	27	0.0	0	9.4
01	29.9	9.2	96	24	0.0	0	8.7
02	28.6	9.5	93	27	0.0	0	9.2
03	28.8	13.4	88	36	0.0	0	6.1
04	31.1	13.0	89	31	0.0	0	8.7
05	31.8	13.2	91	27	0.0	0	9.4
06	32.0	14.2	89	27	0.0	0	9.2
07	31.5	13.6	82	29	0.0	0	8.8
08	35.2	13.5	79	17	0.0	0	10.4
09	34.9	16.5	72	15	0.0	0	9.9
10	33.7	13.0	72	18	0.0	0	9.9
11	33.2	13.7	78	16	0.0	0	9.6
12	36.5	16.9	67	16	0.0	0	9.6
13	39.4	21.6	72	16	0.0	0	9.3

8.1.4 OUAT, Bhubaneswar

Month	Temperature (°C)		RH (%)		Total rainfall (mm)	Evaporation (mm)	Wind speed (km/h)	BSSH	Rainy days
	Temp		Morn.	Even.					
April 2016	40.8	26.5	86	36	7.6	6.9	9.7		01
May	38.8	26.4	82	47	114.9	7.1	7.6		09
June	34.7	26.3	94	71	264.8	5.0	4.8	5.3	19
July	32.2	25.8	92	79	222.2	3.4	4.2	5.1	16
August	31.8	25.5	94	80	247.8	3.3	3.5	4.1	22
September	31.4	25.4	93	80	238.2	3.3	2.5	3.6	24
October	32.2	22.6	89	68	132.8	3.5	2.4	6.3	11
November	31.0	17.4	92	47	20.3	3.6	2.1	7.1	2
December	30.1	15.1	88	38	0.0	3.6	2.3	7.2	0

8.1.5 PAU, Ludhiana

Month	Temperature (°C)		RH (%)		Total rainfall	Evaporation (mm)	Wind speed	BSSH	Rainy days
	Max.	Min.	Morn.	Even.					
April 2016	36.6	19.6	62	62	30.01	250.0	3.7	9.7	5
May 2016	39.6	24.6	57	27	25.2	306.6	6.2	9.1	4
June 2016	39.8	28.5	65	42	86.0	270.5	6.5	7.8	3
July 2016	33.5	27.3	85	66	305.6	346.5	3.9	5.8	9
August2016	33.3	26.2	85	65	87.6	115.8	2.9	5.5	7
Sep. 2016	34.0	25.5	86	55	15.0	132.9	1.7	7.5	2
Oct. 2016	32.5	19.0	89	38	0.0	107.0	1.4	6.1	0
Nov. 2016	27.7	12.0	89	32	2.0	74.0	2.2	5.6	0
Dec.2016	22.2	8.6	95	49	0.0	38.9	2.1	4.7	0
Jan. 2017	18.2	7.6	94	58	46.1	40.9	3.1	4.3	3
Feb. 2017	23.1	9.3	91	47	5.2	65.3	3.0	7.5	1
March 2017	27.2	12.5	86	38	40.8	123.5	3.7	9.1	2

8.1.6 PJTSAU, Hyderabad

Month	Temperature ^{0}C		Relative Humidity (%)		Rainfall (mm)
	Max	Min	I	II	
April, 2016	40.3	24.1	59	21	2.6
May, 2016	38.0	24.2	71	36	157
June, 2016	32.9	23.2	84	60	90
July, 2016	30.2	22.8	89	31	145
August, 2016	31.0	23.0	87	66	180.6
Sept., 2016	28.5	22.0	94	76	391
Oct., 2016	30.2	18.5	91	48	32.2
Nov.,2016	30.3	12.8	88	33	0.0
Dec., 2016	29.0	11.3	90	37	2.0
Jan.,2017	29.3	12.2	87	33	0.0
Feb.,2017	32.7	13.6	79	27	0.0
March, 2017	35.7	18.2	74	25	5.6

8.1.7 SKUAST, Srinagar

Date	Max. Temp.˚C	Min. Temp.˚C	Av. Temp.	Rainfall	Max. Humidity	Min. Humidity	Av. Humidity	SSH
Jan. 1st	8.7	-2.1	3.3	1.5	91.7	71.5	81.6	2.3
Jan 2nd	10.9	7.2	-2.8	0.7	92.9	55.5	74.2	4.3
Feb 1st	11.5	-1.3	5.1	1.6	90.9	51.3	71.1	4.4
Feb 2nd	16.7	-0.7	8.0	2.2	87.1	38.7	62.9	7.4

March 1st	16.0	2.4	9.2	4.1	86.5	53.9	70.2	10.2
March 2nd	14.2	3.1	8.6	8.3	84.9	66.4	75.7	3.0
April 1st	16.8	6.3	11.6	4.5	90.5	75.1	82.8	2.8
April 2nd	20.6	5.8	13.2	3.3	84.9	62.8	73.8	6.4
May 1st	24.4	9.1	16.8	2.1	81.7	56.3	69.0	5.8
May 2nd	28.0	10.4	19.2	2.1	77.0	49.2	63.1	8.3
June 1st	29.8	13.1	21.4	0.2	72.4	42.3	57.4	9.4
June 2nd	31.1	15.3	23.2	0.0	74.1	52.0	63.1	8.6
July 1st	31.5	16.7	24.1	0.8	76.7	44.7	60.7	8.0
July 2nd	29.2	16.5	22.8	6.0	84.3	53.4	68.8	6.5
Aug 1st	27.8	16.8	22.3	2.2	85.3	52.9	69.1	6.8
Aug 2nd	26.8	14.4	20.6	4.1	87.4	62.3	74.9	5.0
Sep 1st	28.5	12.5	20.5	0.8	82.2	54.9	68.5	7.0
Sep 2nd	29.4	9.7	19.5	0.0	88.3	38.3	63.3	8.1
Oct 1st	26.6	5.9	16.2	0.4	82.3	35.2	58.8	7.3
Oct 2nd	23.2	1.3	12.3	0.0	82.4	41.4	61.9	6.6
Nov 1st	18.6	-2.2	8.2	0.0	89.0	40.4	64.7	3.4
Nov 2nd	13.5	-0.8	6.4	0.0	89.7	53.6	71.7	0.0
Dec 1st	12.5	-2.6	5.0	0.3	93.3	57.5	75.4	0.9
Dec 2nd	10.1	-5.3	2.4	0.0	94.6	53.4	74.0	0.6

8.1.8 TNAU, Coimbatore

S. No.	Standard week	Date	Max. temp. (^{o} C)	Min. temp. (^{o} C)	R.H (%)	Rainfall (mm)	Rainy days
1	14	02 Apr – 08 Apr	37.1	24.8	82	0	0
2	15	09 Apr – 15 Apr	36.8	25.7	80	4.2	1
3	16	16 Apr – 22 Apr	37.4	25.8	82	0	0
4	17	23 Apr – 29 Apr	37.7	25.7	80	0	0
5	18	30 Apr – 06 May	37.8	25.5	80	0	0
6	19	07 May – 13 May	35.5	24.4	83	46.3	3
7	20	14 May – 20 May	32.1	24.6	85	15.1	2
8	21	21 May – 27 May	35.1	24.7	82	0	0
9	22	28 May – 03 Jun	33.5	23.6	86	7.8	2
10	23	04 Jun – 10 Jun	32.8	24.2	85	9.8	2
11	24	11 Jun – 17 Jun	32.4	24.5	77	1.7	0
12	25	18 Jun – 24 Jun	31.4	23.1	80	9.0	1
13	26	25 Jun – 01 Jul	29.7	24.0	81	8.9	1
14	27	02 Jul –08 Jul	31.3	24.5	80	3.1	0
15	28	09 Jul – 15 Jul	31.0	23.5	80	7.6	1
16	29	16 Jul – 22 Jul	31.6	23.4	86	2	0
17	30	23 Jul – 29 Jul	31.7	23.3	88	11	2
18	31	30 Jul – 05 Aug	31.2	24.5	74	0.2	0
19	32	06 Aug – 12 Aug	32.8	23.8	81	0	0

20	33	13 Aug – 19 Aug	32.8	23.3	83	0	0
21	34	20 Aug – 26 Aug	33.2	23.4	90	0	0
22	35	27 Aug – 02 Sep	31.4	23.2	86	5.5	1
23	36	03 Sep – 09 Sep	31.8	21.8	85	0	0
24	37	10 Sep – 16 Sep	32.6	22.5	87	0	0
25	38	17 Sep – 23 Sep	32.6	22.2	86	0	0
26	39	24 Sep – 30 Sep	32.6	22.9	86	4.8	1
27	40	01 Oct – 07 Oct	33.4	21.5	86	0	0
28	41	08 Oct – 14 Oct	32.7	22.3	87	19.5	1
29	42	15 Oct – 21 Oct	31.9	23.3	89	0	0
30	43	22 Oct – 28 Oct	31.9	22.8	89	1	0
31	44	29 Oct – 04 Nov	31.3	22.9	88	67.7	2
32	45	05 Nov – 11 Nov	31.3	21.9	86	0	0
33	46	12 Nov – 18 Nov	31.2	23.6	87	1.4	0
34	47	19 Nov – 25 Nov	31.4	20.6	85	0	0
35	48	26 Nov – 02 Dec	31.4	18.5	84	7.4	1
36	49	03 Dec – 09 Dec	28.8	21.1	89	28.5	2
37	50	10 Dec – 16 Dec	29.3	20.0	88	9.1	2
38	51	17 Dec – 23 Dec	30.6	20.8	88	0	0
39	52	24 Dec – 31 Dec	31.2	19.7	87	0	0
40	1	01 Jan – 07 Jan	31.3	18.2	85	0	0
41	2	08 Jan – 14 Jan	30.9	20.4	83	0	0
42	3	15 Jan – 21 Jan	30.5	19.9	84	0	0
43	4	22 Jan – 28 Jan	30	21.3	82	6.4	2
44	5	29 Jan – 04 Feb	30.2	20.8	84	20.4	1
45	6	05 Feb – 11 Feb	31.9	18.4	80	0	0
46	7	12 Feb – 18 Feb	31.0	20.1	75	0	0
47	8	19 Feb – 25 Feb	34.6	19.2	84	0	0
48	9	26 Feb – 04 Mar	33.2	21.6	81	0	0
49	10	05 Mar – 11 Mar	34.2	23.8	88	51.3	1
50	11	12 Mar – 18 Mar	33.9	23	87	7	1
51	12	19 Mar – 25 Mar	34.5	23.7	87	4.7	1
52	13	26 Mar – 01 Apr	35.9	22.2	83	0	0

8.1.9 YSPUHF, Solan

Month	Temperature (^{0}C)		Relative Humidity (%)		Total Rainfall (mm)	No. of Rainy days
	Max.	Min.	Morning	Evening		
March,2016	24.20	9.10	67	44	87.50	10
April,2016	29.40	13.50	57	32	25.60	05
May,2016	30.50	16.60	61	31	115.00	05
June,2016	29.60	19.20	70	60	118.90	11
July,2016	27.40	20.60	87	77	151.90	07
August,2016	26.90	19.90	88	78	164.10	17

Sep. 2016	28.60	17.40	82	65	11.20	04
Oct.2016	27.40	11.60	67	43	00.00	Nil
Nov.2016	25.20	6.40	53	28	00.00	Nil
Dec. 2016	21.90	4.20	59	34	8.60	02
Jan. 2017	16.40	3.10	74	64	122.20	07
Feb. 2017	21.30	6.10	67	31	07.60	03

8.2 Visitors

8.2.1 AAU, Anand

Sr. No.	Visitors	Total
1	VIPs	3
2	Govt. officers	22
3	Farmer	271
4	Student	266
	Total	**562**

1. The Director NBAIR, Bengaluru, visited AICRP on Biological Control of Crop Pests, AAU, Anand, from 23-8-2016 to 24-8-2016.
2. Dr. M. Mohan Principal Scientist and Dr. K. Selvaraj, Scientists, NBAIR, Bengaluru, visited Anand centre from 22-01-2017 to 23-01-2017 and also attended farmers' day (*Trichogramma* day) at Devagadhbaria, on 23.01.2017.

8.2.2 AAU, Jorhat

1. A group of progressive farmers of Golaghat district (14Nos) visited the mass production laboratory on 11.08.2016
2. A group of progressive farmers of Kamrup district (10Nos) visited the mass production laboratory on 06.09.2016
3. Dr. M.K. Gupta**,** Professor and Head, Department of Entomology, Central Agricultural University, Imphal, Manipur, visited AICRPBC Jorhat centre, Assam Agricultural University, Jorhat on 9th December,2016
4. Dr. S. K. Jalali and Dr. T. Venkatesan from NBAIR, Bengaluru visited AICRPBC Jorhat centre, Assam Agricultural University, Jorhat on 10th and 11th January,2017 to review the progress of the research programme.
5. Dr. G. T. Behere**,** Principal Scientist, ICAR Borapani and Dr. K. Saikia, Senior Scientist, Regional Rainfed Lowland Rice Research Station (RRLRRS), Gerua, Dist. Kamrup (Assam) visited AICRPBC Jorhat centre, Assam Agricultural University, Jorhat on 8th February,2017
6. A group of scientist led by Dr. P. Mohanraj from NBAIR, Bengaluru visited AICRPBC Jorhat centre, Assam Agricultural University, Jorhat on 21st February to 25th February, 2017.

8.2.3 MPKV, Pune

1. Dr. Balasaheb Sonwane, Lecturer, Missouri, Columbia visited the Biocontrol Laboratory on 14.03.2016.

2. Dr. K.S.R.K. Murthy, Former president, Plant Protection, Hyderabad visited the Biocontrol Laboratory on 13.4.2016.
3. Dr. John Wiles and Associates, German Scientist, Du-Pont Plant Protection, London, (UK) visited the Biocontrol Laboratory on 23.05.2016.
4. Dr. N.K. Krishnakumar, Deputy Dirctor General (Horticulture) visited the Biocontrol Laboratory on 16.06.2016.
5. Hon. Dr. K.P. Vishwanatha, Vice Chancellor, MPKV, Rahuri visited the Biocontrol Laboratory on 16.06.2016.
6. Dr. K.D. Kokate, Direcor of Research, Mahatma Phule Krishi Vidyapeeth, Rahuri visited the Biocontrol Laboratory on 26.07.2016.
7. Dr. A.L. Pharande, Associate Dean, College of Agriculture, Pune visited the Agril. Entomology Sectional field on 15.11.2016 and 18.11.2016, and Biocontrol laboratory to take review the trials.
8. Dr. H.R. Sardana, Principal Scientist and Dr. M.N. Bhatt, Principal Scientist, ICAR-National Centre for Integrated Pest Management (NCIPM), New Delhi visited the Biocontrol laboratory on 01.12.2016.
9. Dr. S.S. Jadhav, Head, Department of Entomology, Mahatma Phule Krushi Vidyapeeth, Rahuri visited the Biocontrol laboratory on 19.12. 2016 and took review of the progress of research work.
10. Hon. Dr. K.P. Vishwanatha, Vice Chancellor, MPKV, Rahuri visited the Biocontrol Laboratary, Agril, Entomology Section, A.C., Pune on 07.01.2017.
11. Dr. Sunil Joshi, Principal Scientist, NBAIR, Bangalore, visited the Biocontrol laboratory as well as experimental plots on 24.2.2017 and took review of the progress of research work.
12. Dr. A.L.Pharande, Associate Dean, A.C., Pune, visited the Biocontrol Laboratory, Pune, on 03.03.2017 regarding the visit of ICAR Monitoring and Review committee team.
13. Hon. Dr. Maheshwari, Chairman, ICAR Monitoring and Review committee, Hon. Dr. K.P. Vishwanatha, Vice Chancellor, MPKV, Rahuri, Dr. B.R. Ulmek, Dean, Faculty of Agriculture, MPKV, Rahuri and Dr. A.L. Pharande, Associate Dean, A.C., Pune, visited the Biocontrol Lab., Pune, on 04.03.2017 and take review of production of bioagents.
14. Hon. Dr. P.A. Salimath, Vice Chancellor, UAS, Raichur, visited the Biocontrol Laboratory, Pune, on 18.03.2017.

8.2.4 OUAT, Bhubaneswar

1. Farmers, KVK Scientists and State Govt. officials are frequently visiting the bio control laboratory

8.2.5 PAU, Ludhiana

S. No.	Name	Date of visit
1.	Prof. V S Tomar, Vice-chancellor, JNKVV, Jabalpur Dr S K Rao, Director of Research, JNKVV, Jabalpur	April 29, 2016
2.	Dr Md. Monobrullah, Principal Scientist, ICAR-Institute of Natural Resins and Gums, Namkum, Ranchi	May 10-11, 2016
3.	Dr S K Jalali, Principal Scientist (Entomology) and Head, Division of Molecular Entomology, ICAR-NBAIR,	July 4-6, 2016

	Benagaluru Dr Shylesha, Principal Scientist (Entomology) and Head, Division of Insect Ecology, ICAR-NBAIR, Benagaluru	
4.	Team of trainees headed by Dr A S Sohi from RGS Cell of Sir Rattan Tata Trust, PAU Ludhiana	September 12, 2016
5	Team of organic farmers from different districts of Punjab	December 6, 2016
6.	Ms Bhargavi K, Corporate and IP Lawyer, Hyderabad	December 9, 2016

8.2.6 PJTSAU, Hyderabad

1. Dr. K.K.Sharma, Director, IINRG, Ranchi (Jharkhand) visited the centre on 1.9.2016
2. Dr. Chandish R. Ballal, Director, NBAIR and Project Coordinator, AICRP on Biological control visited the Centre on 2.9.2016.
3. Dr. P. K. Chakravarthy, ADG (Plant Protection & Bio Safety), ICAR, New Delhi visited the Centre on 2.9.2016.
4. Dr. D. Raji Reddy, Director of Research, PJTSAU visited the Centre on 10.9.2016.
5. Dr. D. Vishnuvardhan Reddy, Associate Dean, College of Agriculture, Rajendranagar PJTSAU visited the Centre on 2.1.2017.
6. Dr. I. Srinivas, CEO, Agri. Experiential Learning, PJTSAU visited the centre on 23.1.2017
7. Dr. Venkata Ramana, Associate Director of Research, RARS, Palem visited the Centre on 16.1.2017.

8.2.7 SKUAST, Srinagar

1. Six farmers of district Bandipore visited on 3.05. 2016. Regarding use of bio agents for various crops
2. Visit of line departments from district Bandipora on 7.06.2016 regarding management of horticultural pests through bioagents
3. Visit of line departments from district Srinagar on 12.10. 2016. Regarding Organic management of crops
4. Visit of Orchardists of district Shopian on 14.02. 2017. For the management of mites on apple through anthocorid bugs
5. Visit of officers/farmers/Line departments on 11- 12.3.2017 in stall of Entomology Division and interaction with scientists regarding use of bio agents against different crops.
6. Visit of 20 SMS from Department of Agriculture, under 3 days training programme on Integrated Pest Management in temperate fruits and vegetables w.e.f 23-25th of March, 2017 Under SAMEITI conducted by Directorate of Extension, SKUAST-K.

8.2.8 TNAU, Coimbatore

Sl. No.	DATE	VISITORS	PURPOSE
1.	30.05.2016 & 31.5.2016	ICAR Accreditation team visit	Accreditation of the University

2.	7.06.16	Dr. M. Mani, Emeritus Scientist, NBAIR	Visited the biocontrol lab.
3.	22.08.2016	IPM Professionals from Bangladesh	Visited the biocontrol lab.
4.	06.10.2016	Agricultural Production Commissioner, Tamil Nadu	Visited Paddy breeding station and Entomology glass house
5.	20.10.2016	Vice chancellor, University of Horticulture Sciences, Bhagalkot	Bio Control lab visit
6.	11.11.16 and 12.11.16	Dr. Chandish R. Ballal, Director, NBAIR, Bengaluru	Review of AICRP biocontrol of crop pests scheme
7.	24.11.16	Dr. S.K. Jalali and team of scientists from NBAIR	Visited the biocontrol lab and survey on cotton whitefly incidence
8.	20.03.2017 & 21.03.2017	Dr. Chandish R. Ballal, Director, NBAIR, Bengaluru and the team of scientists	Brain storming session on rugose whitefly

8.2.9 YSPUHF, Solan

1. 152 farmers visited the AICRP Bio-control laboratory for acquaintance with the biocontrol agents and their role in pest control.

8.2.10 IGKV, Raipur

S.N.	Name of visitors	Visiting date	Comments
1.	Dr. Mridula Billore Dean, CoA, Khandwa (M.P.)	11.07.2016	Very much impressed to see the lab. and particularly the dedicated and scientist to worth appreciating commendable job. Best wishes for long time the aware sprite of institute.
2.	Dr. C. R. Satapathy Professor (Entomology) PI AICRP on HB&P, OUAT, Bhubaneshwar (Orissa)	04.08.2016	The rearing of Assasin bug was really very interesting there is a lot of scope too I will be happy if more M.Sc. & Ph.D. students are involved.
3.	Mr. Ajay Kumar Soni Administrative officer (ICAR) Indian Institute of Seed Science Mau (U.P.)	23.08.2016	The bio-agents are reared & multiplied efficiently by them theses activities will help for controlling the insect pests and useful for farmers in future aspects.

4.	Dr. S. N. Upadhyay Professor (Entomology) CoA, Indore (M.P.)	24.08.2016	Most of the bio-agents are reared & multiplied efficiently by them these activities will help in controlling the different harmful insect pests in crop field.
5.	Dr. O. P. Veda Retd. Prof. & Head (Indore)	24.08.2016	The outcome of the efforts will be useful for farmers and all concerned.
6.	Dr. S. P. Mishra Professor, Plant Pathology, CoA, Indore (M.P.)	03.09.2016	Beneficial for farmers and very important for future aspects.
7.	Dr. M.S. Rao Principal Scientist (ICAR) IIHR, Bangalore (Karnataka)	07.09.2016	Excellent work is being carried out in this bio-control lab the work team is very hard working dedicated, and devoted to their research work. They are doing great services to the farmers and nation for sustainable agriculture.
8.	Dr. S. S. Shaw DI, IGKV, Raipur	21.09.2016	Excellent efforts are being made in developing bio-control lab for management of various crop pests
9.	Dr. A. K. Khatri Retd. Professor & Head (Entomology) JNKVV, Jabalpur (M.P.)	21.09.2016	Excellent work has being carried out Bio-control lab of the department. I hope same spirit will continue in future with all good wishes to your staff and students.
10.	Mr. Sonu Daliya Training Coordinator AcABC ISAP Raipur Manage	26.09.2016	Excellent work done in bio-control lab.
11.	Dr. R. K. Choudhary Professor (Entomology) CoA, Indore RVSLVV Gwalior (M.P.)	07.10.2016	Excellent work is going on the devotion of the scientist is very encouraging and this is valuable for farmers encouragement also towards farming.
12.	Smt. Jagriti Sonker & Mrs. Dehut Bedgahe DB girls PG college Raipur with group	21.10.2016	Very good lab setup & really like it.
13.	Dr. Sharanbasappa Asstt. Professor (Entomology) Agriculture College Sivamossa (Karnataka)	07.11.2016	Very excellent lab with majority of the natural enemies which you are mass multiplication work.

14.	Dr. D. K. Marothia SPC, CG Govt. and President National Institute of Ecology, New Delhi	21.11.2016	The lab is moving towards higher knowledge frontier, research input can transform the agriculture and allied ecosystem.
15.	Dr. Brij Gopal Ex-Professor, Jawahar Lal Nehru University, New Delhi & Centre for Inland Waters in SAS in Jaipur	24.11.2016	Excellent very impressive in-depth work on Bio-control Biological the mass culture of Bio-control agents will be extremely useful.
16.	Dr. Anil Negi, Scientist, Member Accreditation team of forestry, ICFRE, Deheradhun and Dr. Ram Prasad Singh, Retd. Chief conservator of Forestry (External Expert)	22.11.2016	Visited bio-control lab and seen various bio-agents being multiplied and reared in the laboratory.
17.	Dr. S. K. Panda Professor & Head (Entomology) CoA, OUAT Bhubanehswar (Orrisa)	26.12.2016	One of the nicest bio-control lab. I had ever seen within a short span of time the progress made in establishing & enriching the lab. Is price worth full credit to the principal Investigators. All the best for future ventures by the PI. Students who are Putting their sincere effort for the cause of the science.
18.	Dr. D.C. Rajak Joint Director, DIPQS, Faridabad	21.12.2016	Visited laboratory for bio-control laboratories of parasitoids, predators entomopathogens and trichogramma. All are well maintained and cultures are living and impression.
19.	Shri A. Chaudhary, Deputy Management Govt. of India, M.O. Agri. & Farmers Welfare along with Shri P.S. Baghel and Shri Pargania (Agril. Deptt.)	24.11.2016	Very good experience. This has to be encouraged and more of field lead integration would benefit immensely very well done.
20.	Dr. Brajesh Mishra Assistant Director (F) Central IPM Centre Gorakhpur (U.P.)	13.01.2017	Visited bio-control laboratory and observed that many bio-control agents are being maintained the team under the excellent supervision very well work.
Student visitors from different campus of IGKV, Raipur.			
21.	Shri Ram College of Agriculture, Rajnandgaon	17.01.2017	25 students are visiting in Bio-control lab 4 year students Excellent work.
Student visitors from different state Agricultural Univerisities			

22	Chiplima, Sambalpur (orrisa)	11.01.2017	40 students from Chiplima, Sambalpur (Orrisa) visited Bio-control laboratory.
23.	Jharkhand	19.03.2017	40 farmers from Jharkhand visited Bio-control laboratory.
24.	Sher Kashmir University, Jammu & Kashmir	31.03.2017	50 students from Sher e kashmir University, J&K, visited our Bio-control laboratory along with two staff members.

List of farmers from different districts of Chhattisgarh plains visiting Bio-control laboratory under State Govt. programme "Hamar Chhattisgarh"

S. No.	Districts	Number of farmers visited	Date
1	Dhamtari	360	02-07-16
2	Bijapur	131	05-07-16
3	Balodabazar	300	08-07-16
4	Janjgir Champa	194	12-07-16
5	Kanker	150	14-07-16
6	Jashpur (Kansabel)	116	16-07-16
7	Surajpur	138	21-07-16
8	Rajnandgaon	139	23-07-16
9	Durg	147	26-07-16
10	Bemetara	189	26-07-16
11	Raigarh	200	28-07-16
12	Baludabazar (Bhatapara)	155	28-07-16
13	Gariyaband	150	28-07-16
14	Janjgir Champa	165	30-07-16
15	Kanker	103	02-08-16
16	Narayanpur	113	02-08-16
17	Dantewada	165	04-08-16
18	Kanker	155	17-08-16
19	Raigarh	145	20-08-16
20	Jashpur	143	20-08-16
21	Korea	77	20-08-16
22	Korba	116	20-08-16
23	Dantewada	160	23-08-16
24	Bijapur	171	23-08-16
25	Raipur	92	27-08-16
26	Mahashamund	150	27-08-16
27	Gariyaband	134	27-08-16

28	Surguja	138	30-08-16
29	Balrampur	165	30-08-16
30	Surajpur	170	30-08-16
31	Janjgir champa	158	01-09-16
32	Mungeli	168	01-09-16
33	Bilaspur	175	01-09-16
34	Dhamtari/Kurud	198	03-09-16
35	Kawardha	165	03-09-16
36	Rajnandgaon	170	03-09-16
37	North Bastar/Kanker	151	07-09-16
38	Narayanpur	147	07-09-16
39	Kondagaon	133	07-09-16
40	Bastar	149	07-09-16
41	Bemetara	120	09-09-16
42	Balod	177	09-09-16
43	Raigarh	110	14-09-16
44	Korea	124	14-09-16
45	Korba	137	14-09-16
46	Raipur/Tilda	113	16-09-16
47	Gariyaband	137	16-09-16
48	Mahashamund	165	16-09-16
49	Dantewada	158	20-09-16
50	Janjgir champa	158	22-09-16
51	Bilaspur	154	22-09-16
52	Mungeli	164	22-09-16
53	Surguja	155	27-09-16
54	Surajpur	164	27-09-16
54	Balrampur	155	27-09-16
55	Dhamtari	153	29-09-16
56	Kabirdham (Kawardha)	164	29-09-16
57	Rajnandgaon	193	29-09-16
58	Bemetara	161	01-10-16
59	Balod	156	01-10-16
60	Durg	178	01-10-16
61	Surguja	160	03-10-16
62	Gariyaband	28	03-10-16
63	Bilaspur	16	03-10-16
64	Korba	9	03-10-16
65	Jashpur	84	03-10-16
66	Mungeli	28	03-10-16

67	North Bastar/Kanker	122	06-10-16
68	Narayanpur	137	06-10-16
69	Kondagaon	129	06-10-16
70	Raipur	135	06-10-16
71	Janjgir champa	114	08-10-16
72	Mungeli	173	08-10-16
73	Bilaspur	144	08-10-16
74	Jashpur	115	14-10-16
75	Raigarh	114	14-10-16
76	Korba	145	14-10-16
77	Korea	125	14-10-16
78	Dhamtari	165	18-10-16
79	Kawardha	28	18-10-16
80	Rajnandgaon	169	18-10-16
81	Sukma	123	20-10-16
82	Dantewada	217	21-10-16
83	Surguja	190	25-10-16
84	Surajpur	270	25-10-16
85	North Bastar/Kanker	164	27-10-16
86	Bastar	156	27-10-16
87	Korba	146	02-11-16
88	Raipur	158	04-11-16
89	Dantewada	196	08-11-16
90	Bijapur	168	08-11-16
91	Janjgir champa	145	10-11-16
92	Bilaspur	218	10-11-16
93	Bastar	257	12-11-16
94	Kanker	224	14-11-16
95	Surguja	32	16-11-16
96	Surajpur	73	16-11-16
97	Dhamtari	158	18-11-16
98	Kondagaon	128	22/11/2016
99	Bastar	135	22/11/2016
100	Bijapur	71	28.11.2016
101	Raigarh	170	03.12.2016
102	Jashpur	127	03.12.2016
103	Balod	143	10.12.2016
104	Narayanpur	109	15.12.2016

105	Bilaspur	194	21.12.2016
106	Korba	80	24.12.2016
107	Raigarh	106	24.12.2016
108	Surguja	172	30.12.2016
109	Bilaspur	181	04.01.2017
110	Mungeli	155	04.01.2017
111	Balrampur	164	10.01.2017
112	Mungeli	124	24.01.2017
113	Gariyaband	110	09.02.2017
114	Raipur	105	09.02.2017
115	Kondagaon	105	20.02.2017
	Total	**16701**	

8.3 Miscellaneous Information

8.3.1 Awards/Honorous/Recognition

8.3.1.1 Awards

AAU, Anand

1. Dr Raghunandan BL Assistant Research Scientist (Micro) awarded Young Achiever Award 2015 by SADHNA (Society for Advancement of Human and Nature, Dr YSPUHT, Nauni, Solan)

GBPUAT, Pantnagar

1. Sujata Singh, Roopali Sharma and Archana Negi. 2016. Induced biochemical changes due to seed treatment by biocontrol agents for controlling sheath blight of rice. at National Symposium "Eco-friendly Approaches for Plant Disease Management: Recent Trends and Opportunnities" held during 29-30 December, 2016 at ICAR-IIPR, Kanpur. (**Best poster presentation award**)

MPKV, Pune

1. Dr. S. M. Galande elected as Executive council Member of the Society for Biocontrol Advancement, NBAIR, Bengaluru, for two years from 10.2.2017.
2. Dr. S.M. Galande nominated by Hon. Vice- Chancellor, Bharati Vidyapeeth Deemed University, Pune as Member of the National Service Scheme Advisory Committee from 6th September, 2016

PAU, Ludhiana

1. Best thesis award - Mr Prasun Karmakar under the guidance of Major Advisor, Dr P.S. Shera got "Third Best Thesis Award" at the National Symposium on "Impact of Climate Change, Biodiversity and Good Plant Protection Practices for Crop Productivity" organized by the Association for the Advancement in Plant Protection at **Bidhan Chandra Krishi Viswavidyalaya (**BCKV), Kalyani (West Bengal) from December 22-23, 2016.
2. Best oral presentation award - On-farm impact of egg parasitoids, *Trichogramma* spp. against lepidopteran pest in organic rice by K.S. Sangha, P.S. Shera, Sudhendu Sharma and Rabinder Kaur in the Fifth national Conference on Biological Control: Integrating Recent Advances in Pest and Disease management at NBAIR, Bengaluru (February 9 – 11, 2017)
3. Best poster presentation award - Host stage preference and progeny fitness of *Aenasius arizonensis* (Girault) on *Phenacoccus solenopsis* Tinsley by Prasun Karmakar and P.S. Shera in the Fifth national Conference on Biological Control: Integrating Recent Advances in Pest and Disease management at NBAIR, Bengaluru (February 9 – 11, 2017)
4. Best poster presentation award - Influence of crop seasons and host stages of *Phenacoccus solenopsis* Tinsley on fitness of the solitary endoparasitoid, *Aenasius arizonensis* (Girault) (=*Aenasius bambawalei* Hayat) on cotton by Prasun Karmakar and P.S. Shera in the 12th National Symposium on Biotic Stress Management Strategies: Challenges and Environmental Harmonization at Uttar Banga Krishi Viswavidyalaya, West Bengal (February 17-1, 2017).

PJTSAU, Hyderabad

1. Dr. S. J. Rahman, Principal Scientist & Univ. Head of Entomology - Received **Distinguished Scientist Award & Gold Medal** from Venus International Foundation, Chennai for the contributions and achievements in the field of Biological Control of Crop Pests during December, 2016

TNAU, Coimbatore

1. Awasthi N.S and Sridharan,S- **Awarded Best Poster** for the Paper on Compatibility of different oils with Metarihiziumanisopliae (Metchinkoff) Sorokin in the National symposium (West Zone) on Plant Health Management for Sustainable Agriculture 11-12 Dec.2016 organised by Indian Phyto pathological Society –New Delhi).

DRYSRHU, Ambajipeta

1. Dr.N.B.V.Chalapathi Rao, Senior Scientist (Ent.) received "**Best Research Scientist"** award for the year 2016 by Dr.YSR Horticultural University and the award was presented during 2nd convocation of Dr.YSR Horticultural University on 30.09.2016 at University campus, Venkataramannagudem.
2. Dr.N.B.V.Chalapathi Rao, Senior Scientist (Ent.) received **two awards one** Prof. B.C. Jena award **for best paper** presentation on "Biological management of coconut black headed caterpillar" and **best oral presentation award** in National Symposium on New Horizons in Pest Management for Sustainable Developmental Goals from 23-24 December, 2016 at OUAT, Bhubaneswar organized by Society for plant protection of environment.

8.3.1.2 Honours

PJTSAU, Hyderabad

1. Dr. S. J. Rahman, Principal Scientist & Univ. Head of Entomology - Received **Telangana Intellectual Personality Award (*Telangana Medhavi Award*)** from TNGOs and was honoured by Chairman, Telangana Legislative Council at L. B. Stadium on 9.2.2017 for contributions in the field of Agriculture for development of Telangana.

8.3.1.3 Recognition

PAU, Ludhiana

1. Dr K.S. Sangha, Sr. Entomologist, appointed as Chairman, Academic Committee (Research), Department of Entomology, PAU, Ludhiana
2. Dr P.S. Shera, Assistant Entomologist, appointed as Member, Academic Committee (Research), Department of Entomology, PAU, Ludhiana
3. Dr Sudhendu Sharma, Assistant Entomologist, appointed as Member, Academic Committee (Teaching), Department of Entomology, PAU, Ludhiana
4. Dr Sudhendu Sharma, Assistant Entomologist, appointed as Member, Social Welfare Committee, Department of Entomology, PAU, Ludhiana
5. Dr P. S. Shera, Assistant Entomologist, appointed as Incharge, Entomological Research Farm, PAU, Ludhiana, *w.e.f.*, 1.3.2017

PJTSAU, Hyderabad

1. Dr. S.J. Rahman as an Expert Member for Telangana State Bio Diversity Board (TSBDB), Govt. of Telangana
2. Dr. S.J. Rahman as an Expert Member for Committee for developing Effective Vector Control practices by ICMR, New Delhi
3. Dr. S.J. Rahman as a Member of Review Committee on Genetic Manipulations (RCGM), Ministry of Science & Tech., Govt. of India
4. Dr. S.J. Rahman as a Member of High level Expert Committee on Environmental Risk Assessment (ERA), Ministry of Environment, Forests and Climate Change, Govt. of India.

SKUAST, Srinagar

1. Dr. Jamal Ahmad acted as Dean P.G. Nominee of Ph.D. student of Environmental Science, SKUAST-K.
2. Dr. Jamal Ahmad acted as Dean, P.G. Nominee for M. Sc. (Pathology) student of SKUAST-K.
3. Dr. Jamal Ahmad acting as Major Advisor for Ph.D. student entitled "Studies on the taxonomy of hymenopteran parasitoids of agricultural pests of Kashmir".
4. Dr. Jamal Ahmad acting as *In Charge* Head, Entomology, SKUAST-K from 20th December' 2016 till date.

5. Dr. Jamal Ahmad acted as Member for Academic Council, SKUAST-K.
6. Dr. Jamal Ahmad acting as Chairman, comprehensive package of Practices for Royal Spring Golf, Srinagar.

IIHR, Bangalore

1. Dr. Ganga Visalakshy the Co chairman for the crop protection session on AICRP- cashew held at Vridachalam , RARS, TNAU, from 27th and 29th January, 2017

8.3.2 Education & Training

AAU, Anand

1. 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.
2. Participated and arranged exhibition during Krushi Mela, farmers' meeting and other special occasions as per the directives received from Directorate of Extension Education, AAU, Anand and Extension education Institute.

Details of Khedut Shibirs/farmers training programmes arranged during 2016-17

Sl. no	Date	Village & Taluka	No. of farmers attended
1	23-08-2016	Anand	132
2	12-01-2017	Devagadhbaria, Dahod Dist	48
3	20-1-2017	Vyara, Tapi Dist	89
4	23-1-2017	Devagadhbaria, Dahod Dist	62
5	20-03-2017	Devagadhbaria, Dahod Dist	43
6	27-03-2017	Vyara, Tapi Dist	51

Following talks were delivered to farmers/ extension workers/ students by Dr. D. M. Mehta and Dr. B. L. Raghunandan, on the topic 'Biological control of crop pests' during their visit to the Laboratory.

Sl. No.	Date	Visitor/Trainee	Visitor/Trainee details
1	22.03.2016	RAWE Students (21 nos.)	College of Horticulture, AAU, Anand
2	4.4.2016	Students (34 nos.)	Junagadh Agril University, Junagadh
3	19.04.2016	RAWE Students (26 nos.)	College of Horticulture, AAU, Anand
4	30.07.2016	Farmers (45)	ATMA Project, Bhavanagar
5	09.08.2016	RAWE Students (50	College of Agriculture, Vaso, AAU

		nos.)	
6	31.08.2016	Farmers/trainees (23)	EEI, AAU, Anand
7	21.09.2016	Farmers (60 nos.)	GSFC, Sihor Taluk
8	23.09.2016	Students (78 nos.)	UAS, Raichur
9	27.09.2016	Farmers (40 nos.)	Dist Institute of Education and Training, Valasan, Anand
10	05.10.2016	Farmers (20 nos.)	CIPMC,Baroda
11	19.11.2016	Students (20)	College of Agriculture, Jabugam, AAU
12	14.02.2017	Students (34)	College of Horticulture SDAU
13	20.02.2017	Farmers (24 nos.)	Group of soil and water testing farmers
14	18.03.2017	Dairy Farmers (11 nos.)	Ralanpur
15	22.03.2017	BASF Trainees (12)	BASF Ltd Ahmedabad
16	23.03.2017	Farmers (18 nos.)	ATMA Project, Raigad, Maharashtra
17	24.03.2017	Farmers (18 nos.)	Jalaram Fertilizers, Bodeli

AAU, Jorhat

1. Dr. D.K.Saikia, Principal Scientist, conducted a training programme on organic farming organized by the Defence Research Laboratory , Tezpur on 4th July'2016
2. Dr. D.K.Saikia, Principal Scientist, conducted a training programme on "Production and use of Trichogrammatid egg parasitoid" for SMS of KVK's AAU, Jorhat under Programme on biopesticide and Biofertilizers, DBT-AAU centre from 19th to 24th September,2016
3. Dr.D.K.Saikia, Principal Scientist, conducted Ph.D courses on Recent trends in Biological control (ENT-606), Advanced Insect Ecology (ENT 604) and Insect Behavior (ENT- 605).
4. One M.Sc (Agri) and three Ph.D students are being carried out P.G. research work under the guidance of Dr. D.K.Saikia,
5. 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) students
6. Dr. D.K.Saikia, Principal Scientist, impart coaching to UG students for JRF examination
7. Dr.D.K.Saikia acted as a Question setters and external examiner for Comprehensive Examination of M.Sc and Ph.D. (Agri) students of CAU (Umium and Imphal campus) during 2017.
8. Dr. D.K.Saikia acted as a Co- investigator in the Biopesticides programme under DBT – AAU, Centre
9. R. N. Borakakati, Jr. scientist, acted as a course leader of UG courses viz., Pests of crops, stored grain and their management (Ent 323) and Insect Pest of Vegetables and Ornamental crops [PP(Ento)-323] of Faculty of Horticulture. Besides these he also act as course instructor of NRM(ENT)-223 of Feculty of Sericulture and PG courses like Biological Control (ENT 507) and IPM (Ent510).
10. R. N. Borakakati, Jr. scientist, acted as a course instructor for Experiential learning programme (Bio-control agents and bio-pesticide) offered to B.Sc. (Agri) students
11. One M.Sc (Agri) student is being carried out P.G. research work under the guidance of R. N. Borakakati

Training Imparted

Sl. No.	Programme	Place	Resource person	Date	Trainee
1	IPM of oil seed crops	Conference Hall, DEE, AAU, Jorhat	Dr.D.K.Saikia	3.9.2016	KVKs Scientist and State Govt. SMS (Agri.)
2.	Farmers Scientist Interaction	Neul Gaon, allengmora	Dr.D.K.Saikia	18.03.2017	25 nos. of farmers.
3.	Awareness Programme about Swarming Catewrpillar	Allengmora, Jorhat	R. N. Borakakati	September,2017	Farmers
4	Farmers Scientist Interaction	Aventine, Final year B.Sc (Agri) Programme AAU, Jorhat	R. N. Borakakati	31.04.2017	Farmers

Television/ Radio Programme

SL. NO.	TITLE	NAME OF RESOURCE PERSON	RECORDING DATE	BROADCASTING DATE
1	Hellow Kishan Vani	D.K.Saikia	21.03.2017	22.03.2017
2	Hellow Kishan Vani	R. N. Borkakati	16.07.2016	23.07.2016
3	Xitkaleen Xak Pachalir Keet Potanga Niyantran	R. N. Borkakati	23.12.2016	26.12.2016
4	Jawik Paddhatire Keet Potanga Niyantran	R. N. Borkakati	Telecasted on 24.08.2016 (5.30pm)	
5	Jawik Paddhatire Xitkaleen Xak Pachalir Keet Potanga Niyantran	R. N. Borkakati	Telecasted on 26.10.2016 (5.30pm)	

GBPUAT, Pantnagar

1. A. K. Tewari 2016. Perspectives of Plant-microbe Interactions in Promoting Plant Health and Disease Management" as Course coordinator September 07-27, 2016 (21 days) under CAFT in the department of Plant pathology, College of Agriculture, GBPUAT, Pantnagar.

KAU, Thrissur

Education and Training

1. Trainings obtained: Dr. Madhu Subramanian, Assoc. Professor attended a ten day Capacity building programme on recent advances in use of microbials for pest management at NBAII, Bangalore from 14-24th of December, 2016.
2. Trainings imparted: One day training on mass production of Trichogramma spp was imparted to selected women farmers of Thiruvali Panchayat in Malappuram District on 05.08.2016.

Sessions on biocontrol and IPM have been handled as per the details given below

Sl. No	Date of training	Topic	Venue	Beneficiaries
1	27-12-16	Mass production of Biocontrol agents	Palghat	Agrl. Officers
2	16-02-16	Research extension interface	Palghat	Farmers
3	28-02-16	Pest management in banana	Thamarassery	Farmers
4	04-03-16	Climatic change and pest management	Varandarappilly	Farmers
5	29-03-16	Climatic change and pest management	College of Horticulture, Vellanikkara	Farmers

Radio / TV talk

1. Dr. Madhu Subramanian gave a radio talk on the "Management of insect pests in Vegetables" on 10th January 2017.

MPKV, Pune

1. Dr. Sharad Galande, Dr. Kharbade, Satappa, Dr. Nakat, Ramesh and Dr. Tamboli, Najir. 2016. *Yashogatha : Lokri Mava Jaivik Kid Niyatrnachi*. Folder released in XXV Biocontrol Workers'Group Meeting held at Andhra University Campus, Visakhapatnam, organized by ANGRAU, Anakapalle, on May 17-18, 2016.
2. Dr. Nakat, Ramesh, Dr. Kharbade, Satappa, Dr. Sharad Galande, and Dr. Tamboli, Najir. 2016. *Papaivaril Pithya Dhekun Jaivik Kid Niyatrnachi Yashogatha*, Folder released in Joint Agresco Meeting held at Dr. Punjabrao Deshmukh Krushi Vidyapeeth, Akola, on May 28-30, 2016.
3. Organized one-day training programme and demonstration of different technology at Dalapatpur village of Trimbakeshawar tahasil, Dist. Nashik to tribal farmers under TSP programme on 07.06.2016. Dr. S. M. Galande deliverd lecture on IPM of paddy and other important pests of *Kharif* crops, and conducted the demonstration of mango harvester as well as enrichment of FYM with Biopesticide and Biofertilizer with it's application in fruit orchard.
4. Organized one-day training programme at Dalapatpur village of Trimbakeshawar tehsil of Nashik district to the tribal farmers under TSP programme on 21.01.2017. Dr. D. S. Pokharkar and Dr. S. M. Galande delivered lecture on IPM of mango and cashew nut crop with .ppt presentation.

5. Dr. N. D. Tamboli deliverd lecture on IPM of chickpea and pigeon pea for the Surveyors and field staff of CROPSAP at Krishi Bhavan, Pune, on 16.11.2016.

OUAT, Bhubaneswar

1. Educating the farmers on the use of trichocards, pheromone traps and biopesticide in brinjal, paddy and sugarcane crops while conducting large scale demonstrations in their fields.

PAU, Ludhiana

Title of the lecture	Event, Date and Venue
Dr Kamaldeep Singh Sangha	
Insect pest of sugarcane and their management	TV talk on 18.04.2016
Biological control in organic farming	Seminar on "Organic Farming in Kandi Region of Punjab: Opportunities & Limitations" on 27.07.2016 at PAU-Regional Research Station, Ballowal Saunkheri
Insect pest management in organic farming	Training course on "Organic Farming" for farmers and farm women on 23.08.2016 organized by Director Extension Education, PAU Ludhiana
Insect pest control in organic farming using predators and biopesticides	Training for trainers programme work – "Organic Farming" organized by Agriculture Skill Council of India in collaboration with the Department of Agronomy, PAU, Ludhiana
Dr Parminder Shera	
Biological control of insect pests	Training for trainers programme work – "Organic Farming" organized by Agriculture Skill Council of India in collaboration with the Department of Agronomy, PAU, Ludhiana
Dr Rabinder Kaur	
Producing safe food by bio-control agents	Training programme on Organic Farming for Soil and Water Conservation, 5-9 December 2016 at PAMETI, PAU, Ludhiana

PJTSAU, Hyderabad

TV/Radio Talk

1. Participated in Radio Talk on Bio Agents & Bio Pesticides at All India Radio, Hyderabad, during April, 2016.
2. Participated in Doordarshan Phone in Live Programme and answered the queries of farming community on Biological Control at Doordarshan Kendra, Hyderabad, during September, 2016.

Trainings (As Organizer/Resource Person)

1. Imparted training on "Biological Control as viable component of Pest Management" to First & Second batch MAOs under Govt. Telangana programme, "Agro Technologies for Productive & Profitable Agriculture in Telangana State" during August, 2016.
2. Imparted training on "Strengthening of mass production of Bio Agents & Bio Pesticides" to all the staff of State Bio Agent Production Units/Labs under Govt. Telangana from 13-15, December, 2016.
3. Imparted training on "Bio Intensive Pest Management" to the delegates from other countries under International Programme organized by NIRD, Hyderabad during December, 2016.

Education

1. Trained as Bio Safety Expert under UNEP-GEF Programme by MoEF &CC, Govt. of India, New Delhi.

SKUAST, Srinagar

1. Involvement in attending and organizing of Exhibition cum Sale-cum-Exhibition Mela on 6/07-03-2016.
2. Delivered T.V. talk on *IPM of San Jose scale* on apple on 07-03-2016.
3. Lecture delivered on *Apple spray schedule-2016 and its significance in training programmme on* "Spray schedule Advisory and safe handling of Pesticides" organized by Directorate of SAMETI, SKUAST-K, Shalimar, w.e.f., 23-25, March, 2016. 23-03-2016.
4. Training provided to farmers for management of Codling moth at various places of Kargil viz., Karkichoo, Chanigund, Silkchey and Mingy, on 7th. of June, 2106.
5. Training provided to farmers at various places of Kargil, *viz*., Karkichoo, Chanigund, Silkchey and Minji, Bage-Khumani and Poyen regarding management of Codling moth through Integrated Pest Management, w.e..f., 22 to 24th. September, 2016.

YSPUHF, Solan

Trainings

SN	Lecture delivered	Training programme	Date	No. of lectures
1	Biological control of insect pests of vegetable crops	Scientific cultivation of vegetable crops	25.5.2016	1
22	Biological control of insect pests of fruit crops	Training on Organic Farm Management for Horticulture officers held at SAMATI, Mashobra	24.5.2016	1
3	Use of eco-friendly techniques (other than biological control) for insect pest management	Training on Organic Farm Management for Horticulture officers held at SAMATI, Mashobra	24.5.2016	1
4	Use of eco-friendly methods of pest management for apple, apricot and vegetable crop pests	Training programme for farmers of Tabo village of Lahaul and Spiti district	25.6.2016	1

		under TSP		
5	Role of biological control in pest management and practical demonstration on identification and use of biocontrol agents	Training programme on Organic farming of Horticultural crops organized by DEE	01-09-2016	1
6	Role of biological control in pest management and practical demonstration on identification and use of biocontrol agents	Training programme on Technology led development in Horticulture organized by DEE	21-09-2016	1
7	Biological control of insect-pests of temperate fruits	Training programme on Package of Practices for Temperate Fruits organized by DEE	23-09-2016	1
8	Role and use of biological control in pest management with practical demonstration on identification of biocontrol agents	Farmers' training programme organized by DEE	28-09-2016	1
8	Honey processing, storage and use	Farmers' training programme on Beekeeping organized by Department of Entomology	29-09-2016	1
10	Bio-control agents, their use and business potential	Training programme on Production Technology of Horticultural Crops organized by DEE	15-10-2016	1
11	Bio-control agents, their use and business potential	Training programme on Production Technology of Horticultural Crops organized by DEE	24-10-2016	1
12	Use of eco-friendly methods of pest management for apple, apricot and vegetable crop pests	Training programme for farmers of Morang village of Kinnaur district under TSP	17-11-2016	1
13	Use of eco-friendly methods of pest management for apple, apricot and vegetable crop pests	Training programme for farmers of Akpa village of Kinnaur district under TSP	18-11-2016	1
14	Biological control of insect pests of vegetable crops	Farmers' training programme organized by DEE	18-11-2016	1
15	Importance of bee flora in apiculture industry	Farmers' training programme on Beekeeping organized by Department of Entomology	21-12-2016	1
16	Innovations in pest control – Hands on Biological control	Farmers' training programme on organized by DEE	31-12-2016	1
17	Role and use of biological control	Farmers' training	14-01-	1

	in pest management with practical demonstration on identification of biocontrol agents	programme on organized by DEE	2017	
18	Non-chemical methods of pest control: Hands on biocontrol agents	Training programme for Horticulture Extension Officers of Detp. Horticulture	02-02-2017	1
19	Role of biocontrol in pest management of ornamental crops	Farmers training at KVK Kandaghat	23-03-2017	1
20	Use of eco-friendly methods of pest management for apple, almond and vegetable crop pests	Training programme for farmers of Nichar village of Kinnaur district under TSP	27-03-2017	2
21	Use of eco-friendly methods of pest management for apple, almond and vegetable crop pests	Training programme for farmers of Sungra village of Kinnaur district under TSP	28-03-2017	2

Demonstrations

S. No.	Date	Topic	Place(s)	No of Orchards/No of farmers
1	29.01.2016	Practical demonstration on the use of bio-control agents in pest management	Nauni	30
2	05.02.2016	Bio-control agents, formulations and their use	Nauni	20
3	19.02.1016	Identification of common bio-agents present in the field	Sainj, Sagrah dist. Sirmour	50
4	25.02.1016	Identification of common bio-agents present in the field	Keyodi, Nalagarh	50
5	25.6.2016	Use of eco-friendly methods of pest management for apple, apricot and vegetable crop pests	Tabo village of Lahaul and Spiti district under TSP	50
6	01.09.2016	Identification of bio-control agents, and their use	Nauni	25
7	21.09.2016	Identification of bio-control agents, and their use	Nauni	20
8	28.09.2016	Identification of bio-control agents, and their use	Nauni	25
9	17.11.2016	Use of eco-friendly methods of pest management in apple and vegetable crops.	Morang	50
10	18.11.2016	Use of eco-friendly methods of pest management in apple and vegetable crops.	Akpa	50
11	27.03.2017	Use of eco-friendly methods of	Nichar	50

		pest management in apple and vegetable crops		
12	28.03.2017	Use of eco-friendly methods of pest management in apple and vegetable crops	Sungra	50

Mera Gaon Mera Gaurav

S. No.	Date	No. of Farmers	Purpose/ activity
i)	2.2.2016	48	Collected baseline information of gram panchayat Nainatikkar and selected village Majgaon Samlati for further activities of MGMG.
ii)	20.4.2016	32	Conducted training camp cum diagnostic field visits in the fields of tomato, onion, garlic, potato. Detailed report has already been submitted to the quarter concerned.
iii)	19.07.2016	24	Visited village Naligushan under the Nainatikker Panchayat and created awareness among the farmers about the diagnosisof problems in the fields of tomato, capsicum, cucumber, brinjal, termeric and ginger.
iv)	9.9. 2016	28	Visited village Naligushan under the Nainatikker Panchayat and created awareness among the farmers about the diagnosisof problems in the fields of tomato, capsicum, cucumber, brinjal, termeric and ginger.
v)	13.12. 2016	16	Visited village Aanji under the Nainatikker Panchayat and created awareness among the farmers about the nursery production of fruit crops, registration procedure and diagnosisof problems in raising the nursery of stone and pome fruits. In addition, farmers were also enlightened about the diseases and pests of tomato, capsicum, cucumber, brinjal, termeric and ginger which are traditionally grown in the area.

Post/under graduate teaching

AAU, Anand

Sr. No.	**Name of Teacher**	**Courses taught**	**PG Students Guiding**
1.	Dr. D. M. Mehta	Immature Stages of Insects	3 (Ph.D.) 1 (M.Sc)
		Recent Trends in Biological Control	
		Advances in Integrated Pest Management	
		Insect Vectors of Plant Viruses and other Pathogens	

KAU, Thrissur

1. Dr. Madhu Subramanian, Scientist of the Project have been handling classes on biocontrol and IPM for U.G, P.G. and Ph. D programmes as well as guiding M. Sc. and Ph.D. students on regular basis.

MPKV, Pune

1. Dr. D. S. Pokharkar conducted two UG Courses No. ENT- 353 (Crop Pests, Stored Grain Pests and their Management**)** and ENT- 242 (Insect Ecology, Integrated Pest Management and Beneficial Insects), and two PG Courses ENT- 505 (Insect Ecology) and ENT- 507 (Biological Control of Crop Pests and Weeds).
2. Dr. S. M. Galande conducted the PG Course ENT- 501 (Insect Morphology) and ENT- 508 (Toxicology of Insecticides).
3. Dr. S. M. Galande conducted the viva–voce examination of the RAWE programme on 19.10.2016.
4. Dr. S. M. Galande visited Krishi Vigyan Kendra, Malegaon and NIAM, Malegaon, along with 88 RAWE students on 07.10.2016.
5. Dr. D. S. Pokharkar worked as Senior Supervisor twice for the Semester End Theory Examination at College of Agriculture, Ambi from 10.11.2016 to 23.11.2016 and G. D. College of Food Technology, Mohol from 05.12.2016 to 13.12.2016.
6. Dr. S. M. Galande worked as Senior Supervisor for the Semester End Theory Exam at College of Agriultural Biotechnology, Paud from 5.12.2016 to 13.12.2016.
7. Dr. D. S. Pokharkar guided 2 students of M. Sc. (Agri.) and 2 students of Ph. D. for the PG degree programme.
8. Dr. D. S. Pokharkar worked as External examiner for the thesis evaluation of one M. Sc. (Agri.) and Internal Examiner for the thesis viva-voce of one M. Sc. (Agri.) student.
9. Dr. S. M. Galande worked as External examiner for the thesis evaluation of one M. Sc. (Agri.) student.
10. Dr. N. D. Tamboli conducted the practical class of UG programme ENT- 486 (Mass Production of Biagents and Biopesticides).
11. Dr. N. D. Tamboli conducted Annual Practical examination of Agriculture Polytechnic College, Bavada, Indapur Tahasil, Dist. Pune and worked as External Examiner during 06.03.2017 to 17.03.2017.
12. Dr. S. M. Galande conducted Annual Practical examination of Agriculture Polytechnic College, Bhor, Dist. Pune and worked as External Examiner during 17.03.2017 to 19.03.2017.

OUAT, Bhubaneswar

Sl. No.	Course No.	Course Title	Credit Hours	Course offered to		
(1)	(2)	(3)	(4)	Entomology classes (5)	Semester (6)	No. of Students (7)
1.	ENT -	Advance insect	1+1	1st yr Ph.D.	1st	5

	604	ecology				
2.	ENT - 505	Insect ecology	1+1	1st y yr M.Sc.(Ag)	1st	16
3.	PGS - 502	Technical writing & communication skill	0+1	1stYrM.Sc.(Ag) & 1st yr Ph.D.	1st	19
4.	ENT - 513	Storage entomology	1+1	2nd yr. M.Sc.(Ag) &1st yr. Ph.D.(Nematology)	1st	12
5.	ENT - 507	Biological control of crop pests and weeds	1+1	1styrM.sc.(Ag)in Entomology,Pathology &Nematology	2nd	43
6.	ENT - 606	Recent trends in biological control	1+1	1styrPh.D in Nematology &Pathology	2nd	2
7.	ELP	Experiential learning on production of tricocards	0+20	4th yr B.Sc(Ag)	2nd	10

PAU, Ludhiana

Teacher	No. of courses taught	
	PG	UG
Dr K S Sangha	4	3
Dr Neelam Joshi	3	3
Dr Parminder Singh Shera	2	4
Dr Rabinder Kaur	1	2
Dr Sudhendu Sharma	1	2
	No. of PG Students Guiding/Guided	
	Ph. D.	M.Sc.
Dr K S Sangha	1	1
Dr Neelam Joshi	1	3
Dr Parminder Singh Shera	-	1
Dr Rabinder Kaur	1	1
Dr Sudhendu Sharma	-	-

PJTSAU, Hyderabad

1. 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.
2. Guiding M.Sc. (Ag) and Ph.D. students for their Research work in the capacity of Member of Advisory Committee
3. Sixth Batch of AELP on Biological Control is being trained for entrepreneurship on mass production of Bio agents as part of B.Sc. (Ag) under graduation programme.

SKUAST, Srinagar

1. Dr. Jamal Ahmad and Dr. Sajad Mohiuddin involved in teaching of ten different courses of UG and PG classes of Agriculture and Horticulture

TNAU, Coimbatore
UG courses

1. EXP401 – Commercial production of biocontrol agents (0+5) – Dr. S. Sridharan and Dr. P. A. Saravanan
2. EXP 301 – Commercial beekeeping (0+5) – Dr.M. R.Srinivasan, Dr. P. A. Saravanan

P.G.Courses

1. ENT 607 – Biological control of crop pests and weeds (2+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

YSPUHF, Solan

S.No.	Student Name	Degree	Title of thesis	Guided By
1	Gavkare Omkar	PhD	Studies on Zoophytophagy of *Nesidiocoris tenuis on tomato*	PL Sharma
2	Sarawati Negi	Ph D	Bio-ecology and management of invasive leafminer, *Tuta absoluta*(Lepidoptera: gelechidae) on tomato	PL Sharma
3	Anil Jaswal	PhD	To be decided	PL Sharma
4	Anamika Saini	M Sc	Parasitization potential of *Cotesia vestalis* (Haliday) against *Plutella xylostella* (L.) and its interaction with *Diadegma* sp	PL Sharma
5	Manohar TN	Msc	Laboratory evaluation of *Trichogramma* spp and *Neochrysocharis formosa* against invasive tomato pinworm, *Tuta absoluta*	PL Sharma
6	Khushi Ram	MSc	To be decided	PL Sharma
7	Gaikwad Mahesh Balasahab	PhD	To be decided	SC Verma
8	Shikha	MSc	To be decided	SC Verma
9	Deeksha Kumari	MSc	To be decided	SC Verma

Post/under graduate teaching

Course No	Title	Credit hours	Teachers' name
ENT-505	Insect Ecology	1+1	P L Sharma and S C Verma
ENT-517	Soil arthropods and their management	1+1	P L Sharma and S C Verma
ENT-507	Biological Control of Crop Pests and Weeds	1+1	P L Sharma and S C Verma
ENT-513	Storage Entomology	1+1	Devender Gupta and SC Verma
ENT604	Advanced Insect Ecology	1+1	P L Sharma and S C Verma
ENT-606	Recent Trends in Biological Control	1+1	P L Sharma and S C Verma
ENT-609	Advanced Host Plant Resistance	1+1	P L Sharma and R S Chandel
ENT-616	Plant Biosecurity and Biosafety	2+0	PL Sharma
PPE-221	Insect-pests of Fruits, plantation, Medicinal and Aromatic crops	2+1	Devender Gupta and SC Verma
ENT-591	Master's Seminar	1+0	PL Sharma

8.3.3 List of Publications

AAU, Anand

Technical Bulletin - English & Gujrati Version

1. Raghunandan B.L, Godhani, P.H, Mehta, D.M., Sushma Deb and Nehaben M Patel. *Tuta absoluta:* Current status and management strategy in Gujarat, 2016.

AAU, Jorhat

Research papers

1. Saikia, D. K., Borkakati, R. N. and Das, P. 2016. Comparative Study of Bipm Package of Rice over Farmers' Practice. *Pestology*. XL(2): 56-58.
2. Begam, N., Saikia, D. K. and Borkakati, R. N. 2016. Bio-efficacy of certain biopesticides against sucking pests of Bhut Jolokia. *Pestology*. XL(3):48-52
3. Ahmed, S. S., Saikia, D. K. and Borkakati, R. N. 2016. Seasonal incidence of major pests of cabbage and their natural enemies in Jorhat district of Assam. *Pestology*. XL(5): 54-60.
4. Borah, N., Saikia, D. K. and Borkakati, R. N. 2016. Field efficacy of certain insecticides and biopesticides against the major pests of Brinjal and their effect on natural enemies. *Pestology*. XL(7): 29-33.
5. Begam, N., Saikia, D. K. and Borkakati, R. N. 2016. Seasonal incidence of major insect-pests and their natural enemies of Bhut Jolokia. *Ann. Pl. Protec. Sci*. 24(2): 259-264.

6. Buragohain, P., Saikia, D. K., Dutta, B. C. and Borkakati, R. N. 2017. Influence of colours and height of the sticky traps against sucking pests of *Bhut Jolokia*, *Capsicum chinense* Jacq. *Res. on Crops* 18 (1): 145-152.
7. Gogoi, B., Boruah, Saradi, Srivastava, R. , Saikia, D.K. and Senapoti, D. 2017. Report of Insect Pest and Diseases in Pippali and sarpagandha from Assam. International Journal of scientific Research. 6(3): 67-69.
8. Saikia, R. Mishra, H., Devi, A. and Saikia, D. K. 2016. Bioderversity of Odonates in rice ecosystem, Titabar, assam. Journal of Entomology and Zoology studies. 4(4): 1376-1381.

Books

1. Begam, N., Saikia, D. K. and Borkakati, R. N. (2016). Insect Pests of Bhut Jolokia: Search for an eco-friendly management option. Lambert Academic Publishing, Germany (ISBN: 987-3-659-92009-7)
2. Buragohain, P., Saikia, D. K. and Borkakati, R. N. (2016). Coloured sticky traps against pests of Bhut Jolokia: An eco-friendly pest management approach. Lambert Academic Publishing, Germany (ISBN: 978-3-659-92009-7)
3. Ahmed, S. S., Saikia, D. K. and Borkakati, R. N. (2016). Lepidopteran Pests of Cabbage: Exploration for Bio-intensive management. Lambert Academic Publishing, Germany (ISBN: 978-3-659-93034-8)
4. Barman, S., Borkakati, R. N. and Changmai, H. K. (2016). Coconut cultivation in Nalbari district of Assam: An economic analysis of production and marketing. Lambert Academic Publishing, Germany (ISBN: 978-3-659-92860-4)

Book chapter

1. Borkakati, R. N. (2016). Biological Control as a component of Integrated Pest Management p. 35-37 In: *Training manual for laboratory assistants*(Ed by B. Deka et. al.) Assam Agricultural University, Jorhat-785013

Leaflets

Sl. No.	Title	Official AAU No.
1	*Kabi Jatiya Pachalir Anistakari Potanga*	AAU/DR/17(LL)/142/2016-17
2	*Amitar Apokari Kapahi Pookar Jaiwik Niyantran Byabastha*	AAU/DR/17(LL)/143/2016-17
3	*Xurpookar Upodrabar Pora Rehai Puwar Upai*	AAU/DR/17(LL)/144/2016-17
4	*Bilahi Khetir Krishakoloi Kichu Kotha*	AAU/DR/17(LL)/145/2016-17
5	*Bengena Khetir Krishakoloi Kichu Kotha*	AAU/DR/17(LL)/146/2016-17
6	*Xukhma Chakori "Tuta": Bilahir Nabagot Xatru*	AAU/DR/17(LL)/147/2016-17
7	*Krishakor Bondhu "Trichogramma" Porajiwi Potangar Karma Paddhati*	AAU/DR/17(LL)/148/2016-17
8	*Krishakar Bondhu Keibidhman Parabhuji Xandhipodi*	AAU/DR/17(LL)/149/2016-17
9	*Jalaj Apotrin Pane Metekar Jaiwik Niyantran*	AAU/DR/17(LL)/150/2016-17

Popular article/Technical/ Extension Bulletin(s)

1. Borkakati, R. N. and Saikia, D. K. (19.7.2016). Potangar Jaiwik Niyantran. Dainik Asam: 11

2. Borkakati, R. N. and Saikia, D. K. (29.7.2016 & 5.08.2016). Biological Pest Control. Horizon(Assam Tribune):2
3. Borkakati, R. N. (9.8.2016). Apokari Uii Poruar Pora Rehai Puar Upai. Dainik Asam: 11
4. Borkakati, R. N. and Saikia, D. K. (30.8.2016). Bengenar Krishake Mon Dibo Loga Kichu Kotha. Dainik Asam: 11
5. Borkakati, R. N. (19.9.2016). Xur Pukar Pora Kenedore Pabo Paritran. Asomiya Pratidin (Front Page):1
6. Borkakati, R. N. (16.9.2016). Xur Pukar Akramonar Pora Dhananir Pratiraksha. Asomiya Khabar (Front Page):1
7. Borkakati, R. N. (22.9.2016). Xur Puka Damanar Nidan. Amar Asom:5
8. Borkakati, R. N. (4.10.2016). Jaiwik Krishir Babe Upojukta Kichu Drabya. Dainik Asam: 11
9. Borkakati, R. N. (3.1.2017). Bilahir Samanwit Potanga Niyantran Byabasthapona. Dainik Assam: 11

GBPUAT, Pantnagar

Research papers

1. Rai, D., Bisht, K.S. and Tewari, A.K. 2016. The *in- vitro* effect of commonly used newer fungicides on mycelial growth in the bio-control fungus *Trichoderma harzianum* (Th 14). *Journal of Hill Agriculture.* 6 (1): 7(1): 162-164
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2. Deepika Saxena, Tewari, A.K. and Kumar, J. 2017. Development of *Trichoderma* Formulations to get higher CFU and Shelf-life. ***In***: Fifth National Conference on Biological Control on "Integrating recent Advances in Pest and Disease management" at NBAIR, Bangalore. Feb. 9-11, 2017 18 pp.

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1. Roopali Sharma 2016. Bio-fumigation for plant health and disease management. 14th International Workshop on *Trichoderma* and *Gliocladium*, Nagpur, held on November 27-30, 2016. p. 154-155.
2. Kabadwal, B.C., Sharma, R., Negi, A., Tewari, R. and Kumar, J. 2017. A Common Minimum Programme for sustainable Tomato cultivation in Golapar area of District Nainital of Uttarakhand. National Symposium on Diagnosis and Management of Plant Diseases: Integrated Approaches and Recent Trends. Umiam, Meghalaya, held on January 9-11, 2017. pp. 65.
3. Sharma, R., Negi, A., Kabadwal, B.C., Tewari, A.K. and Kumar, J. 2017. Ecofriendly management for sheath blight of rice through potential biocontrol agents. National Symposium on Diagnosis and Management of Plant Diseases: Integrated Approaches and Recent Trends. Umiam, Meghalaya, held on January 9-11, 2017. pp. 87.
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6. Sharma, R., Negi, A. and Singh, A. 2017. Isolation, Identification and Mass Production Techniques of *Trichoderma*. *In* Proceedings of the 34th Training on "Adoption of suitable conventional and biotechnological approaches for biotic and abiotic stress management in crops". 13th Feb - 05th March. 183-188 pp.

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Scientific Publications (MPKV, Pune)

1. Pokharkar, D.S., Nakat, R.V. Galande, S. M., Kharbade, S. B. and Tamboli, N. D. 2017. Evaluation of *Metarhizium anisopliae* against mango hopper, *Idioscopus niveosparsus* (Leth.) in Maharashtra. *Proc. V National conference on "Biological Control: Integrating*

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2. Dr. Nakat, Ramesh, Dr. Sharad Galande, Dr. Kharbade, Satappa, and Dr. Tamboli, Najir. 2016. *Papaivaril Pithya Dhekun Jaivik Kid Niyatrnachi: Yashogatha.* Folder released in Joint Agresco Meeting held at Dr. PDKV, Akola on May 28-30, 2016.

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3. Patro,B. and Mallick, B, 2016. Silk worm biotechnology in human welfare. Abstract: National seminar on plant genomics and biotechnology: challenges and opportunities in 21st century 23-24 January, 2016, OUAT, Bhubaneswar.225p.
4. Mahapatra, M., Gupta, P.K. and Patro, B.2016.Succession of insect pests in black gram [*Vigna mungo* (L.) Hepper] Crop. Abstract: National seminar on 'Forestry and Agriculture for sustainable future organized on the occasion of the Odisha Bigyan O Paribesh Congress (December 03-04, 2016) by Orissa Environmental society at OUAT, Bhubaneswar pp. 80-81.
5. Patro, B., Mishra, M. and Mohapatra, M. 2016. Evaluation of crop and pest management indices on brinjal based inter-cropping. Abstracts: National symposium on New Horizons in Pest Management for Sustainable Developmental Goals (23-24 December,2016).Society for Plant Protection and Environment, Department of Entomology, College of Agriculture, OUAT, Bhubaneswar, Odisha, India.pp.6-7.
6. Prithvi, P. and Patro, B. 2017. Bio efficacy of botanical extracts against cotton mealy bug, *Phenacoccus solenopsis* Tinsely.Book of Abstracts : Fifth National Conference on Biological Control : Integrating Recent Advances in Pest and Disease Management (9-11 February 2017) .Society for Biocontrol Advancement, ICAR-NBAIR, Bangalore, India. p.43
7. Prithvi, P., Patro, B. and Mohapatra, M. 2017. Biology of *Aenasius arizonensis* (Girault) (Hymenoptera: Encyrtidae) a nymphal adult parasitoid against *Phenacoccus solenopsis* Tinsely (Hymenoptera: Pseudococidae) in Odisha. Book of Abstracts: Fifth National Conference on Biological Control: Integrating Recent Advances in Pest and Disease Management (9-11 February 2017) .Society for Biocontrol Advancement, ICAR-NBAIR, Bangalore, India. p.125.
8. Patro, B. Prithvi, P. and Mohapatra, M. 2017. Host range and natural enemies of *Phenacoccus solenopsis Tinsely* (Hymenoptera: Pseudococcidae) in coastal Odisha. Book of Abstracts: Fifth National Conference on Biological Control: Integrating Recent Advances in Pest and Disease Management (9-11 February 2017) .Society for Bio control Advancement, ICAR-NBAIR, Bangalore, India. p. 199.

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A. Research papers in referred journals

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4. Kaur K and Kaur R (2016) Influence of two acaricides on survival of predator *Blaptostethus pallescens* (Poppius) (Hemiptera: Anthocoridae). Journal of Biological Control, 30(1): 11-14. (NAAS rating 3.96)
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8. Sharma S, Shera P S, Kaur R, and Sangha K S (2016) Standardization of egg dosages for mass production of *Corcyra cephalonica* (Stainton) *Phytoparasitica* 44: 459-464. (NAAS rating 6.90)
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B. Abstracts

1. Karmakar P and Shera P S **(**2017) Host stage preference and progeny fitness of *Aenasius arizonensis* (Girault) on *Phenacoccus solenopsis* Tinsley. p 103. In: Kumar Sreerama, Salini S, Gupta A, Gandhi Gracy R, Subaharan K and Ballal C R (eds) Book of Abstracts, Fifth National Conference on Biological Control: Integrating Recent Advances in Pest and Disease Management, February 9-11, 2017, Society for Biocontrol Advancement, Bengaluru, India.
2. Karmakar P and Shera P S **(**2017). Influence of crop seasons and host stages of *Phenacoccus solenopsis* Tinsley on fitness of the solitary endoparasitoid, *Aenasius arizonensis* (Girault) (=*Aenasius bambawalei* Hayat) on cotton. 12th National Symposium on Biotic Stress Management Strategies: Challenges and Environmental Harmonization, February 17-19, 2017, Uttar Banga Krishi Viswavidyalaya, West Bengal.
3. Kaur Kirandeep, Sangha K S, Kaur Rabinder, Shera P S and Sharma S (2016) Survey of lac insect *Laccifera lacca* (Kerr) in different regions of Punjab. Pp 57-58. International Conference on Biodiversity: Current Scenario and Future Strategies. October 6-7, 20146. Department of Zoology and Botany, St. Bede's College, Shimla.
4. Kaur R and Sangha K S (2017) Evaluation of anthocorid predator *Blaptostethus pallescens* (Poppius) against spider mite *Teranychus urticae* on okra under insect net cage condition. Pp 104. Fifth National Conference on Biological Control: Integrating Recent Advances in Pest and Disease Management 9-11 February 2017, Bengaluru, India.
5. Kumar R, Shera P S, Sharma S and Sangha K S (2017) Standardization of release rate of *Trichogramma chilonis* for bio-intensive management of spotted stem borer *Chilo partellus* in fodder maize. p 106. In: Kumar Sreerama, Salini S, Gupta A, Gandhi Gracy R, Subaharan K and Ballal C R (eds) Book of Abstracts, Fifth National Conference on Biological Control: Integrating Recent Advances in Pest and Disease Management, February 9-11, 2017, Society for Biocontrol Advancement, Bengaluru, India.
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7. Sharma S, Shera P S and Sangha K S (2017) Impact of bio-intensive integrated pest management practices on insect pests and grain yield in *basmati* rice. p 33. In: Kumar Sreerama, Salini S, Gupta A, Gandhi Gracy R, Subaharan K and Ballal C R (eds) Book of Abstracts, Fifth National Conference on Biological Control: Integrating Recent Advances in Pest and Disease Management, February 9-11, 2017, Society for Biocontrol Advancement, Bengaluru, India.

C. Extension Articles

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2. Shera P S, Sharma S and Sangha K S 2016. Bio-suppression of lepidopteran insect-pests in major *kharif* crops. *Progressive farming*, July 2016. pp 20-21.
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D. Newsletters

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E. Pamphlets/Folders

Folders

1. Sangha K S and Tak P S (2017) *Janglati rukhan de kere ate bimarian di pehchan ate roktham.*
2. Sangha K S and Tak P S (2017) Identification and management of insect pests and diseases of forest trees.

F. Extension Booklets

1. Sangha K S, Dhaliwal A K and Tak P S (2017) *Rukhan de mukh kere ate bimarian di pehchan ate roktham* pp. 24.
2. Sangha K S, Dhaliwal A K and Tak P S (2017) Identification and management of insect pests and diseases of forestry trees. pp 24.

PJTSAU, Hyderabad

1. Sunil Kumar, G.V., Vijaya Bhaskar, L., Satish,Y. and Rahman, S.J. 2016. Evaluation of liquid formulations of *Bt* against gram pod borer, *Helicoverpa armigera* (Hubner) and spotted pod borer, *Maruca vitrata* (Geyer) in pigeonpea. *J. Applied Biol. and Bio Tech.* **4**(1): 39-42.

SKUAST, Srinagar

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2. Shanmuga Prema M., S.Sridharan and S.Kuttalam.2016. Evaluating the biosafety of newer and conventional insecticide against Parasitoids, Predators and pollinators prevailing in agricultural ecosystem: To achieve Agricultural sustainability in future. Research journal of Res. J. Recent SciVol 5(8),11-15
3. P.Lakshmidevi, C.Gopalakrishnan and S.Sridharan. 2016. Bioassay of entomopathogenic fungi (*Beauveria bassiana)* against tomato fruit borer under in vitro conditions. *Indian journal of Tropical Agriculture*33 (4) 1-5
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1. Muthukumar, M., S. Sridharan and J.S. Kennedy .Gall midge *Lasioptera falcata* Felt (Cecidomyiidae: Diptera) a potential pest of bitter gourd. Paper presented in the national conference on "Insect biodiversity studies where does India stand in the Global Map?", Organized by Department of Animal Science, Central University of Kerala, at Kasaragod, India- 2016 p. 55.
2. Elango, K. and S. Sridharan. Arthropod diversity in pomegranate under high density planting. Paper presented in the national conference on "Insect biodiversity studies where does India stand in the Global Map?", Organized by Department of Animal Science, Central University of Kerala, at Kasaragod, India- 2016 pp53-54
3. Nikita S. Awasthi and S. Sridharan. Native isolates of entomopathogenic fungi against banana pesudostem borer *Odoiporuslongicollis* (Olivier). Paper presented in the national conference on "Insect biodiversity studies where does India stand in the Global Map?", Organized by Department of Animal Science, Central University of Kerala, at Kasaragod, India- 2016 pp54-55
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5. Gopalakrishna K. Pillai, P.N. Ganga Visalakshy 2016. *Encarsia transvena* (Timberlake), a candidate biological control agent for the management of whitefly, *Bemisia tabaci* (Hemiptera: Aleyrodidae) in polyhouses. In Chakravarthy et al. 2016, Abstracts:, 3rd National Meet of Entomologists, 7-8 October 2016, IIHR, Bengaluru, p.30
6. Jayanthi Mala B. R, Kamala Jayanthi P. D and Ganga Vishalakshy P.N, 2016. Prey-host plant association of hemipterophagous butterfly *Spalgis epius* (West wood) (Lepidopter: Lycaenidae). Souvenir, 3rd National Meet of Entomologists held at KVC, Bengaluru on 7-8th October, 2016, pp56.

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7	Ramanujam. B, Renuka. S Poornesha. B and Shylesha, A.N.2016. Electron Microscopic studies for confirmation of endophytic colonization of *Beauveria bassiana* in Maize. *Journal of Pure and Applied Microbiology*, **10** (4): 3017-3021.
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12	Veenakumari, K., Buhl, P. N., Rameshkumar, A. and Prashanth Mohanraj. 2016. First report of the parasitoid wasp *Piestopleura* Forster (Hymenoptera: Platygastridae) from India. *Journal of Threatened Taxa*, **9**: 9864-9865.
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24	P. Shrivastava, R. Kumar and M. S. Yandigeri. 2017. In vitro biocontrol activity of halotolerant *Streptomyces aureofaciens* K20: A potent antagonist against *Macrophomina phaseolina* (Tassi) Goid. *Saudi Journal of Biological Sciences* **24**(1):192–199
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29	Ankita Gupta, A. K. Das, K. Neog and A. Verghese 2016. First report of *Cotesia dictyoplocae* (Hymenoptera: Braconidae), a larval parasitoid of *Antheraea assamensis* (Lepidoptera: Saturniidae), from India. *Florida Entomologist*, **99** (3): 541−543.
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32	Ankita Gupta, Mark Shaw, Sophie Cardinal and Jose Fernandez-Triana (2016) A review of unusual species of *Cotesia* (Hymenoptera, Braconidae, Microgastrinae) with the first tergite narrowing at midlength. *ZooKeys*, **580**: 29–44.
33	Ankita Gupta, K. Saji and P. Manoj 2016. Parasitoids of butterflies: reassignment of Dolichogenidea hasorae (Wilkinson, 1928) as a new combination along with new host-parasitoid linkages and notes on host specificity from Kerala, India. *Journal of Biological Control*, 30(2): 61-67.
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37	Varshney, Richa and Bisht, R.S. 2016. Feeding propensity of the syrphid larvae, *Episyrphus balteatus* (de Geer) and *Ischiodon scutellaris* (Fabricius) on the mustard aphid, *Lipaphis erysimi* (Kalt.). *Current Biotica* **9**(4):374-387.
38	Selvaraj, K., Sundararaj, R., Venkatesan, T., Chandish R. Ballal, Jalali, S. K., Ankita Gupta and Mrudula H. K. 2016. Potential natural enemies of the invasive rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin in India.

8.3.4 Participation in Seminars / Symposia / Workshops, etc.

AAU, Anand

1. 25th Annual workshop of AICRP on Biological Control of Crop Pests at ANGRAU, Visakhapatnam on 17-18 May, 2016
2. 13th Plant Protection Subcommittee (PPSC) meeting held at AAU Anand on 2-3 March 2017
3. 13th Joint Agricultural Research committee meeting held at AAU, Anand on 21-03-2017
4. Dr. B. L. Raghunandan, Assistant Research Scientist, participated in capacity building program on 'Advances and innovations in promotion and utilization of microbials for biological control of crop pests' December 14- 24, 2016 held at NBAIR, Bangalore

GBPUAT, Pantnagar

International Visit

1. Tewari, A.K. Warwick University of life Sciences, UK., from June 5-19, 2017.

National Conference/Seminar/Workshop attended

1. A. K. Tewari 2016. 25th Annual Group Meeting of AICRP on Biological control of crop pests from Andhra University Campus Visakhapatnam, from May 17-18, 2016.
2. Roopali Sharma 2016. 25th Annual Group Meeting of AICRP on Biological control of crop pests from Andhra University Campus Visakhapatnam, from May 17-18, 2016.

3. A. K. Tewari 2017. 5th National Conference on Biological Control on "Integrating recent Advances in Pest and Disease management" at NBAIR, Bangalore. Feb. 9-11, 2017.

KAU, Thrissur

1. Dr. Madhu Subramanian, Asst. Professor attended 25th Annual workshop of AICRP on Biological Control of Crop Pests at ANGRAU, Visakhapatnam on 17-18 May, 2016.

MPKV, Pune

1. Dr. S. M. Galande attended and presented the research report of AICRP on Biological Control of Crop Pests and Weeds of MPKV centre for the year 2015-16 in XXV AICRP Biocontrol Workers' Group Meeting held at AU Campus, Visakhapatnam on 17-18th May, 2016 and presented the TSP report.
2. Dr. S. M .Galande attended Brain Storming Session on " Popularization of released rice varieties by the Agricultural Universities of Maharashtra state among farmers" organized by the Associate Director of Research, NARP, Ganeshkhind on 18.07.2016 in the conference hall of Agril.Entomology Section, A.C., Pune.
3. Dr. S. M. Galande attended one-day workshop at MPKV, Rahuri, organized by Bayer Crop Sciencs Ltd., Pune, in collaboration with MPKV, Rahuri, on 01/09/2016.
4. Dr. D. S. Pokharkar worked as Expert for conducting the interview of SMS of Agril. Entomology in KVK at Dr. PDKV, Akola, on 16/09/2016.
5. Dr. D. S. Pokharkar attended 74th Board of Studies Meeting on 22-23rd September, 2016 at the Department of Agril. Entomology, MPKV, Rahuri.
6. Dr. S. M. Galande attended and participated in discussion in Scientific Advisory meeting of KVK, Baramati, on 19.11.2016.
7. Dr. S. M. Galande attended one-day workshop on "*Marathi Viswakosh*" meeting held at MPKV, Rahuri, on 07.01.2017.
8. Dr. S. M. Galande attended Pre-RRC and presented the report in meeting held at Biocontrol Laboratory hall, MPKV, Rahuri, on 24.01.2017.
9. Dr. D. S. Pokharkar attended and presented report of AICRP on Biological Control of Crop Pests and Weeds for the year 2016-17 in the Research Review Committee meeting in Plant Protection of Agril. Entomology and Nematology held at Directorate of Research, MPKV, Rahuri, on 06.02.2017.
10. Dr. S. M. Galande attended V National conference on "Biological control: Integrating Recent Advances in Pest and Diseases Management" and presented paper at NBAIR, Bangalore during 9-11 February, 2017.
11. Dr. D. S. Pokharkar and Dr. S. M. Galande attended one-day workshop on "*Marathi Viswakosh*" meeting held at College of Agriculture, Pune, on 23.02.2017.
12. Dr. D. S. Pokharkar attended and presented the Technical programme of AICRP on Biocontrol for year 2017-18 in the Research Planning meeting held at the Directorate of Research, MPKV, Rahuri, on 17.03.2017.

OUAT, Bhubaneswar

Sl No.	Title	Date	Duration	Organizing institution
01.	Zonal Research and Extension Advisory Council meeting – 2016, RRTTS, CZ, OUAT., Bhubaneswar	03.05.2016	1 day	ADR,RRTTS.CZ,OUAT, Bhubaneswar.
02.	25th annual workshop of AICRP on Biological control	17.05.2016 to 18.05.2016	2 days	ICAR, New Delhi and NBAIR, Bangalore.
03.	State Level Research & Extension Council meeting	04.06.2016 to 08.06.2016	5 days	Dean of Research and Dean of Extension OUAT., Bhubaneswar
04.	Education council meeting of OUAT	28.07.2016 to29.07.2016	2 days	Dean, PG-cum-DRI, OUAT., Bhubaneswar
05.	National seminar on "Forestry and Agriculture for sustainable Future" organized on the occasion of the "18th Odisha Bigyan 0 Paribesh Congress" by Orissa Environmental society, Bhubaneswar.	03.12.2016 to 04.12.2016	2 days	OUAT, Bhubaneswar.
06.	4th National Symposium on " New Horizons in Pest Management for Sustainable Developmental Goods" organized by the society for Plant Protection and Environment, Department of Entomology, OUAT, Bhubaneswar ,Odisha.	23.12.2016 to 24.12.2016	2 days	OUAT., Bhubaneswar
07.	1st Dr Niranjan Panda Memorial Lecturer on Climate Change Impact on Crop Pests and Management Interventions.	02.01.2017	1 day	OUAT., Bhubaneswar
08.	National Seminar on "pest free India-2017" and delivered a talk on "Insect pest Management in pulse and oilseed crops".	21.01.2017 to 22.01.2017	2 days	Pest control Association of India organized at OUAT, Bhubaneswar.
09.	Workshop on "Awareness generation on intellectual	30.01.2017	1 day	OUAT,, Bhubaneswar

	property rights."			
10.	National conference on biological control: Integrating recent advances in pest and disease management.	09.02.2017 to 11.02.2017	3 days	Society for Bio control Advancement NBAIR, Bangalore

PAU, Ludhiana

Programme	Dates
Training on "Mass production of *Trichogramma* spp. for use in biological control programmes" held at PAU, Ludhiana for the technical staff of Rana Sugars Limited, Village Buttar Seviyan, District Amritsar	July 12, 2016 and August 10-12, 2016
Organized Farmers' Field Day on "Adoption of Biocontrol Technologies" at village Fatehpur (Patiala) in collaboration with ICAR-National Bureau of Agricultural Insect Resources, Bangalore and Nahar Sugar Mills, Amloh	October 19, 2016

1. Drs K S Sangha, Neelam Joshi, Parminder Singh Shera and Sudhendu Sharma participated in 25th Biocontrol Workers' Group Meeting of AICRP- Biological Control of Crop Pests held on May 17-18, 2016 at ANGRAU Centre, Vishakhapatnam.
2. Drs K S Sangha, Neelam Joshi, Parminder Singh Shera, Rabinder Kaur and Sudhendu Sharma participated in Workshop on "Monitoring of Pesticides Residues at National Level" and "All India Network Project on Pesticide Residues" held on 25-27 May, 2016 at PAU Ludhiana.
3. Dr K S Sangha participated in Research and Extension Specialist's Workshop for Vegetables, Horticulture and Sericulture along with Post-harvest Management, Farm Power and Machinery, Food Technology and Agricultural Economics held on May 30, 2016 at PAU Ludhiana.
4. Drs P.S. Shera and Sudhendu Sharma attended training course on "Mass Production of Biocontrol Agents and Microbial Biopesticides" at ICAR-NBAIR, Bangalore from August 1-8, 2016.
5. Drs K S Sangha, Neelam Joshi, Parminder Singh Shera, Rabinder Kaur and Sudhendu Sharma participated in Research and Extension Specialists Workshop for *Rabi* crops held on August 16-17, 2016 at PAU Ludhiana.
6. Dr K S Sangha attended workshop on "Beneficial insects and bees – A hidden treasure in the agro and horticultural sector in India" on 24.08.2016 organized by the Kingdom of Netherland in collaboration with Koppert Biological Systems at Hotel Taj Mahal, New Delhi.
7. Dr Sudhendu Sharma participated in Regional *Kisan Mela* held on September 16, 2016 at Patiala.
8. Drs K S Sangha and Parminder Singh Shera participated in Regional *Kisan Mela* on September 20, 2016 at Gurdaspur.
9. Drs K S Sangha, Neelam Joshi, Parminder Singh Shera, Rabinder Kaur and Sudhendu Sharma participated in Regional *Kisan Mela* held on September 22-23, 2016 and March 24-25, 2017 at PAU Ludhiana.

10. Dr P S Shera attended training on "Statistical Analysis using SAS software" from September 26-30, 2016 at PAU Ludhiana.
11. Dr Rabinder Kaur participated in short course on "Production Protocol of Biopesticides and Biofertilizers" held on 1-10 November, 2016 at National Institute of Plant Health Management, Hyderabad.
12. Drs K S Sangha, Neelam Joshi, Parminder Singh Shera, Rabinder Kaur and Sudhendu Sharma participated in "Brainstorming Session on Agrochemicals and Spray Technology" organized by Department of Entomology PAU Ludhiana on November 22, 2016 at PAU Ludhiana.
13. Drs K S Sangha and Sudhendu Sharma participated in 4th Workshop/Coordination Committee Meeting of "Network Project on Conservation of Lac Insect Genetic Resources" at AAU, Jorhat from December 6-7, 2016.
14. Drs K S Sangha participated in Research and Extension Specialists' Fruits, Mushroom, Agro-forestry alongwith Post-harvest management, Farm Power and machinery, Food Technology and Agri-Economics' held on 21-22 December, 2016 at PAU Ludhiana.
15. Drs K.S. Sangha, P.S. Shera and Sudhendu Sharma participated in Fifth National Conference on "Biological Control: Integrating Recent Advances in Pest and Disease Management" at NBAIR, Bangalore from February 9-11, 2017.
16. Drs K S Sangha, Neelam Joshi, Parminder Singh Shera, Rabinder Kaur and Sudhendu Sharma participated in Research and Extension Specialists Workshop for *Kharif* crops on February 27-28, 2017 at PAU Ludhiana.

PJTSAU, Hyderabad

1. Participated in Bio Safety Conference organized by Ministry of Env., Forests & Climate Change at Pragathi Resorts, Hyderabad during April, 2016
2. Participated in ZREAC (*Kharif*) at Z.P.Hall, Nalgonda, Telangana during April, 2016
3. Participated in ZREAC (*Kharif*) at Z.P.Hall, Medak, Telangana during April, 2016
4. Participated in ZREAC (*Kharif*) at Z.P.Hall, Karimnagar, Telangana during April, 2016
5. Participated and presented the work done in Biological Suppression of pests of Pulse Oilseed crops during 2015-16 and discussed proposed Technical Programme for 2016-17 at 25th Bio Control Workers' Group Meeting held on 16-17 May, 2016 at Visakha Patnam (A.P.)
6. Participated and presented Work Done Report (2015-16) and Tentative Technical Programme for 2016-17 in State Level Technical Programme (SLTP) held in May, 2016 at University Auditorium, PJTSAU Rajendranagar, Hyderabad
7. Participated in HITEX Agri. Exhibition held at Hi Tech City, Hyderabad during September, 2016 and delivered a lecture on Eco Friendly Pest Management Practices.
8. Participated in Review Meeting on Network Project on Conservation of Lac Insect Genetic Resources (NPCLIGR-ICAR) held at Assam Agri. University, Jorhat on 6.12.2017
9. Participated in Technical Team visit to Gujarat for views on SPLAT technology for management of Pink Boll Worm in cotton in Gujarat on 3rd & 4th January, 2017.
10. Participated in Pre ZREAC Meeting held at RARS, Palem on 23-24, March 2016 and acted as Co- Chairman for Plant Protection Group.

SKUAST, Srinagar

Dr. Jamal Ahmad

1. Presented work on Tropical & Temperate fruits and Mealy bugs, as speaker, in the 25th Annual Group Meet of AICRP on Biological Control held at Vishakhapatnam 17-18th May' 2016.
2. Presented Annual work on AICRP on Biocontrol in the secretariat of Vice Chancellor, SKUAST-K, on 20th April' 2016.
3. Presented Pre RCM (RCM 52) results of the Division of Entomology, SKUAST-K, to Directorate of Research on 3rd October' 2016
4. Attended interaction meeting related to interdisciplinary research work related to 52nd RCM with Director Research on 6.10.2016.
5. Attended preliminary meeting with Director Research, on HMO under pesticide evaluation programme, in the capacity of I/C Head, Division of Entomology on 14th December' 2016.
6. Attended preliminary meeting with Director Research on pesticides under pesticide evaluation programme, in the capacity of I/C Head, Division of Entomology on 21st December' 2016.
7. Attended 3rd Meeting of Horticulture with Dean Faculty of Horticulture on 26.12.2016.
8. Attended meeting with Vice Chancellor regarding Revolving fund of Research Training Centre Pollenizers & Pollination on 23rd Jan' 2017.
9. Attended 36th Academic Council Meeting on 6.02.2017 in Vice Chancellor's Secretariat, SKUAST-K.
10. Attended Interaction meeting with KVK, SMS on 8.02.2017. in the Directorate of Extension
11. Acted as Dean P.G. nominee for the Ph.D. viva voce of a student in the Division of Environmental Sciences, SKUAST-K. on 8.02.2017.
12. Acted as Dean P.G. nominee for the M.Sc.viva voce of a student in the Division of Plant Protection, SKUAST-K. on 16.03.2017.
13. Chaired a meeting of Royal Golf Course, Srinagar for the status of comprehensive package of practices on 17.03.2017.
14. Conducted M.Sc. thesis viva of student of Division of Entomology, SKUAST-K on 17.03.2017.
15. Delivered lecture on "Biological control an important component of Integrated
16. Pest Management" on 24.03.2017 in 3 days training programme on Integrated
17. Pest Management in temperate fruits and vegetables w.e.f 23-25th of March, 2017

Dr. Sajjad Mohiuddin

6. Attended SAC meeting at KVK, Bandipora on 20-02-2016.
7. Involvement in attending and organizing of Exhibition cum Sale-cum-Exhibition Mela on 6/07-03-2016.
8. Delivered T.V. talk on *IPM of San Jose scale* on apple on 07-03-2016.
9. Lecture delivered on *Apple spray schedule-2016 and its significance in training programmme on* "Spray schedule Advisory and safe handling of Pesticides" organized by Directorate of SAMETI, SKUAST-K, Shalimar, *w.e.f*., 23-25, March, 2016. 23-03-2016.
10. Attended ATIC. Interaction with farmers and solution provided regarding management of different insect pests from March, 2016 to February, 2017.

11. Visited Batalik, Gharghardoo and Darchick, Achinthang, Khalsi areas of Kargil and Leh (Ladakh) for identification and management of Brown tail moth infesting fruit and forest trees w.e.f 3-8 th. of June, 2016.
12. Participated in 25th Bio-Control Workers Group Meeting on Biological Control of Crop Pests and Diseases w.e.f 17.05.2016 to 18.05.2016 at ANGARU, Vishakhapatnam, Andhra Pradesh.
13. Attended 11 days training programme on *Advances and Innovations in Promotion and Utilization of Microbials for Biological Control of Crop Pests* at National Bureau of Agricultural Insect Resources (NBAIR), Bengalaru, w.e.f., 14th to 24th December, 2016.
14. Delivered lecture on "Principles and Concepts of Integrated Pest Management (IPM)" on 23.03.2017 in 3 days training programme on Integrated Pest Management in temperate fruits and vegetables w.e.f 23-25th of March, 2017
15. Delivered lecture on "Integrated Pest Management of key pests of pome fruits" on 24.03.2017 in 3 days training programme on Integrated Pest Management in temperate fruits and vegetables, w.e.f., 23-25th of March, 2017.

TNAU, Coimbatore

Paid hands on one day training programme on "Mass production of biological control agents" under Venture Capital Scheme was organised once in a quarter by Dr.S.Sridharan, Professor and Dr.P.A.Saravanan, Asst.Professor.

S. No.	Training/Seminar/ Conference	Trainees participated	Date/ Period	Activity
1.	One day training on mass production of insect biocontrol agents	22	22.6.16	The participants were provided with technologies on the mass production of insect biocontrol agents and also supplied with technical manual, illustrative CD and certificate
2.	Mass production of insect biocontrol agents	5	29.09.16	The participants were provided with technologies on the mass production of insect biocontrol agents and also supplied with technical manual, illustrative CD and certificate
3.	Mass production of insect biocontrol agents	10	31.01.17	The participants were provided with technologies on the mass production of insect biocontrol agents and also supplied with technical manual, illustrative CD and certificate

In addition to this training program, Dr. P.A. Saravanan, Asst. Professor is also co-ordinating with Dr.M.R.Srinivasan, Professor, in conducting the one day training on Beekeeping to farmers and Public on 6th of every month at Dept. of Agrl.Entomology, TNAU.

MPKV, Pune

Training imparted / lectures delivered during the year

S.NO	Title of the training /lecture	Beneficiary /participants	Date	Sponsor
1	Mass Production of biocontrol agents	B.Sc. (Ag) Students – 18	28.3.2016	Mahatma Phule Krishi Vidyapeeth Rahuri (Maharashtra)
2	Mass Production of biocontrol agents	B.Sc. (Ag) Students – 104	30.03.2016	TRIARD, Perambalur
3	Mass Production of biocontrol agents	Scientists - 40	21.04.2016	Shri AMM Murugappa Chettiar Research Centre, Chennai
4	Mass Production of biocontrol agents	B.Sc. (Ag) Students – 100	29.03.2016, 30.03.2016 & 01.04.2016	AC & RI, Coimbatore
5	Mass Production of biocontrol agents	Students (90) & staff (4)	3.8.16	CS academy, VLB Engineering College Road, Kovaipudur, Coimbatore
6	IPM in vegetables	Farmers	16.8.16	ATMA – Thondamuthur block
7	Mass production of Bio control agents	Students (46)	27.09.16	Govt. Arts college, Ariyalur
8	Mass production of Bio control agents	Pesticide input dealers (42)	20.10.16	MYRADA KVK, Gobi
9	Pest management in horticultural crops	Farmers	29.11.16	ATMA, Dept. of market extension
10	Biological control in pest management	Farmers	30.11.16	ATMA, Dept. of market extension

Extension / Outreach programmes participated

S. No.	Date	Tittle of Program	Benificiary/ Participants	Organizers
1	25.07.2016	Lecture on culturing of host insects on natural and artificial diet.	AICRP Nematode scientists	Dept. of Nematology, TNAU
2	24.10.2016	Kharif training to Kisan call centre	Level I, II officials of Kisan call centre	Directorate of Extension Education - TNAU
3	Two year course	Personnel contact programme – M.F.Tech course	Farmers and Public	ODL - TNAU
4	28.6.2016	Interaction with farmers.	Farmer’s	ATMA – Madhukarai

				block
5	14 – 16 July 2016	Exhibited different biocontrol agents and explained to farmers	Farmers and Public	CODISSIA and TNAU
6	21.09.16	Activities of biocontrol lab	Reporters of dinamalar	Dinamalar group
7	7.3.2017 & 8.3.17	Exhibition – Second KVK Symposium .Exhibited the various biocontrol agents and explained its application and use in pest management	Farmers and students	Directorate of Extension, TNAU

YSPUHF, Solan

1. XXV Biocontrol Workers' Group Meeting on AICRP on Biological Control of Crop Pests and Weeds held on 17-18 May, 2016 at Vishakhapattanam.
2. Review meeting of World bank funded Himachal Pradesh Horticulture Development Project at Shimla on 01-03-2017
3. Workshop on Phase II Capacity Building Project on Biosafety: Outcome and way forward at Ministry of Environment, Forests and Climate change, New Delhi on 15-03-2017.

DRYSRHU, Ambajipeta

1. Dr.N.B.V.Chalapathi Rao, Senior Scientist (Ent.) participated in one day training cum awareness programme on "coconut technologies and insurance to coconut palms" organized by Department of Horticulture to the coconut farmers (300 nos.) at Amalapuram on 17.10.16 and the programme was Chaired by Sri N. Chinnarajapppa Hon'ble Deputy Chief Minister, A.P.
2. Dr.N.B.V.Chalapathi Rao, Senior Scientist (Ent.) delivered lecture on coconut production and protection technologies to 100 FOCT trainees (Friends of coconut trees) organized by Noveeal Coconut Producer Company Limited at HRS, Ambajipeta on Oct, 21 & 28th 2016.
3. Dr. N.B.V.Chalapathi Rao, Senior Scientist (Entomology) participated and delivered lecture to 100 farmers in one day training programme on "Coconut slug caterpillar management" organized by Department of Horticulture, Amalapuram at Sakinetipalli village of East Godavari district on 8.11.16.
4. Dr.N.B.V.Chalapathi Rao, Senior Scientist (Ent.) participated in Agricultural educational day celebration at Agriculture Private Polytechnic, Mulapolam, East Godavari district being organized by M.P. Rammayya Memorial Trust and addressed the students about Agriculture and its importance in Indian economy and Importance of bio control in pest management on 3.12.16.
5. Dr.N.B.V.Chalapathi Rao, Senior Scientist (Ent.) participated in farmers group meeting organized by Samaikya farmer club association, Sakinetipalli and Chaitanya coconut producer company (C.P.C), Gondi and explained about biocontrol approaches for the management of coconut insect pest and diseases on 27.12.16.
6. Dr.N.B.V.Chalapathi Rao, Senior Scientist (Ent.) participated in Janmabhoomi Programme at Ramachandrapuram and displayed the exhibits on bio control in coconut in exhibition stall on 05.01.17 for the benefit of farming community.
7. Dr.N.B.V.Chalapathi Rao, Senior Scientist (Ent.) imparted one day training programme for seven Multipurpose Extension Officer's, Department of Horticulture, Razole on "slug

caterpillar damage and management practices under field conditions" at Horticultural Research Station, Ambajipeta on 23.01.17.

8. Dr.N.B.V.Chalapathi Rao, Senior Scientist (Ent.) participated as resource person in one day training programme on "Mango and Cashew crop protection" at Agricultural Market Yard, Tuni, East Godavari district to create awareness on plant protection measures to Cashew and mango farmers organized by Assistant Director of Horticulture, Department of Horticulture, Govt of A.P on 14.03.17

IGKV, Raipur

Workshop/Training programme

1. Attended training programme (10 days) on "Production protocol of Bio- fertilizers and Bio-pesticides" from 01-11-2016 to 10-11-2016 at National Institute for Plant Health Management (NIPHM) Hyderabad.
2. Dr. Jaya Laxmi Ganguli and Rashmi Gauraha participated and presented poster in the workshop on "Conserving wet land Wealth of Chhattisgarh" on 2nd February 2017 at Yojna Bhavan, Chhattisgarh State Planning Commission, Naya Raipur, C.G.
3. Dr. Jaya Laxmi Ganguli attended workshop on National Seminar on "Advances in Environmental Science & Technology January 23-24, 2017 organized by Department of Botany Govt. Digvijay autonomous P.G. College, Rajnandgaon C.G.

Other activities

1. Dr. Jaya Laxmi Ganguli delivered radio talk on "Dhan phasal mein jaivik keet nitantran" on 11-07-2016.
2. Dr. Jaya Laxmi Ganguli delivered lecture on 29.09.2016 on "Integrated Pest Management of Kharif crops-Rice, soybean & Sugarcane. At Samiti, Krishi Vibhag, Raipur.
3. Dr. Jaya Laxmi Ganguli delivered lecture on 07-10-2016 on the topic "*Trichogramma* card Banane ki vidhi evam mahatwa" at Samiti, Krishi Vibhag, Raipur.
4. ICAR accreditation team visited Biological control laboratory and exhibition of Hamar Chhattisgarh on 20-11-2016.
5. Visit of monitoring and review of the Education Division of ICAR team, along with Hon'ble Vice Chancellor visited the Bio- control of laboratory on 20-11-2016.
6. Dr. Jaya Laxmi Ganguli delivered lecture for DAESI (Diploma in Agricultural Extension Services for input Dealers) at Samiti, Raipur on 20-11-2016.
7. Dr. Jaya Laxmi Ganguli delivered lecture on 15th December 2016 Delivered lecture on "Mealy bugs biology, bio-control laboratory by 34 trainees, under DAESI,(Diploma in Agriculture Extension services for input dealers).
8. On 5th December 2016, Live Demonstration of Bio-agents was displayed at the venue of auditorium on occasion of "Soil Health Day".
9. Dr. Jaya Laxmi Ganguli delivered lecture on14/2/2017at DES for training of Tata-Rallis on the topic "Insect pest of crops/classification of insects".
10. Price of Bio-agents, *viz.*,Trichocards, Bracocards, *Corcyra* eggs and low cost non-electricity based candle operated light trap fixed for commercial purpose for farmers and KVK's.

IIHR, Bangalore

1. Dr.Ganga Visalaskhy.PN participated in National meet of Entomologists October7-8/2016, IIHR, bangalore
2. Dr.Ganga Visalaskhy.PN participated in National seminar on Enhancing productivity of fruit crops - mitigating major challenges, held at IIHR, Bangalore on 8///2017,228p

IIVR, Varanasi

1. Participated on XXV Annual Group meet of AICRP on ***"Biological Control of Crop Pests"*** on ANGRAU, Visakhapatnam during 17-18th May, 2016 and acted as a "**Rapporteur**" for the "Session IV: Biological suppression of pests of fruit and vegetable crops, polyhouse crop pests, storage pests and weeds" on 17/05/2016.

8.3.5 Biocontrol agents maintained

AAU, Anand

Trichogramma chilonis
T. bactrae
T. achaeae
T. pretiosum
Beauveria bassiana
Lecancillium lecanii
Metarhizium anisopliae
Nomuraea rileyi
Trichoderma harzianum

AAU, Jorhat

Trichogramma japonicum
T. chilonis
T. mwanzai
T. pieridis
Blaptostethus pallescens
Trichogramma pretiosum
Telenomus sp recovered from tea
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 U.G. (ELP) and P.G. Research. Cultures of parasitoids (*Trichogramma japonicum, T. chilonis, T. pieridis)* and water hyacinth beetle *Neochetina eichhorniae and N. bruchi* have been supplied to different regional research stations of AAU, KVKs and Agricultural officers, Govt. of Assam for their field demonstration against pests of rice, sugarcane and vegetables.

KAU, Thrissur

Entomopathogenic micro organisms: *Pseudomonas fluorescens, Trichoderma viride, Metarhizium anisopliae var. anisopliae, Lecanicillium lecanii, Beauveria bassiana, Bacillus thuringiensis* and parasitoids like *Trichogramma chilonis* and *T. japonicum*.

MPKV, Pune

Following cultures of bioagents and host insects were maintained in the Biocontrol laboratory, and used for experimental purposes as well as supplied to other Biocontrol laboratories in the State. Besides, *Trichogramma* spp., *Cryptolaemus montrouzieri, Ha*NPV, *Sl*NPV, *Metarhizium anisopliae* and *Nomuraea rileyi* were mass cultured and used for demonstrations on research farms of the University and farmers' fields. These were also distributed to needy farmers.

Trichogramma chilonis Ishii
Trichogramma chilonis TTS
Trichogramma chilonis SAS
Trichogramma japonicum Ashmead
Trichogramma pretiosum Riley
Trichogramma pretiosum arrhenotokous strain
Trichogramma pretiosum thelyotokous strain
Trichogramma achaeae Nagaraja and Nagarkatti
Chelonus blackburni Blanchard
Acerophagus papayae Noyes & Schauff
Cryptolaemus montrouzieri Mulsant
Chrysoperla zastrowi sillemi (Esben-Petersen)

Nomuraea rileyi
Metarhizium anisopliae
Beauveria bassiana
Lecanicillium lecanii

Phthorimaea operculella Zeller
Corcyra cephalonica Stainton
Maconellicoccus hirsutus Green
Paracoccus marginatus W. and G.

OUAT, Bhubaneswar

Trichogramma japonicum
T. chilonis
T. pretiosum
Trichogrammatoidea bactrae
Chrysoperla zastrowi sillemi
Goniozus nephantidis
Chilonis blackburni
Cryptolaemus montrouzieri
Xylocoris flavipes

PAU, Ludhiana

Trichogramma chilonis (temperature tolerant strain)
T. japonicum (temperature tolerant strain)
T. brassicae
Bracon hebetor
Chrysoperla zastrowi sillemi
Coccinella septempunctata
Cheilomenes sexmaculatus
Blaptostethus pallescens
Aenasius arizonensis
Cotesia glomerata
PAU Bt
Helicoverpa armigera
Spodoptera litura
Galleria mellonela
Corcyra cephalonica
Phenacoccus solenopsis
Plutella xylostella

PJTSAU, Hyderabad

Sl. No.	Bio Agent being cultured and mass produced	Type of Bio Agent
1.	*Trichogramma japonicum*	Egg parasitoid
2.	*Trichogramma pretiosum*	Egg parasitoid
3.	*Trichogramma chilonis*	Egg parasitoid
4.	*Trichogramma achae*	Egg parasitoid
5.	*Trichogramma brasilensis*	Egg parasitoid
6.	*Trichogrammatoidea bactre*	Egg parasitoid
7.	*Chelonus blaclburni*	Egg larval parasitoid
8.	NPV of *Helicoverpa*	Bio Pesticide
9.	NPV of *Spodoptera*	Bio Pesticide

SKUAST, Srinagar

The culture of following bio agents (obtained from NBAII, Bangalore) including parasitoids and predator, along with their actual/ fictitious hosts, was maintained for the purpose of mass production mainly for distribution to farmers/ experimental purposes, teaching, training to P.G.students, farmers, FCLAs, extension workers and exhibitions in Kisan melas, etc.

Trichogramma brassicae (from NBAIR)
Trichogrammatoidea bactrae (-do-)
T. chlionis (-do-)

T. cacoeciae	(-do-)
T. embryophagum	(-do-)
Blaptostethus pallescens	(-do-)
Chrysoperla zastrowi	(Local strain)
Quadraspidiotus perniciosus	(Local strain)
Corcyra cephalonica	(Local strain)
Heterorhabditis indica	(from NBAIR)

TNAU, Coimbatore

S.No	Organisms produced	Quantity sold	Amount (Rs.)
1	*Trichogramma sp.*	1135 cc	56750
2	*Acerophaguspapayee*	26600	13300
3	*Braconbrevicornis*	77950	38975
4	*Goniozusnephantidis*	400	360
5	*Cryptolaemusmontrouzieri*	2754	4131
6	*Chrysoperlazastrowi*	321800	96540
7	*Corcyra* eggs	139cc	6950
	Total	**2,33,61,504**	**2,17,006**

YSPUHF, Solan

1. Entomopathogeic fungi: *Metarhizium anisopliae, Beauveria bassiana Lecanicillium lecanii*
2. Entomopathogenic nematodes: *Steinernema* sp. and *Heterorhabditis* sp (These are maintained by the Nematology section of the Department)
3. Parasitoids: *Trichogramma chilonis. T. pretiosum, T. achaeae* and *T. pieridis*
4. Predators: *Neoseiulus longispinosus, Chrysoperla zastrowi sillemi*

Host/prey insects:

5. *Corcyra cephalonica, Tetranychus urticae, Plutella xylostella, Tuta absoluta*

IIVR, Varanasi

Trichogramma chilonis, *Chrysoperla zastrowi sillemi*, *Eucanthecona furcellta*, *Beauveria bassiana* IIVR strain and *Metarhizium anisopliae* IIVR strain.

8.3.6 Technologies Assessed & Transferred

AAU, Jorhat

Technology assessed

- Seedling root dip treatment with *Pseudomonus fluorescens* @ 2 % solution, Two sprays of *Beauveria bassiana* @ 10^{13} spores/ha against sucking pests, erection of bird perches @ 15 nos /ha, six releases of *Trichogramma japonicum* @ 1,00,000 /ha at ten days interval starting from 30 DAT against *Scirpophaga* spp. and *Cnaphalocrocis* spp., spray of Botanicals @ 5ml/lit) against foliar as well as sucking pests at ETL and spray of *P. fluorescens* 10g/lit against foliar diseases could suppress the yellow stem borer, leaf folder, geeen leaf hopper and contributing

higher yield in BIPM package. The technology has been transferred to the farmers through KVKs under AAU, Jorhat.

- Mass production procedure for natural enemies has been demonstrated and transferred the technology through training to the unemployed youth to develop entrepreneurship. Balaji chemicals, Dibrugarh, Assam has come forward to establish the mass production unit of trichogrammatids.

GBPUAT, Pantnagar

- Common Minimum Programme Under Bio-intensive IPM at Tribal areas
- WP, Oil and paste based formulations with high CFU (3-9X 10^{7}-^{10}) and shelf life (> 11 months)

PAU, Ludhiana

- Management of maize stem borer, *Chilo partellus* (Swinhoe) with two releases of biocontrol agent, *Trichogramma chilonis* Ishii; first release on 10 days old crop and second release a week thereafter, included in Package of Practice for *Kharif* Crops (2017)
- Management of diamondback moth, *Plutella xylostella* L. with bacterial (*Bacillus thuringiensis kurstaki*) biopesticide Delfin WG @ 300 g/acre on cole crops has been approved by Research Evaluation Committee (PAU) for Adaptive Research Trials during 2016-17.

PJTSAU, Hyderabad

1. Cost Effective Production Protocol for Decentralized Bio Agent Production units by rural SHGs and women SHGs.

SKUAST, Srinagar

1. Mass production of *Corcyra cephalonica*
2. Automatic rearing of *Corcyra* for increased Mass production
3. Mass production of *Trichogramma* spp.
4. Mass production of entomopathogens
5. Trunk banding for trapping of overwintering larvae of Codling moth, *Cydia pomonella* in Laddakh
6. Mass production technique of *Blaptostethus pallescens*
7. Mass production of EPN

YSPUHF, Solan

1. For the management of apple root borer, *Dorysthenes hugelii,Metarhizium anisopliae* (10^{6} conidia/cm^{2}) was as effective as chlorpyriphos (0.06%).
2. *Tuta absoluta* has been recorded from all the tomato growing areas of Himachal Pradesh and natural enemies like *Nesidiocoris tenuis* and *Neochrysocharis* were associated with the pest.
3. Different biopesticides (Bt, *Trichogramma achaeae* and neem) resulted in 56.8 to 69.6 per cent control of *Tuta absoluta* over control).

8.3.7 Centres visited during 2016-17

Sl. No.	AICRP Centre	Name(s) of monitoring officer	Month / period of visit
1	AAU, Anand	Dr. Chandish R. Ballal Dr. M. Mohan Dr. K. Selvaraj	August third week January 2017
2	PAU, Ludhiana	Dr. Chandish R. Ballal Dr. S. K. Jalali	October second fortnight
3	ANGRAU, Anakapalle	Dr. S K Jalali Dr. B. Ramanujam	December
4	YSPUHF, Solan	Dr. G. Mahendiran	December
5	MPKV, Pune	Dr. Sunil Joshi	February
6	MPUAT, Udaipur	Dr. Sunil Joshi Dr. Prashanth Mohanraj	Mid-November
7	TNAU, Coimbatore	Dr. Chandish R. Ballal Dr. S. K. Jalali Dr. T. Venkatesan Dr. G. Sivakumar	November November
10	PJTSAU, Hyderabad	Dr. Chandish R. Ballal	September second fortnight
11	DRYSRHU, Ambajipeta	Dr. S K Jalali Dr. B. Ramanujam	December
12	OUAT, Bhubaneswar	Dr. Omprakash Navik	January
13	UAS, Raichur	Dr. Omprakash Navik	February
14	AAU Jorhat	Dr. S. K. Jalali Dr. T. Venkatesan	January
15	CAU, Pasighat	Dr. G. Mahendiran	March

9. Acronyms

AAU-A	Anand Agricultural University, Anand
AAU-J	Assam Agricultural University, Jorhat
ANGRAU	Acharya N.G.Ranga Agricultural University, Anakapalle
CAU	Central Agricultural University, Pasighat
GBPUAT	Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar
KAU	Kerala Agricultural University, Thrissur
MPKV	Mahatma Phule Krishi Vidyapeeth, Pune
MPUAT	Maharana Pratap University of Agriculture & Technology, Udaipur
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
DRYSRHU	Dr. Y.S.R. Reddy Horticulture University, Ambajipeta
IGKV	Indira Gandhi Krishi Viswa Vidyalaya, Raipur
UBKV	Uttar Banga Krishi Vishwavidyalaya, Pundibari
RARS-K	Regional Agricultural Research Station, Kumarakom
RARS-V	Regional Agricultural Research Station, Vellayani
CPCRI	Central Plantation Crops Research Institute, Kayangulam
CTRI	Central Tobacco Research Institute, Guntur
CISH	Central Institute of Sub-Tropical Horticulture, Lucknow
DARE	Department of Agricultural Research & Education, New Delhi
DSR	Directorate of Soybean Research, Indore
DSR	Directorate of Sorghum Research, Hyderabad
DSR	Directorate of Seed Research, Mau
DWSR	Directorate of Weed Sciences Research, Jabalpur
IARI	Indian Agricultural Research Institute, New Delhi
ICAR	Indian Council of Agricultural Research, New Delhi
IIHR	Indian Institute of Horticultural Research, Bangalore
IIRR	Indian Institute of Rice Research, Hyderabad
IISR	Indian Institute of Sugarcane Research, Lucknow
IIVR	Indian Institute of Vegetable Research, Varanasi
NBAIR	National Bureau of Agricultural Insect Resources, Bangalore
NCIPM	National Centre for Integrated Pests Management, New Delhi